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The effect of diet supplementation with linseed scrap on the meat quality and fatty acid profile of the meat and backfat in fattening gilts

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Abstract: The study was designed to evaluate the effect of diet supplementation with linseed on the carcass characteristics, meat quality and oxidative stability as well as the composition of the fatty acids in *M. longissimus lumborum et thoracis* (MLLT) and the backfat of fattening gilts. A total of 40 animals were used, 20 in the experimental and 20 in the control group. The results indicate that gilts fed with the control feed mixture (C) showed a higher ($P < 0.05$) content of intramuscular fat and backfat as compared to the experimental group (L) of gilts. A higher drip loss ($P < 0.001$) was recorded in the L group as same as higher pH_{45} and pH_{24} values ($P < 0.01$). The fatty acid profile analysis in the MLLT showed that the content of the MUFA (monounsaturated fatty acids) was lower ($P < 0.01$) in the L group than in the C group of the animals and also showed a higher ($P < 0.01$) content of the PUFA (polyunsaturated fatty acids) in the L group. The content of the n-6 and n-3 PUFA was higher ($P < 0.001$) in the L group. The ratio of the n-6/n-3 PUFA was significantly lower ($P < 0.001$) in the L group. The PUFA/SFA (saturated fatty acids) ratio was more favourable in the L group of gilts ($P < 0.01$). The results of the fatty acid profile analysis in the backfat proved the higher ($P < 0.05$) content of the UFA (unsaturated fatty acids) in the L group, while the content of the MUFA was lower ($P < 0.001$) in the L group. The total content of the SFA was lower ($P < 0.05$) in the L group. A higher content of the PUFA ($P < 0.001$) in the backfat was recorded in the L group than in the C group and the content of the n-3 PUFA was higher ($P < 0.001$) in the L group. The ratio of the n-6/n-3 PUFA was more favourable ($P < 0.001$) in the L group than in the C group. Also, the PUFA/SFA ratio was higher ($P < 0.001$) in the L group.

Keywords: pigs; linseed scrap; nutrition; carcass value; fatty acid composition

Fat additives to compound feeds are one of the sources of fatty acids and contribute to the fatty acid profile in pig fat. Oilseeds are the most important source of fat in the feeds for pigs. The fat content and the fatty acid composition in the oilseeds depend on the species and variety of the crop. The analyses of the vegetable oils in terms of the fatty acid composition imply that certain varieties of flax (*Linum usitatissimum* L.) show a beneficial fatty acid composition, mainly a high content of the n-3 polyunsaturated fatty acids (PUFA) and particularly the alpha-linolenic acid, which is a precursor for other fatty acids of the n-6 and n-3 series (Beckova and Vaclavkova 2010; Jasinska and Kurek 2017). The works of Brodowska et al. (2018) and Leikus et al. (2018) suggest that a diet supplemen-

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tation for pigs with linseed can increase the nutritional value of their meat without a negative effect on the organoleptic properties or the oxidative stability. Linseed is added to the diet in various forms (crushed, extruded, scrapped). The doses of linseed in the feed mixtures range from 1% to 15% (Matthews et al. 2000; Corino et al. 2008; Okrouhla et al. 2013). The studies show that even a 1% share changes the fatty acid profile in the pork fat. A dose of at least 5% of linseed in the diet can be considered optimal (Vaclavkova and Beckova 2007; Juarez et al. 2010).

Pork belongs to one of the very favourite types of meat, though rich in saturated fatty acids (SFA), which entails a certain health risk. At present, pressure on the food quality in terms of the composition is constantly increasing. The possible additions of various components increasing the nutritional value of the final products are being studied. Consumers require food that is healthy and contains functional components (Tartrakoon et al. 2016). The interest in the PUFA is mainly a result of its possible utilisation in therapy, in the food industry and nutrition. The PUFA are known to efficiently prevent sudden heart attacks, have a positive effect on the immune system, lower mortality rates due to cardiovascular diseases, reduce arrhythmia and help to protect against these conditions even at small doses. The effects of the PUFA are also hypocholesterolaemic and anti-inflammatory. Effects leading to a slowdown of the metastatic activity of tumours have been described. The PUFA are necessary for the correct development of brain functions in the prenatal period. The beneficial effects are mainly associated with the content of the alpha-linolenic (C18:3 n-3), gamma-linolenic (C18:3 n-6), eicosatetraenoic (C20:4 n-3), eicosapentaenoic (C20:5 n-3) and docosahexaenoic acids (C22:6 n-3).

