**THE CHEMICAL COMPOSITION OF DOMESTIC SOYBEAN SEEDS
AND THE EFFECTS OF PARTIAL SUBSTITUTION OF SOYBEAN MEAL
BY RAW SOYBEAN SEEDS IN THE DIET ON PIGS' GROWTH
PERFORMANCE AND PORK QUALITY
(*M. LONGISSIMUS LUMBORUM*)***

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Abstract

The objective of the study was to determine the effect of replacing soybean meal with 5% of raw soybean seeds on the growth, feed consumption and utilization of growing pigs, also the carcass and pork quality. The growth experiment was conducted on 120 pigs of approx. 18.5 kg allocated to two dietary treatments. The animals from the control treatment (CON) were offered a diet with soybean meal, and the experimental group (EXP) was given 5% raw soybean seeds (NON-GMO, Augusta var.) instead of SBM. The experiment lasted 88 days. After the experiment, eight pigs from each group were euthanized and meat samples were collected. No diet effects on the animals' performance and carcass quality were observed ($P > 0.05$). The experimental diet affected ($P < 0.05$) meat color, and also meat composition (higher water content and lower intramuscular fat content). The composition of fatty acids in the meat did not differ significantly, except for higher C16:1 content in the EXP group. The introduction of 5% raw soybean seeds into the diets did not impact animal performance, but it reduced some indices of the pork quality.

Key words: raw soybean, growing pigs, meat quality

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For many years, the European Union has observed a protein deficit that has generated a dependence on imported protein feed components. Soybean meal (SBM) is an excellent source of protein in diets for pigs, but it is costly, fluctuates in supply, and comes mostly from transgenic plants. The resolution points of the EU Parliament on 8 March 2011 treat the seeds of native legumes as alternative sources of protein. In recent years, the cultivation of legumes and especially NON-GMO soybean for feed has become popular in Poland and in Europe (Michalek and Borowski, 2006; Boczar, 2016). This is possible primarily due to the global warming, but also intensive genetic and selection work over the assortment of the varieties better prepared for growing in temperate climates (Liu, 2012; Boczar, 2016). Plant species and growth conditions could have a decisive influence on seed composition but the knowledge about the differences in the composition between domestic and imported varieties is poorly recognized (Michalek and Borowski, 2006; Thuzar, 2010). The usage of raw soybeans in the nutrition of growing pigs is unpopular because of the presence of anti-nutrients, especially protein inhibitors and corrected allergens (Choct et al., 2010; Radcliffe et al. 2019). Deactivation of these compounds in thermal processes is expensive. That is why farmers are interested in how much raw soybean seeds can be offered to pig diets without a negative effect on their performance indices and health. Generally, raw soybeans offered to adult animals reduce production potential and lower digestibility of nutrients (Caine et al., 1998; Rada et al., 2017). The pork, as a protein source is a very important ingredient of human diet. Raw soya seeds, because of high oil content, could affect meat quality and also fat content in muscles. The intermuscular fat content has influence on meat quality, especially on traits such as flavor, juiciness and softness (Fiedorowicz et al., 2016). The meat is also a rich source of minerals, which are necessary for nervous system functionality.

The aim of the study was to determine the effect of partial SBM substitution in a diet with raw soybean seeds (NON-GMO) on the growth of pigs, feed consumption and utilization, and the carcass and pork quality.

Material and methods

Soybean seeds

Glycine Max Merrill seeds of the Augusta cultivar (NON-GMO) harvested in 2015 were obtained from the Plant Breeding Stations. The composition of the seeds is shown in Table 1. Soybean seeds samples (n=4) were analyzed in duplicate.

Animals and diets

The experiment complied with the guidelines of the local ethics commission with respect to animal experimentation and the care of animals under study. The pigs received all the necessary veterinary vaccinations and had unlimited access to water and feed.

