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THE EFFECT OF GENDER ON PROPERTIES OF BELLY-RIB PART OF PIGS FED DIET CONTAINING SOYBEAN OIL

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Abstract: Total of 40 castrated fatteners of Swedish Landrace breed, divided into two groups based on their gender (20 pigs in each group) were used in the study to determine the effect of gender on share of tissues and chemical composition of the fat taken from the belly carcass part. All pigs were fed diet containing additive of 1.25% of soybean oil. Even though the weight of belly part was similar in animals of both genders, female animals had higher share of muscle tissue ($P<0.05$), whereas male animals had higher share of intermuscular and total fat tissue ($P<0.01$). Addition of soybean oil, with high share of PUFA, to pig nutrition can significantly influence the increase of unsaturated fats. Female fatteners had more extracted fat in fat tissue and higher content of PUFA, however, statistically significant difference was established only in share of SFA, which was considerably lower ($P<0.05$) in comparison to male animals. Consequently, PUFA:SFA ratio was significantly higher in female animals (0.51) compared to male fatteners (0.39). Iodine number/value determined for fat was in the range from 63.00 in males to 64.36 in female animals without statistically significant difference.

Based on obtained results it can be conlcuded that, inr egard to the nutritional quality, belly part from female fatteners may provide a balanced fatty acid intake for consumers (PUFA:SFA>0.4). However, in regard to the technological quality, fat (bacon) obtained from female animals had lower sustainability, due to more rapid fat oxidation, and it was of poorer technological quality due to softer fat tissue and more difficult cutting.

Key words: gender, pork belly, soybean oil, PUFA, SFA, iodine value

Introduction

The most often used and studied sources of fat in animal nutrition – animal food, used in pig feeding, have high percentage of poly unsaturated or mono unsaturated fatty acids *(Raes et al., 2004)*. Pig as mono gastric animal is suitable for change in the composition of fatty acids of the fat tissue and muscles through use of different oils in their nutrition because, contrary to ruminants, they absorb fatty acids in intact form *(Wood et al., 2008)*. Use of oil obtained from the soybean grain, which is known to have high content of unsaturated fatty acids, in nutrition of pigs can induce significant changes in fatty acid profile/composition of pork in direction of increase of unsaturated fatty acids *(Migdal et al., 1998, 2001; Mitchaothai et al., 2007)*, which is in concordance with health recommendations about reduced intake of saturated fatty acids through food. However, meat with a high content of polyunsaturated fatty acids may lead to meat and meat products, which can be characterized as ''soft'', and therefore of inferior quality *(Jørgensen et al., 1996; Warnants et al., 1998; Cameron et al., 1999)*. Finally, there is a strong inverse correlation between the amount of fat and the concentration of polyunsaturated fatty acids *(Wood and Enser, 1997)*. Hence, as a consequence of the efforts to obtain lean carcasses, the concentration of polyunsaturated fatty acids has increased and enhanced oxidative instability, especially during processing.

There are different fat depots in pig carcass, of which the belly part has gone through greatest changes over the years, in direction of reduction of the quantity of fat tissue. According to recent reports, bellies lost almost 29% of fat over the last 40 years, leading to thinner and softer bellies, and lower processing yields *(Person et al., 2005)*. Soft pork fat and bellies are an economic concern for today's pork processors, because they have decreased yields, poor sliceability, and potentially decreased shelf life *(Correa et al., 2008)*.

Regarding this, this study was designed to explore the variation in belly composition and chemical characteristics between male and female fatteners, fed with diet containing soybean oil.

Materials and Methods

Trial was carried out on the farm, in slaughterhouse and laboratory of the Institute for Animal Husbandry (Belgrade, Serbia) on 40 castrated fatteners of Swedish Landrace breed. Pigs were divided into two groups, based on their gender (20 pigs in each group). Composition of animal food used in the fattening is presented in Table 1, whereas in Table 2, data on chemical characteristics of soybean oil used in the trial are presented.

Table 1. Composition of food used in the nutrition of pigs

Mixture ingredients (%)	First 7 days of fattening	To the end of fattening
Corn - dry	67.50	68.75
Livestock flour	10.00	10.00
Soybean meal	14.80	14.80
Sunflower meal	2.00	2.00
Soybean oil	2.50	1.25
Lime	1.30	1.30
Monocalcium phosphate	0.80	0.80
Salt	0.45	0.45
Premix	0.50	0.50
Synthetic lysine	0.05	0.05

Table 2. Iodine value and composition of soybean oil used in pig nutrition

IV	132.15
SFA (%)	15.58
MUFA (%)	23.59
PUFA (%)	60.72

All animals were slaughtered on the same day. Average pre-slaughter weight of male fatteners was 103.37 kg, and of female fatteners 103.28 kg. Animals were denied food 12h prior to slaughtering, but had free access to water. After slaughtering, pig carcasses were processed using standard techniques. After hair removal and evisseration, carcasses were cut into carcass sides and put in cooling chamber at temperature of 2-4^{0}C for next 24 hours. After chilling, bellies were removed from the left carcasses side. Each belly section was knife-dissected into lean tissue, subcutaneous fat tissue (SFT), intermuscular fat tissue (IFT), skin and bone and weights of each component were divided by the initial belly sectionweight to calculate component percentages.