At present, the n-6/n-3 PUFA ratio in a modern diet is high (10–15 : 1). The optimal ratio is considered to be 4 : 1; that is why the production of pork enriched in n-3 fatty acids is becoming more and more interesting for many producers (Wood et al. 2003; Ruxton et al. 2005; Vaclavkova el al. 2016).

Support for the production of pork, which can have a more beneficial composition of the n-3 PUFA and, therefore, a more beneficial influence on the human organism, could increase interest in this meat type. Thus, the aim of this study was to evaluate the effect of a diet that contained linseed scrap on the carcass value parameters, the quality and the oxidative stability of the meat. Another aim was to analyse the effect of the linseed diet on the fatty acid profile in the intramuscular fat of *M. longissimus lumborum et thoracis* and the backfat in fattening gilts.

MATERIAL AND METHODS

Animals and diets. A total of 40 gilts of a hybrid combination (Large White × Landrace) × (Duroc × Pietrain) were included in the experiment. The gilts were divided into two groups (20 animals per group) fed with two different feed mixtures: a control feed mixture (C) and an experimental feed mixture (L) with the addition of the linseed scrap (7%). The composition of the feed mixtures and the nutrient contents are shown in Table 1. The fatty acid composition in the feed mixtures is shown in Table 2. The gilts were housed in an experimental stable in 4 pens of 12 animals. The gilts were included in the experiment at the age of 125 days and a mean weight of 65.67 ± 7.04 kg and slaughtered when 182 days old weighing 111.25 ± 8.39 kg on average. For the duration of the experiment, the feed and water were available for the pigs *ad libitum.*

The provisions preceding the slaughter and measuring after the slaughter. After the fattening was finished, the gilts were transferred to a slaughterhouse at a maximum distance of 40 km from the experimental stable. The animals were not fed on the day when they were slaughtered, but water for drinking was available. After resting for at least two hours, the gilts were slaughtered after previously being stunned. The slaughterhouse provided data on the lean meat content and the backfat thickness collected during the classification of the carcasses according to the ZP method (Zwei-Punkt-Verfahren) of the SEUROP system (EU decision 2005/1/ES). The collection of the meat and backfat samples was performed within 24 hours after the slaughter from the area between the second and the third last rib and a portable fridge was used for their transport to the laboratory. The drip loss was determined from the weight change of 150 g of meat hanging in a bag at 5 °C during the interval from 24 to 48 h after the slaughter.

Analyses. The thiobarbituric acid method of Piette and Raymond (1999) was used for the determination of the meat and the backfat oxidative stability and the results were expressed as the amount of thiobarbituric acid reactive substances

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Table 1. The components and nutrient composition of the feed mixtures

Ingredients (g/kg)	Control (C)	Linseed scrap (L)
Wheat	634	564
Barley	120	120
Soybean meal, extracted	80	80
Linseed	0	70
Rapeseed meal	70	70
Wheat bran	30	30
Malt sprouts	30	30
Rapeseed oil	2	2
Limestone	14.5	14.5
Salt	4	4
Monocalcium phosphate	4.5	4.5
Magnesium oxide	1	1
Amino acids and vitamins[1]	10	10
Nutrients (g/kg)		
Dry matter	895.92	896.03
Starch	439.60	389.78
Crude protein	162.20	173.27
Ash	50.70	54.21
Fat	24.98	40.40
Crude fibre	37.69	42.88
Carbohydrates	27.86	31.57
ME (MJ/kg)	12.88	13.13

ME = metabolizable energy for pigs

[1]1 kg of vitamin-mineral premix provided: vitamin A, 667 000 IU; vitamin D_3, 110 000 IU; vitamin E, 2800 IU; vitamin K_3, 130 mg; vitamin B_1 140 mg; vitamin B_2, 470 mg; vitamin B_6, 195 mg; vitamin B_{12}, 280 µg; niacinamide, 1445 mg; Ca pantothenate, 1000 mg; biotin, 5700 µg; choline Cl, 111 170 mg; $CuSO_4.5H_2O$, 1100 mg; $FeSO_4.H_2O$, KI, 84 mg; M_nO, 3340 mg; Z_nO, 10 000 mg; $Na_2O_3Se_1$, 34 mg; lysine, 331 g; methionine, 66 g; threonine, 142 g; tryptophan, 8 g; endo-1,4-beta-xylanase (EC3.2.1.8), 122 100 VU; endo-1,3 (4)-beta-glucanase (EC3.2.1.6), 166 500 VU