Table 1. The chemical composition of soybean seeds (n=4) var. Augusta (% DM), calculated energy value (MJ /kg DM), amino acid profile of protein (g/100g CP) and antinutrients content

	Proximate analysis (%)	Amino acid (g/100 g CP)	Antinutrients content
Dry matter	92.5±1.1	Aspartic acid	Raffinose (%)
Crude ash	6.2±0.1	Threonine	Stachyose (%)
Crude protein	38.0±0.3	Serine	Verbascose (%)
True protein	22.4±0.3	Glycine	Total RFO (%)
Crude fiber	10.3±0.6	Proline	Raffinose (% RFO)
Ether extract	18.3±0.7	Cystine	Stachyose (% RFO)
NFE	27.2±0.4	Glutamic acid	Verbascose (% RFO)
NDF	13.3±0.5	Alanine	P-phytate (%)
ADF	9.9±0.4	Valine	TIA (mg/g)
RS	4.9±0.1	Methionine	AF (ppb)
TC	14.6±0.4	Isoleucine	OTA (ppb)
Viscosity (cP)	1.2±0.1	Leucine	DON (ppb)
ME (MJ/kg)	16.2±0.6	Tyrosine	NIV (ppb)
P-total (%)	0.9±0.1	Phenylalanine	DAS (ppb)
		Histidine	T2 (ppb)
		Lysine	HT2 (ppb)
		Arginine	ZEN (ppb)

ME = metabolizable energy, NFE = nitrogen-free extractives ADF = acid detergent fiber, NDF = neutral detergent fiber, RS = reducing sugars, TC = total carbohydrates, RFO = raffinose family oligosaccharides, TIA = trypsin inhibitor activity, AF = aflatoxins, OTA = ochratoxins A, DON = deoxynivalenol, NIV = nivalenol, DAS = diacetoxyscirpenol, T2 = T2 toxin, HT2 = HT2 toxin, ZEN = zearalenone, NF = not found, results are expressed as mean ± standard deviation.

Growth experiment

The growth experiment was conducted on 120 pigs (Naima × (Pietrain × Duroc)) of approx. 18.5 kg BW. The pigs were allocated by body weight and sex (30♀ and 30♂; $n=60$) to two dietary treatments and housed in individual pens. All of the diets were offered in mash form. The animals had *ad libitum* access to water and feed. The animals from the control treatment (CON) were offered a diet with SBM, whereas in the experimental group (EXP), 5% raw soybean seeds were introduced into the feed mixtures mainly of SBM (Table 2). The protein profile was supplemented with crystalline amino acids, according to the pig requirements (GfE, 2006).

Table 2. The composition and nutritional value of diets in the experiment

Components (%) / treatment groups	Grower		Finisher	
	CON	EXP	CON	EXP
Soybean seeds 35.2%	0.00	5.00	0.00	5.00
Soybean meal 46%	25.00	21.50	13.00	9.50
Triticale	68.00	67.09	82.90	82.11
1-Ca phosphate	1.20	1.10	0.30	0.30
Limestone	1.30	1.30	1.40	1.40
Sodium chloride	0.34	0.34	0.25	0.25
Rapeseed oil	3.50	3.00	1.50	0.75
Premix 0.5%	0.50	0.50	0.50	0.50
L-lysine	0.14	0.15	0.14	0.15
DL-methionine	0.02	0.02	0.01	0.04
Calculated nutrient contents (g/kg)				
ME (MJ/kg)	14.10	14.20	13.50	13.50
Crude protein (g/kg)	185	186	160	160
Lysine	10.60	10.70	8.40	8.47
Methionine+cystine	6.30	6.30	5.30	5.57
Tryptophan	2.30	2.30	1.80	1.80
Threonine	6.90	6.90	5.56	5.50
Calcium	9.60	9.40	7.52	7.52
Phosphorus	6.60	6.40	2.37	2.45
Sodium	1.50	1.50	1.12	1.12
Crude fiber	35.10	35.60	28.20	28.80

CON = control group, EXP = experimental group, ME = metabolizable energy was calculated in the program WinPasze, based on chemical composition of diets, Premix = Mineral and vitamin premix content per kg diet. Fe (75 mg); Cu (20 mg); Co (0.3 mg); Mn (30 mg); Zn (75 mg); I (0.6 mg); Se (0.15 mg); vitamin A 7500 IU; vitamin D₃ 1500 IU; vitamin E, 52.5 mg; vitamin K₃, 1.1 mg; vitamin B₁, 1.1 mg; vitamin B₂, 3.0 mg; vitamin B₆, 2.25 mg; choline chloride, 200 mg; pantothenic acid, 7.5 mg; nicotinic acid, 15 mg; folic acid, 1.5 mg; vitamin B₁₂, 18.5 µg; biotin, 75 µg; Ca, 1.3 g; antioxidants (butylated hydroxyanisole, butylated hydroxytoluene).