(TBARS) in mg malondialdehyde per kg of meat. The intramuscular fat content was measured by extraction in a Soxtec 1043 device (FOSS Tecator AB, Hoganas, Sweden) in accordance with CSN ISO 1444 (1997). For the measurement of the pH in the meat, a portable pH meter (pH 340i) equipped with a glass electrode was used and the measurement was performed in the fresh samples, 45 min (pH_{45}) and 24 hours (pH_{24}) *post mortem*. The samples of the intramuscular fat (collected from *M. lon-*

Table 2. The composition of the fatty acids (%) in the feed mixtures

Fatty acids	Control (C)	Linseed scrap (L)
C6:0	0.000	0.000
C8:0	0.164	0.060
C10:0	0.141	0.058
C11:0	0.136	0.060
C12:0	0.133	0.069
C13:0	0.143	0.062
C14:0	0.767	0.416
C15:0	0.146	0.060
C16:0	22.897	15.301
C17:0	0.149	0.114
C18:0	7.802	5.580
C20:0	0.220	0.209
C22:0	0.000	0.150
C24:1	0.000	0.122
C15:1 n-5	0.206	0.085
C16:1 n-7	2.794	1.212
C17:1 n-7	0.142	0.115
C18:1 n-9	34.183	29.120
C20:1 n-9	0.647	0.860
C22:1 n-9	0.151	0.160
C18:2 n-6	25.661	33.036
C18:2 (9, 11)	0.000	0.302
C18:2 (10, 12)	0.000	0.250
C20:2 n-6	0.135	0.089
C18:3 n-3	2.651	12.055
C18:3 n-6	0.000	0.061
C20:3 n-6	0.138	0.058
C20:4 n-6	0.435	0.281
C20:5 n-3	0.159	0.000
SFA	32.698	22.194
UFA	67.302	77.806
MUFA	38.123	31.674
PUFA	29.179	46.132
n-6 PUFA	26.369	33.525
n-3 PUFA	2.810	12.055
n-6/n-3 PUFA	9.389	2.781
PUFA/SFA	0.892	2.079

MUFA = monounsaturated fatty acids; PUFA = polyunsaturated fatty acids; SFA = saturated fatty acids; UFA = unsaturated fatty acids

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gissimus lumborum et thoracis) and backfat were used for the determination of the fatty acid composition after the chloroform methanol extraction of the total lipids performed according to Folch et al. (1957). The fatty acid methyl esters were prepared according to CSN EN ISO 12966-2 (588767) (2017) and analysed by gas chromatograph (6890N Agilent Technologies, Santa Clara, CA) equipped with a DB-23 cyanopropyl-methylpolysiloxane column (60 m × 0.25 mm × 0.25 μm) using nitrogen as the carrier gas with a flow rate of 0.8 ml/min, according to CSN EN ISO 12966-1 (588767) (2015). The temperature regime during the procedure: 120 °C – 6 min, heating (15 °C/min) to 170 °C and then heating (3 °C/min) to 210 °C, this temperature was maintained for 13.5 min followed by heating (40 °C/min) up to 230 °C which was held for 7 minutes. The temperature of the flame ionisation detector was 260 °C. Comparison with the standards (37 Component FAME Mix, PUFA No. 1, PUFA No. 2, PUFA No. 3; Sigma-Aldrich, St. Louis, MO) was used for the determination of the fatty acid profile and the percentages of the total fatty acids were calculated.

Statistical analysis. The data were statistically analysed in the form of a mean ± standard error by a one-way ANOVA (analysis of variance) and the Student's test in the QC expert software (TriloByte Statistical Software Ltd., Staré Hradiště, Czech Republic). The differences between the means were considered very highly statistically significant (***) when $P < 0.001$, highly statistically significant (**) when $P < 0.01$ and statistically significant (*) when $P < 0.05$.

RESULTS

The carcass characteristics and the parameters of the meat quality and oxidative stability

The selected characteristics of the carcass traits and the quality and the oxidative stability of the meat in the gilts fed with the control (C) feed mixture and the mixture with the addition of linseed (L) are shown in Table 3.

The findings imply that the gilts fed with the C mixture showed a higher backfat thickness by 0.63 mm ($P < 0.05$) than the gilts in the L group. In the L group, a higher share of the lean meat was observed when compared to the C group, by 1.3%, however, the difference was not significant. A higher content of intramuscular fat was found in the C group, by 0.21% ($P < 0.05$). A higher drip loss value was observed in the L group, by 0.92% ($P < 0.001$). Also, the values of pH_{45} and pH_{24} were higher ($P < 0.01$) in the L group than in the C group. Evaluation of the oxidative stability of the fat in the meat showed no effect of the linseed scrap addition to the feed mixture on the malondialdehyde concentration.

The fatty acid profile in the intramuscular fat and the backfat samples

The analysed MLLT and backfat samples contained 13 types of saturated fatty acids (SFA),

Table 3. The characteristics of the carcass, meat quality and oxidative stability in the control and linseed group (mean ± standard error)

Specification	Control (C)	Linseed scrap (L)	Significance
Backfat thickness (mm)	14.98 ± 0.31	14.35 ± 0.43	*
Lean meat content (%)	57.62 ± 0.78	58.92 ± 0.36	ns
Intramuscular fat (%)	2.72 ± 0.10	2.48 ± 0.07	*
Drip loss (%)	4.87 ± 0.19	5.79 ± 0.14	***
pH_{45}	5.77 ± 0.06	5.89 ± 0.02	**
pH_{24}	5.51 ± 0.11	5.67 ± 0.03	**
TBARS (malondialdehyde) concentration (mg/kg)			
Day 1	0.06 ± 0.01	0.06 ± 0.00	ns
Day 3	0.07 ± 0.01	0.09 ± 0.01	ns
Day 6	0.09 ± 0.02	0.10 ± 0.01	ns

ns = not significant; TBARS = thiobarbituric acid-reactive substances
$P > 0.05$; *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

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6 types of monounsaturated fatty acids (MUFA) and 12 types of polyunsaturated fatty acids (PUFA).

Table 4 presents the fatty acid composition in the intramuscular fat of the MLLT in the fattening gilts of the C and L groups. Of the SFA, a higher proportion of C12:0 ($P < 0.05$), C13:0 ($P < 0.01$), C14:0 ($P < 0.01$), C18:0 ($P < 0.05$), and C20:0 ($P < 0.01$) was observed in the L group. On the contrary, the proportions of C16:0 ($P < 0.01$) and C22:0 ($P < 0.01$) were lower in the L group than in the control one. Of the MUFA, the L group of the gilts was characterised by higher proportions of C14:1 n-5 ($P < 0.001$) and C24:1 n-9 ($P < 0.001$) when compared to the C group. Contrariwise, the proportions of C18:1 n-7 ($P < 0.05$), C18:1 n-9 ($P < 0.001$) and C20:1 n-9 ($P < 0.05$) were lower in the MLLT of the L group than of the C group. Regarding the PUFA, a significant effect of the L diet was observed in the increasing proportions of C18:2 n-6 ($P < 0.001$), C18:3 n-3 ($P < 0.001$), C20:3 n-3 ($P < 0.001$), C20:4 n-3 ($P < 0.001$) and C20:5 n-3 ($P < 0.01$). On the contrary, the C18:3 n-6 ($P < 0.01$), C20:3 n-6 ($P < 0.01$), C20:4 n-6 ($P < 0.01$), C22:4 n-6 ($P < 0.001$) and C22:6 n-3 ($P < 0.01$) fatty acids were found in lower proportions in the L group of the gilts. The total proportion of the MUFA was lower ($P < 0.01$) in the L group than in the C group, but the share of the PUFA was higher ($P < 0.01$). This result corresponds to the fatty acid composition in the L feed mixture. The proportion of the n-6 and n-3 PUFA was significantly higher ($P < 0.001$) in the MLLT of the gilts fed with the linseed diet. Also, the n-6/n-3 PUFA ratio was significantly lower ($P < 0.001$) in the L group. The ratio of the PUFA/SFA was more favourable ($P < 0.01$) in the MLLT of the gilts fed with the L feed mixture.