The experiment lasted 88 days and was divided into a grower and finisher period of 53 and 35 days, respectively. The experiment was finished when the animals recorded approx. 95 kg of body weight. The average daily weight gains and feed intake were recorded and, from this, the feed conversion ratio was calculated (Table 3). After the experiment, eight pigs from each group were killed (4♀ and 4♂; $n=8$). The

animals were stunned using Letters Schmidt-Weinberger tongs in accordance with the applicable standards and regulations.

Table 3. Production results within control and experimental groups

Parameters	Period of experiment	CON	EXP	SEM	P
Body weight (kg)	Grower 18–57 kg	18.32±0.21	18.54±0.32	0.345	0.847
	Finisher 57–93 kg	57.24±0.60	57.21±0.74	1.140	0.990
	Total 18–93 kg	93.53±0.91	94.71±1.00	0.640	1.780
Average daily body weight gain (kg)	Grower 18–57 kg	0.73±0.11	0.73±0.10	0.02	0.889
	Finisher 57–93 kg	1.04±0.11	1.01±0.10	0.020	0.589
	Total 18–93 kg	0.89±0.12	0.87±0.08	0.110	0.744
Body weight gain (kg)	Grower 18–57 kg	38.92±0.42	38.67±0.50	1.090	0.868
	Finisher 57–93 kg	36.29±0.43	37.50±0.73	4.950	0.680
	Total 18–93 kg	75.21±0.92	76.17±0.79	1.340	0.740
Average daily feed intake (kg)	Grower 18–57 kg	1.91±0.22	1.88±0.10	0.050	0.669
	Finisher 57–93 kg	3.38±0.22	3.36±0.31	0.090	0.823
	Total 18–93 kg	2.65±0.09	2.62±0.10	0.070	0.744
Feed conversion ratio (kg/kg)	Grower 18–57 kg	2.67±0.23	2.58±0.38	0.579	0.340
	Finisher 57–93 kg	3.24±0.20	3.29±0.11	0.070	0.657
	Total 18–93 kg	2.96±0.08	2.94±0.18	0.060	0.851

CON = control group, EXP = experimental group, SEM = standard error of mean, P = significance, results are expressed as mean ± standard deviation. The experiment lasted 88 days and was divided into a grower and finisher period of 53 and 35 days, respectively.

Analytical procedures

For chemical analysis, all of the samples were ground to pass through a 1.0 or 0.5 mm sieve. The seeds were analyzed in duplicate for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF), crude ash (CA), acid detergent fiber, neutral detergent fiber, and total phosphorus using methods 934.01, 976.05, 920.39, 978.10, 942.05, 973.18, 984.27, and 965.17, respectively, according to AOAC (2007). Nitrogen-free extractives (NFE) were calculated: $NFE = DM - (CP + CA + CF + EE)$. Metabolizable energy was calculated according to GfE (2006). The true protein (TP) content was determined according to 934.01 (AOAC, 2007), followed by suspension of protein with 20% triacetic acid. The amino acid content was determined with an AAA-400 Automatic Amino Acid Analyzer (Prague, Czech Republic) using ninhydrin (Sigma-Aldrich, Munich, Germany) for post-column derivatization. Before analysis, the samples were hydrolyzed with 6 N HCl (POCH, Gliwice, Poland) for 24 h at 110°C (AOAC, 2007). Approximately 2 g of the seeds were placed in microcentrifuge tube added with 8 ml water and centrifuged at $12,700 \times g$ for 5 min for viscosity analysis. The supernatant was withdrawn and stored on ice until viscosity ($mPas \cdot s = cP = 1 \times 100 \text{ dyne s cm}^{-2}$) was determined using a Brookfield Digital DV-II+ cone/plate viscometer (Brookfield Engineering Laboratories Inc., Stoughton, MA, USA) at a shear rate of 42.5 s^{-1} at 40°C. Oligosaccharides from raffinose family (RFOs), and reducing sugars were extracted and analyzed

by high-resolution GC as described previously by Zalewski et al. (2001). Phytate-P was determined using the method described by Haug and Lantzsch (1983), while trypsin inhibitor activity (TIA) was analyzed according to PN EN ISO 14902:2005. Aflatoxins and ochratoxin A were determined by HPLC method with fluorescence detection. The assays were purified on immunoaffinity columns AlphaTest for aflatoxin and OchraPrep for ochratoxin A, according to the procedure given by the manufacturer. Analysis of deoxynivalenol, nivalenol, diacetoxyscirpenol, zearalenone, toxin T2 and HT2 was performed by HPLC-MS/MS. The samples were purified on Agilent Bond Elut Mycotoxin columns.