Table 5 presents the composition of the fatty acids in the backfat of the observed gilts in the C and L group. Of the SFA, a higher proportion of C22:0 ($P < 0.001$) was found in the L group. Contrariwise, the L group was characterised by lower proportions of C13:0 ($P < 0.01$) and C16:0 ($P < 0.05$) in comparison with the control animals. Of the group of the MUFA, the fattening gilts fed with the L diet were characterised by a higher proportion of C18:1 n-7 ($P < 0.001$), C18:1 n-9 ($P < 0.001$) and C20:1 n-9 ($P < 0.001$) when compared to the C gilts. On the contrary, the levels of C24:1 n-9 ($P < 0.01$) and C18:2 n-6 ($P < 0.05$) were higher in the C group. Of the PUFA, a significant effect of the L diet was observed

Table 4. The fatty acid profile (% of total fatty acids) in *M. longissimus lumborum et thoracis* of the control and the linseed group (mean ± standard error)

Fatty acids	Control (C)	Linseed scrap (L)	Significance
C6:0	0.008 ± 0.001	0.007 ± 0.001	ns
C8:0	0.019 ± 0.002	0.023 ± 0.002	ns
C10:0	0.132 ± 0.011	0.167 ± 0.013	ns
C12:0	0.135 ± 0.019	0.214 ± 0.011	*
C13:0	0.016 ± 0.003	0.024 ± 0.002	**
C14:0	1.524 ± 0.109	2.090 ± 0.048	**
C15:0	0.104 ± 0.007	0.132 ± 0.014	ns
C16:0	25.425 ± 0.142	23.896 ± 0.311	**
C17:0	0.329 ± 0.022	0.260 ± 0.018	ns
C18:0	12.095 ± 0.157	12.770 ± 0.168	*
C20:0	0.194 ± 0.006	0.240 ± 0.015	**
C22:0	0.118 ± 0.017	0.049 ± 0.005	*
C24:0	0.439 ± 0.031	0.031 ± 0.004	ns
C14:1 n-5	0.062 ± 0.008	0.126 ± 0.010	***
C16:1 n-7	3.424 ± 0.067	3.529 ± 0.091	ns
C18:1 n-7	4.312 ± 0.122	3.782 ± 0.127	*
C18:1 n-9	39.821 ± 0.419	34.571 ± 0.209	***
C20:1 n-9	0.736 ± 0.021	0.623 ± 0.033	*
C24:1 n-9	0.037 ± 0.004	0.065 ± 0.007	***
C18:2 n-6	6.155± 0.178	10.338 ± 0.393	***
C20:2 n-6	0.311 ± 0.020	0.369 ± 0.010	ns
C18:3 n-3	0.581 ± 0.040	1.918 ± 0.020	***
C18:3 n-6	0.119 ± 0.008	0.080 ± 0.007	**
C20:3 n-3	0.104 ± 0.004	0.350 ± 0.008	***
C20:3 n-6	0.347 ± 0.031	0.195 ± 0.018	**
C20:4 n-3	0.039 ± 0.004	0.164 ± 0.005	***
C20:4 n-6	2.409 ± 0.207	1.209 ± 0.103	**
C22:4 n-6	0.439 ± 0.047	0.163 ± 0.011	***
C20:5 n-3	0.025 ± 0.003	0.087 ± 0.002	**
C22:5 n-3	0.439 ± 0.031	0.464 ± 0.025	ns
C22:6 n-3	0.102 ± 0.008	0.064 ± 0.005	**
SFA	40.538 ± 0.482	39.903 ± 0.247	ns
UFA	59.462 ± 0.482	60.097 ± 0.247	ns
MUFA	48.392 ± 0.419	42.696 ± 0.267	**
PUFA	11.070 ± 0.692	15.401 ± 0.333	**
n-6 PUFA	9.780 ± 0.680	12.354 ± 0.310	***
n-3 PUFA	1.290 ± 0.043	3.047 ± 0.034	***
n-6/n-3 PUFA	7.581 ± 0.582	4.054 ± 0.123	***
PUFA/SFA	0.273 ± 0.022	0.386 ± 0.009	**

MUFA = monounsaturated fatty acids; ns = not significant; PUFA = polyunsaturated fatty acids; SFA = saturated fatty acids; UFA = unsaturated fatty acids

$P > 0.05$; *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

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Table 5. The fatty acid profile (% of total fatty acids) in the backfat of the control and the linseed group (mean ± standard error)

Fatty acids	Control (C)	Linseed scrap (L)	Significance
C6:0	0.004 ± 0.000	0.004 ± 0.000	ns
C8:0	0.010 ± 0.001	0.011 ± 0.001	ns
C10:0	0.070 ± 0.003	0.071 ± 0.003	ns
C12:0	0.076 ± 0.002	0.077 ± 0.003	ns
C13:0	0.010 ± 0.002	0.003 ± 0.000	**
C14:0	1.326 ± 0.024	1.327 ± 0.033	ns
C15:0	0.081 ± 0.007	0.081 ± 0.004	ns
C16:0	25.162 ± 0.228	24.340 ± 0.284	*
C17:0	0.511 ± 0.054	0.474 ± 0.032	ns
C18:0	15.693 ± 0.259	14.989 ± 0.304	ns
C20:0	0.275 ± 0.010	0.248 ± 0.008	ns
C22:0	0.015 ± 0.001	0.057 ± 0.007	***
C24:0	0.010 ± 0.001	0.015 ± 0.003	ns
C14:1 n-5	0.024 ± 0.002	0.022 ± 0.002	ns
C16:1 n-7	2.261 ± 0.088	2.149 ± 0.066	ns
C18:1 n-7	2.976 ± 0.082	2.650 ± 0.047	***
C18:1 n-9	39.444 ± 0.319	36.645 ± 0.429	***
C20:1 n-9	0.990 ± 0.027	0.815 ± 0.026	***
C24:1 n-9	0.010 ± 0.001	0.016 ± 0.002	**
C18:2 n-6	8.837 ± 0.300	10.054 ± 0.417	*
C20:2 n-6	0.481 ± 0.019	0.482 ± 0.022	ns
C18:3 n-3	0.970 ± 0.055	4.160 ± 0.333	***
C18:3 n-6	0.036 ± 0.002	0.036 ± 0.004	ns
C20:3 n-3	0.183 ± 0.008	0.622 ± 0.049	***
C20:3 n-6	0.084 ± 0.005	0.073 ± 0.003	ns
C20:4 n-3	0.020 ± 0.003	0.047 ± 0.002	***
C20:4 n-6	0.207 ± 0.010	0.170 ± 0.006	**
C22:4 n-6	0.081 ± 0.007	0.054 ± 0.005	**
C20:5 n-3	0.010 ± 0.002	0.021 ± 0.004	*
C22:5 n-3	0.085 ± 0.005	0.212 ± 0.023	***
C22:6 n-3	0.021 ± 0.002	0.031 ± 0.003	ns
SFA	43.243 ± 0.328	41.697 ± 0.529	*
UFA	56.757 ± 0.328	58.303 ± 0.529	*
MUFA	45.705 ± 0.279	42.297 ± 0.480	***
PUFA	11.015 ± 0.361	15.962 ± 0.824	***
n-6 PUFA	9.726 ± 0.332	10.869 ± 0.445	ns
n-3 PUFA	1.289 ± 0.066	5.093 ± 0.403	***
n-6/n-3 PUFA	7.545 ± 0.376	2.134 ± 0.159	***
PUFA/SFA	0.255 ± 0.010	0.383 ± 0.024	***

MUFA = monounsaturated fatty acids; ns = not significant; PUFA = polyunsaturated fatty acids; SFA = saturated fatty acids; UFA = unsaturated fatty acids

$P > 0.05$; *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$

in the increased levels of the C18:2 n-6 ($P < 0.05$), C18:3 n-3 ($P < 0.001$), C20:3 n-3 ($P < 0.001$), C20:4 n-3 ($P < 0.001$), C20:5 n-3 ($P < 0.05$) and C 20:4 n-3 ($P < 0.001$) acids, while the C20:4 n-6 ($P < 0.01$) and C22:5 n-3 ($P < 0.01$) acids showed the opposite trend. The total proportion of the SFA was lower ($P < 0.05$) in the L group compared to the control one. The total proportion of the UFA was higher in the L group ($P < 0.05$), however, the share of the MUFA was lower ($P < 0.001$) in the L group. The share of the PUFA in the backfat of the gilts was higher ($P < 0.001$) in the L group when compared against the control. The proportion of the n-3 PUFA was higher ($P < 0.001$) in the L group. The n-6/n-3 PUFA ratio was significantly more favourable ($P < 0.001$) in the L group than in the C group. Also, the PUFA/SFA ratio in the backfat of the gilts was higher ($P < 0.001$) in the L group.