Table 4. Analysis of carcass characteristics of growing pigs (n=8)

Trait	CON	EXP	SEM	P
Cold dressing yield (%)	79.5±0.9	79.7±4.2	0.235	0.784
Final body weight (kg)	105.2±3.0	97.9±7.0	2.228	0.103
Carcass weight (kg)	83.6±2.7	78.0±5.7	1.800	0.123
Carcass length (cm)	74.5±0.4	71.5±1.7	1.195	0.235
Backfat thickness from 5 points (mm)	17.2±3.2	16.6±4.4	0.089	0.708

CON = control group, EXP = experimental group, SEM = standard error of mean, P = significance, results are expressed as mean ± standard deviation.

Meat quality

A day after slaughter, the quality of carcasses was evaluated according to Różycki (1996). The obtained samples were cooled at 4–5°C. In order to evaluate the quality of the pork (Table 5), samples were taken from the *longissimus lumborum* muscle, from the right half-carcass after 24 h from the moment of slaughter. Analyses were carried out 48 h after slaughter. In order to determine the physical and chemical properties of the meat, the acidification of muscle tissue in the muscle of *longissimus lumborum* was measured twice: 45 min after slaughter (the measurement was made on the right half-carcass after the last rib) and 48 h after slaughter (in water extracts of ground meat) using a CX-701 pH meter by Elmetron with a stiletto electrode (Grajewska and Bocian, 2005).

The color of the meat was determined using a colorimeter (Konica Minolta, CR400, Japan), and the standardization was made using white calibration plate No. 21033065 and using the D65Y 86.1 x 0.3188 y 0.3362 scales. The color parameters in the system CIE L* a* b* were determined (L* – brightness, a* – redness, b* – yellowness) (CIE, 1986). The free leakage of meat juice was determined using the method of Honikel (1987), and the amount of the thermal juice leak was determined according to the method of Walczak (1959). Water absorption of meat was determined according to Grau and Hamm (1952). The content of total protein, intramuscular fat, collagen, and water was determined in accordance with the applicable standards (PN A 82109:2010, PN ISO 3496:2000) (Table 6). For the analysis of the samples, the method of near-infrared transmission spectrometry was used, with calibration on the artificial neural networks by the FOSS Food Scan device.

Table 5. Analyzed parameters of meat (*m. longissimus lumborum*) quality

Trait	CON	EXP	SEM	P
pH _{45min}	6.1±0.1	6.1±0.1	0.035	0.614
pH _{48h}	5.9±0.1	5.9±0.2	0.045	0.301
Water holding capacity (%)	13.5±8.0	17.1±9.6	2.967	0.587
Drip loss (%)	4.5±1.8	5.9±1.4	0.593	0.270
Cooking loss (%)	18.5±1.6	19.1±1.9	0.550	0.610
Color parameters				
L* – lightness	50.9±5.4	48.4±1.2	1.382	0.405
a* – redness	7.4*±0.3	5.6±1.9	0.423	0.022
b* – yellowness	4.3*±0.5	1.9±0.7	0.494	0.001

CON = control group, EXP = experimental group, SEM = standard error of mean, P = significance, *significant at P<0.05, results are expressed as mean ± standard deviation.

Table 6. The chemical composition of meat (*m. longissimus lumborum*)

The chemical composition of meat	CON	EXP	SEM	P
Water content (%)	72.9±0.5	73.5*±0.3	0.097	0.005
Total protein content (%)	23.9±0.5	23.9±0.4	0.090	0.961
Intramuscular fat content (%)	2.6*±0.6	1.7±0.3	0.136	<0.001
Collagen content (%)	0.8±0.1	0.8±0.2	0.027	0.848

CON = control group, EXP = experimental group, SEM = standard error of mean, P = significance, *significant at P<0.05, results are expressed as mean ± standard deviation.

Table 7. Fatty acid profile (% of total FA) of fat from the *m. longissimus lumborum* of the studied animals

Trait	CON	EXP	SEM	P
C16:0	24.90±3.76	24.25±1.38	0.936	0.751
C16:1	6.35±1.31	4.63±1.36	0.545	0.119
C18:0	3.10±1.93	6.25±2.06	0.883	0.067
C18:1	42.58±7.02	35.10±2.55	2.234	0.092
C18:2	20.77±8.45	27.62±1.76	2.381	0.164
C18:3	2.30±0.44	2.15±0.57	0.170	0.703
SFA	28.00±2.38	30.50±3.31	1.000	0.427
MUFA	48.93±7.99	39.73±3.89	2.559	0.119
PUFA	23.07±8.82	29.77±1.78	0.936	0.751

CON = control group, EXP = experimental group, C16:0 = palmitic acid, C16:1 = palmitoleic acid, C18:0 = stearic acid, C18:1 = oleic acid, C18:2 = linoleic acid, C18:3 = linolenic acid, SFA = saturated fatty acids, MUFA = monounsaturated fatty acids, PUFA = polyunsaturated fatty acids, results are expressed as mean ± standard deviation.

Fatty acid methyl esters analysis (Table 7) was performed by transesterification of oil with 2 M KOH in methanol and isooctane. GC method was used with HP 6890 (Hewlett-Packard, USA) model equipped with an on-column injector and flame ionization detector (FID). The fused silica capillary column coated with a 1.0 µm film of

HP-FFAP (polyethylene glycol), 30 m and 0.53 mm I.D. was used. Helium was used as a carrier gas at a constant flow rate of 1.2 mL/min. Temperatures of FID detector and the on-column injector were 250 and 103°C, respectively. The oven temperature was 100°C (0 min), and then programmed to 230°C at 10°C/min and held there for 2 min. One µl of sample was injected into the column, and the fatty acids were identified by a comparison of the retention times with those of the methyl esters standards.

Statistical analysis

Statistical analysis was performed using the SAS Enterprise Guide Ver. 7.1 (Statistical Analysis System, 2018) computer program. The significance of the differences between the two groups was calculated using student's t-test at $P < 0.05$. The obtained results were analyzed statistically by calculating the arithmetic mean ($\bar{x}$) and standard deviation (SD) for each characteristic.

Results

The chemical composition of the soybean seeds

The soybean seeds var. Augusta used in the experimental diets contained 92.5% DM, 38% CP, and 22.4% TP (Table 1). The content of CF reached approx. 10%, and EE approx. 18.3%. The NDF and ADF content was 13.3% and 9.9%, respectively. The amino acid profile of protein was characterized by 7.37% of lysine and 0.94% of methionine contents. Among the anti-nutrients, the seeds contained nearly 75 g/kg DM of RFOs, 62 mg/g DM of TIA and 0.50% phytate-P in DM, which is 57% of the total phosphorus. In the RFOs structure, it was approx. 79% of stachyose, below 18% raffinose, and 4% verbascose. From the eight determined mycotoxins, DON, T2 and ZEN were only present in the soybean seeds.

Growth experiment

The total and daily body weight gain did not differ significantly ($P > 0.05$) between the groups during the whole period (grower and finisher), and the pigs achieved an average of 75 to 76 kg of body weight gains and 0.87 to 0.89 kg of daily gains. In the EXP group, where the soybean meal was replaced with raw soybean seeds, there was no deterioration in feed intake compared to the CON group (Table 3). The mean feed intake was approx. 2.64 kg/day. In addition, there were no significant differences in the feed conversion ratio ($P > 0.05$), and in the total experiment, it was 2.96 in the CON groups and 2.94 in the EXP groups.

Carcass and meat quality

Carcasses of growing pigs did not differ significantly ($P > 0.05$) in cold dressing yield, carcass length and mean backfat thickness measured from 5 points (Table 4). The meat in both groups was characterized by similar and proper acidification, water absorption as well as free and thermal leakage (Table 5). The significant

differences ($P < 0.05$) were shown in the meat color between the studied groups. The meat derived from the pigs fed a diet based on raw soybean seeds was characterized by a smaller amount of red but yellow color compared to the meat of pigs fed a diet containing soybean meal. Higher intramuscular fat content but lower water content ($P < 0.05$) were observed in the meat from the CON group (Table 6). In the CON group, the intramuscular fat content of the meat was approx. 0.9% points higher than in the EXP group. The protein and collagen content were similar in the meat from both groups. The content of fatty acids from C16 and C18 groups did not differ significantly (Table 7) except C16:1, the content of which was higher in the muscles of pigs from EXP group ($P < 0.05$). Saturated fatty acids (SFA), monounsaturated fatty acids (MUFA), polyunsaturated fatty acids (PUFA) content did not differ between groups ($P > 0.05$).