DISCUSSION

The analysis revealed differences between the control and experimental group of gilts in the characteristics of the carcass and the meat quality. Vaclavkova et al. (2016) described a similar trend in pigs (Prestice Black-pied pig, both sexes, 72 kg at the start of the experiment) fed with linseed scrap in the dose of 70 g/kg for 53 days when compared to the control. The pigs fed with the addition of linseed were characterised by a lower content of backfat (21.1 mm vs. 23.4 mm) and intramuscular fat (19.4 g/kg vs. 23.2 g/kg), a higher lean meat content (53.1% vs. 51.1%) and a higher drip loss value (2.51% vs. 2.37%). Peiretti et al. (2015) observed a higher drip loss in meat with a higher pH. When the pH was 6.5, the drip loss reached the level of 7.0%. These authors also state that the higher drip loss value indicates a lower meat quality, the more intensive releasing of fluid from the meat decreases its quality from the consumers' point of view. Rezar et al. (2003) state that the utilisation of linseed in the feeding dose for pigs increases the level of the oxidative stress in the meat. Substitution of the saturated fatty acids with polyunsaturated fatty acids in the meat can influence the organoleptic characteristics of the meat, the pH and the colour of the meat. According to Suzuki et al. (2006), there is a positive correlation between the linoleic acid (C18:2 n-6) content and the drip loss value (genetic correlation 0.38,

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phenotypic correlation 0.12) and the pH value (0.23 resp. 0.04). The effect of the linseed in the diet on pH_{24} was also studied by Corino et al. (2008) or Karolyi et al. (2012). In both studies, a higher pH_{24} was recorded in the groups of the pigs fed with the linseed diet, however, the results are not statistically significant. Corino et al. (2008) state that in pigs which were on a diet supplemented with 5% of the linseed and slaughtered with a weight of 110 kg, the pH_{24} value reached 5.58, while in control group it was 5.47. Beckova and Vaclavkova (2010) proved that a linseed diet (the share of linseed was 13.4 %, the weight at the start of the experiment was 38 kg and 88 kg at the end) increased the pH_{45} (6.00 vs. 5.91) in the four-breed hybrid fattening gilts when compared to the control. They also found that the L diet did not affect the lean meat content in the carcass (59.22% vs. 59.13%). The authors observed a lower intramuscular fat content in the experimental group (24.5 g/kg vs. 26.5 g/kg) than in the control, which corresponds to the results of the present study. On the contrary, Huang et al. (2008) and Luo et al. (2009) found an increased content of backfat and intramuscular fat in the pigs fed with a linseed diet, which could be caused by the duration of the supplementation of the diet with the linseed, over 60 days. Huang et al. (2008) conducted an experiment on boars and stated that the increased length of the linseed diet administration was associated with the increased intramuscular fat content ($P < 0.05$). The findings of Okrouhla et al. (2013) indicate that the sex of the pigs can influence the observed parameters. They fed hybrid pigs with a linseed diet in the dose of 150 g/day and found a higher intramuscular fat content in the barrows, however, the difference was not statistically significant.

Guillevic et al. (2009) suggest that the addition of linseed oil to the nutrition of pigs caused the increased sensitivity of the pork meat to oxidation. Also, Jasinska and Kurek (2017) stated that the enrichment of the feed mixture with the n-3 PUFA led to a meat quality deterioration and increased sensitivity to oxidation, which is in contradiction to our findings. Our study confirmed the results of Corino et al. (2008) and Beckova and Vaclavkova (2010) who found no effect of the linseed diet on the fat oxidation in the meat. Although the content of the alpha linolenic acid increased due to diet in this study, it did not reach 3% which is considered a threshold value, when fat oxidation can be observed, as stated by Wood et al. (2003). Dordevic et al. (2016) state that the meat oxidative stability in pigs fed with a mixture enriched in linseed scrap is higher when compared to other feed components (soya, sunflower).