Discussion

The chemical composition of the soybean seeds

The soybean seeds var. Augusta contained a similar amount of dry matter compared to the results of Grela and Skomial (2015). The dry matter of the soybean tested was over 90%, which indicates that the seeds were dried to obtain high-quality material and protection against the development of pathogens. The level of crude protein was higher than that declared by Grela and Skomial (2015) – 34.5% in DM, whereas Jarecki and Bobrecka-Jamro (2015) reported approx. 35.3%. Pande et al. (2014) observed, however, that fertilization modifies the chemical composition of soybean seeds, affecting, among others, a significant increase in the protein content of seeds. In the actual research crude fiber reached a higher level (10%) than in the above-mentioned studies. The analyzed seeds contained approx. 18.3% crude fat, which was lower than reported by Jarecki and Bobrecka-Jamro (2015) – 20.5% or Grela and Skomial (2015) – about 21%. Kolata (2017) established that the soybean varieties cultivated in Poland are characterized by a reduced content of fat, protein, and amino acids but have a larger share of crude fiber and oligosaccharides compared to the foreign varieties. According to Michalek and Borowski (2006), drought can reduce fat content in soybeans by 5% to 14%. There were no differences among the level of EM and ash compared to Grela and Skomial (2015). A higher content of metabolizable energy was reported by Grela and Skomial (2015), which may be due to the lower content of crude fat in analyzed seeds. Among amino acids, higher lysine, arginine, and threonine content were observed than reported by Grela and Skomial (2015). Analyzed seeds contained similar RFOs, trypsin inhibitors and phytate levels to those reported by other authors (Kolata, 2017).

The soybean is often infected with mold fungi that produce mycotoxins. The mycological quality of the tested seeds was good. Mycotoxins level did not exceed the applicable standards. Mycological status of Polish soybeans is generally satisfactory and the TIA was similar to varieties from other countries (Kolata, 2017). The results obtained in our research correlated with the studies of Rodrigues and Naehrer

(2012), showing that DON and ZEN are the mycotoxins most frequently occurring among soybean from all over the world. Varieties grown in Poland are also characterized by quite high resistance to fungal diseases, which reduces mycological contamination (Kukier and Kwiatek, 2011). However, there are no official reports on the mycology state of soybean varieties in Poland. The chemical composition of soybeans may vary due to the variety and habitat conditions (Kołata, 2017). The Central European climate in which the analyzed NON-GMO soybeans grow up departs significantly from the climate prevailing in Asia, the homeland of soybeans, or in America, where the largest amount of soybean is harvested. The chemical composition of the seeds is influenced by many factors such as the length of the growing season, temperature, humidity, soil richness in macro and micro elements, crop production practices, fertilization level, and selection of varieties (Liu, 2012; Van Roekel *et al.*, 2015).

Growth experiment and meat quality

There is limited current data regarding the usage of raw soybean seeds in animal nutrition in the literature as a result of the general conviction of the negative effect of ANFs on animal performance. The use of just 6% raw soybean seeds in pig's diet (1.18 mg/g of trypsin inhibitors per g of diet) significantly reduced their growth although it did not affect the conversion indices (Pontif *et al.*, 1987). Castell and Cliplef (1988) observed major growth and conversion reductions when 9% of seeds were used in diets for growing boars, although they did not find any differences with levels of 4.5%. This is in the agreement with the current experiment, where 5% of the SBM protein in the diet was replaced by raw soybean seeds protein. This level showed no negative response to the growing animals' performance. The total and daily body weight gain, feed intake and feed conversion ratio were on the same level, independently from the diet composition. The other results also show that low levels of raw soybean seeds in the diets of growing pigs (5–10%) and, therefore, low anti-nutrient content did not disturb the feed quality, palatability, and probably digestibility (Young, 1967). Tagliapietra *et al.* (2007) suggest that full-fat soybean seeds can be usefully included in the diets of finishing pigs (80 to 170 kg), even up to 10% of the complete mixture, without a negative effect on growth performance, meat quality, and health status.