The analysis of the fatty acid profile in the MLLT of the pigs revealed that the L diet positively influenced the composition of the fatty acids. Similar findings were also published by Kouba et al. (2003), who fed gilts (Large White × Landrace × Duroc) from the weight of 40 kg with a feed mixture containing 6% of crushed linseed for 20, 60 and 100 days. They found that the L diet decreased the proportion of C18:1 n-9 and increased the proportion of C18:3 n-3 and C20:5 n-3 and improved the PUFA/SFA ratio (0.37% in the control vs. 0.54% in the experimental population), but proved no effect of the linseed diet duration on the fatty acid profile. Also, Bretensky et al. (2016) state that feeding hybrid gilts with linseed oil with a daily dose of 5 ml per animal for 70 days from the live weight of 25 kg led to a decrease of C18:1 n-9 in the MLLT by 1% and an increase of C18:3 n-3 in the MLLT of the experimental animals against the control (1.15% vs. 0.73%) as well as the n-3 PUFA proportion (1.25% vs. 0.73%) and the total proportion of the PUFA (12.27 vs. 10.96), however the proportion of the n-6 PUFA was not statistically different between the groups. The authors also proved a lower n-3/n-6 PUFA ratio in the L population (14.07% vs. 8.84%) similarly to our experiment, however, the ratio was much more favourable in our observation, which indicates that the used variety of linseed can be an important factor, which is also emphasised by Vaclavkova et al. (2016). Also, other studies proved that utilisation of flax in various forms and levels improves the fatty acid profile of the pork. For example, Bee et al. (2008) used 3% of extruded linseed, Kralik et al. (2010) used 2% of linseed oil, Okrouhla et al. (2013) used linseed (150 g/kg) and Leikus et al. (2018) used 25 g of linseed scrap per kg. These studies confirmed the increased n-3 PUFA, the overall improvement of the PUFA/SFA and the n-3/n-6 PUFA ratio in the intramuscular fat.

According to our study, the linseed diet also affects the fatty acid profile in the backfat of the pigs. The observation revealed that the fatty acid profile is even more favourable than in the intramuscular fat in the pigs fed with the L diet. These findings were confirmed by Citek et al. (2015) who gave linseed in a dose of 150 g/kg to pigs from the weight of

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28.7 kg to 110 kg and observed a significantly lower proportion of C16:0 (28.39% vs. 29.48%), C16:1 n-7 (4.97% vs. 6.72%) and C18:1 n-9 (29.37% vs. 34.39%) and a higher proportion of C18:3 n-3 (6.68% vs. 1.41%) and a higher total proportion of the n-3 PUFA (7.17% vs. 1.5%), as well as the n-6/n-3 PUFA ratio (3.6% vs. 15.22%) in the backfat of the L pigs compared to the control. Karolyi et al. (2012) described similar findings in hybrid PIC (Pietrain × Duroc) pigs fed with a linseed diet for 90 days with significantly lower proportions of C18:2 n-6 (13.5% vs. 15.2%), C20:4 n-6 (3.4% vs. 4.8%), C22:4 n-6 (0.40% vs. 0.79%) but higher shares of C18:3 n-3 (1.9% vs. 0.44%), C20:3 n-3 (0.28% vs. 0.08%) and C20:5 n-3 (0.76% vs. 0.14%) and the n-6/n-3 PUFA ratio (4.6% vs. 14.4%) in the experimental population against the control. These findings were confirmed by Dordevic et al. (2016). The differences in the composition of the fatty acids in the mentioned studies can be influenced by the sex of the experimental animals, which was noted by Okrouhla et al. (2013), who recorded higher proportions of C20:4 n-6 and C20:3 n-3 in the gilts. Also, the genotype of the animals can influence the fatty acid profile, for example, the studies of Kasprzyk et al. (2015) and Nevrkla et al. (2017) proved that pigs with a higher fat content are characterised by a lower n-6/n-3 PUFA ratio than the pigs with a higher meat conformation.

The experiment proved that fattening the gilts fed with a linseed diet showed a lower content of backfat and intramuscular fat, but also a higher drip loss value and a higher pH of the meat. It also confirmed that the linseed diet positively influenced the fatty acid profile in the intramuscular fat and backfat. The experimental gilts were characterised by a higher SFA proportion and a higher PUFA proportion, mainly the n-3 PUFA proportion, which was positively reflected in a more favourable n-6/n-3 PUFA ratio. Despite the higher content of the PUFA recorded in the experimental group of the gilts, the oxidative stability of the fat in the meat was not worsened.

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