In the current research, no effect of raw soybean seeds presence in the diet on carcass cold dressing yield and backfat thickness was found, similar to the results of Tagliapietra *et al.* (2007). Leszczyński *et al.* (1992) did not observe any difference between treatments as regards the color, firmness and fat as compared to whole unprocessed soybean seeds and soybean meal. Similar results were also presented by Kuhn *et al.* (2004). In the actual research, the meat from pigs offered diet with 5% of raw soybean seeds was characterized by a darker color in comparison with meat from control group. Soybeans contain 18% of fat rich in linoleic acid (54%) and oleic acid (22%), with a high percentage of linolenic acid (8%) (Leszczyński *et al.*, 1992). In the control group, soybean meal contained a lower fat level, so the diet was supplemented with a higher level of rapeseed oil in comparison to the experimental diets, where full-fat soybean seeds were added. It means that the experimental diets

contain more soybean oil richer in polyunsaturated fatty acids. The color of meat depends largely on myoglobin content and the ratio of its chemical form. Myoglobin in meat exists in three forms: oxygenated oxymyoglobin, oxidized metmyoglobin, and reduced deoxymyoglobin. As a result of oxidative changes, oxymyoglobin is transformed into metmyoglobin of grey-brown color, which is associated by consumers with the meat of poor quality. Substances formed by the oxidation of fatty acids mediate the process of oxymyoglobin-metmyoglobin oxidation, leading to adverse color changes (Pogorzelska-Nowicka et al., 2018). Through the use of appropriate components in animal nutrition, the composition of the meat can be modified (Karpiesiuk et al., 2013). One of the most important parameters affecting the palatability of meat is fat content. On the other hand, pork, due to the relatively high content of intramuscular fat in some carcass elements, is not accepted by consumers who pay attention to the health benefits of food. Pig producers are trying to influence the composition of meat to achieve the health benefits of pork. The quality of fat in muscle is the result of diet composition, soybean form (raw or extruded, whole, meal) and also breed of animals. Leszczyński et al. (1992) found no difference in fat content in pork among groups of pigs offered soybean meal by 10 to 20% of whole extruded soybean seeds. In the current research, the fat content was lower in the experimental group compared to the control group. Better oil (fat) digestion of raw soybean seeds can be achieved by the physical damage to cell structure by thermal or physical processes, which are quite expensive, and (in Poland) they can increase the cost of feed component by about 5 to 10%. Fat from unprocessed seeds could be less utilized than from processed seeds or soybean meal (toasted, extruded, micronized). The fat in animal tissues comes either from *de novo* synthesis or from dietary fat, with a small percentage derived from interconversion between fatty acids (Wiseman and Agunbiade, 1998). The use of soybean oil, both in free form and as a compound, tends to increase the level of *n*-6 fatty acids (linoleic acid) and *n*-3 fatty acids (mainly linolenic acid), and reduce the level of oleic acid in the meat. Warnants et al. (1999) found varied content of SFA, MUFA and PUFA in the backfat when whole soybean seeds were present from 0 to 8% in the diet, but a generally higher level of unsaturated fatty acids was observed when soybean seeds level increased. On the other hand, unsaturated fatty acids lower the carcass quality which results in odors and undesirable taste. Therefore, the use of soybean seeds in the finishing phase should be limited by the level of linoleic (and linolenic) acid in the diet, which must not exceed 1.5% in pigs. In the actual research significant differences were not detected. This is probably a result of a safe, quite low inclusion of raw full-fat soybean seeds in the diet.

Conclusion

Implementation of the partial replacement of soybean seeds *Glycine Max Merrill* var. Augusta (NON-GMO) instead of soybean meal in the diet for growing pigs in the amount of 5% indicated no negative effects on the animals' performance and carcass quality but it can negatively affect the pork color and water content. It also reduced intramuscular fat content, thus decreasing the organoleptic benefits of pork. Low level of raw full-fat soybean seeds in the diet (up to 5%) did not impact signifi-

cantly fatty acid profile. Domestic soybean seeds as a desirable source of protein and fat can provide a component for pig feedstuff.

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