Fat tissue from each belly was ground and frozen to assess the fat content, moisture content, iodine value and the fatty acid composition. Fat content was determend after extraction with the chloroform/methanol method of *Folch et al. (1957)* and water content was determend by drying of samples of fat tissue at temperature of 105^{0}C to a constant mass *(AOAC, 1990)*. Iodine value (IV) was determined in extracted fat by using the Hanus method *(AOAC, 1990)*.

Fatty acid methyl esters (FAMEs) were prepared by transesterification by using trimethylsulfonium hydroxide, according to *SRPS EN ISO 5509 (2007)* procedure. The GC instrument Shimadzu 2010 (Kyoto, Japan), used for FAMEs determination, was equipped with a split/splitless injector, fused silica cianopropyl HP-88 column (length 100 m, i.d. 0.25 mm, film thickness 0.20 μm) and flame

ionization detector (FID). The column temperature was programmed. Injector temperature was 250^0C and detector temperature was 280^0C. The carrier gas was nitrogen at a flow rate of 1.33 ml/min and injector split ratio of 1:50.

The total proportion of saturated fatty acids (SFA) was the sum of the weight percentages of myristic (14:0), pentadecanoic (15:0), palmitic (16:0), stearic (18:0), margaric (17:0) and arachidic (20:0) acid. The total proportion of monounsaturated fatty acids (MUFA) was calculated by summing the weight percentages of palmitelaidic (16:1t), palmitoleic (16:1c), oleic (18:1c9), vaccenic (18:1c11) and gadoleic (20:1c11). Additionally, the total percentage of polyunsaturated fatty acids (PUFA) included linoleic (18:2n6), γ-linolenic (18:3n6), α-linolenic (18:3n3), eicosadienoic (20:2), dihomo-γ-linolenic (20:3n6), eicosatrienoic (20:3n3) and arachidonic (20:4n6). The PUFA:SFA ratio was calculated by dividing the total proportion of PUFA by the total proportion of SFA.

Statistical parameters calculated are: mean value ($\bar{x}$), standard deviation (Sd) and coefficient of variation (Cv). Statistically significant difference between mean values was determined using t-test with Statistica 7 software (StatSoft, USA).

Results and Discussion

The weight of belly part ranged from 4.53 kg in female animals to 4.59 kg in male fatteners and its share in animal carcass was approx. 11% in both groups of pigs (Table 3). In the study of factors which influence the suitability of fat (bacon), *Smith et al. (1975)* state that lighter weight (4.1 to 5.0 kg) bellies had higher lean to fat ratios than heavier weight (5.0 to 5.9 kg) bellies and had higher proportions of desirable bacon slices.

Results of the dissection of the belly-rib part of the carcass are presented in Table 3. Share of muscle tissue showed statistically significant differences between groups ($P<0.05$) and it was higher in female animals. The effect of gender on belly lean meat contents has been described in a number of reports with the conclusion that the lean content in the belly of gilts is higher compared to barrows *(Freeden, 1980; Warnants et al., 1998)*. Female animals also had significantly less intermuscular fat, and hence total fat tissue ($P<0.01$), compared to male animals. Share of subcutanous fat tissue was also higher in male animals, however, no statistically significant difference in this parameter was established, due to high variation within groups and high value of standard deviation. *Vališ et al. (2010)* state that, in comparison with barrows, belly of gilts contained significantly more lean (by 2.15%) and it had significantly lower content of intermuscular fat (by 2.08%), while the contents of remaining tissues, i.e. skin including subcutaneous fat and bones was similar between genders.

Table 3. Weight, share in the carcass side and share of tissues of belly part obtained from barrows and gilts

Index	Male castrated fatteners			Female castrated fatteners			Effect of gender[1]
	$\bar{X}$	Sd	Cv	$\bar{X}$	Sd	Cv	
Weight (kg)	4.59	0.37	8.09	4.53	0.31	6.88	ns
Share in carcass side (%)	11.34	0.83	7.34	11.01	0.56	5.11	ns
Muscle (%)	43.27	4.05	9.36	49.51	5.05	10.19	*
SFT (%)	26.55	3.21	12.08	23.67	4.46	18.85	ns
IFT (%)	17.74	2.07	11.66	12.91	1.73	13.40	**
TFT[2] (%)	44.29	3.85	8.70	36.57	6.00	16.41	**
Skin (%)	6.17	1.53	24.80	7.23	1.44	19.95	ns
Bone (%)	5.77	0.41	7.14	6.07	0.80	13.20	ns

[1] * – P<0.05; ** – P<0.01; ns – non-significant
[2] TFT (Total Fat Tissue)=SFT+IFT

Increased belly leanness can cause the moisture content and proportion of PUFA to also increase, resulting in the production of soft, thin bellies *(Sather et al., 1995)*. Data presented in this paper show that, in spite of greater share of muscle tissue in belly part, female fatteners had more extracted fat from the belly fat tissue and higher content of PUFA, however, statistically significant difference was established only in share of SFA, which was significantly lower (P<0.05) compared to male animals (Table 4). Consequently, the belly fat from female fatteners had higher PUFA:SFA ratios than that from the bellies of male fatteners (P<0.05), which is in concordance with results obtained by *Correa et al. (2008)*. On a nutritional level, based on a PUFA:SFA ratio above the recommended threshold of 0.4 *(Wood et al., 2003)*, the bellies from female animals evaluated in the present study may provide a balanced fatty acid intake for consumers.

In the study of the firmness of belly fat tissue in pig carcasses, *Correa et al. (2008)* state that female animals have significantly softer belly fat tissue than males, a lower proportion of SFA, a higher proportion of PUFA and an increased iodine value. A number of studies have demonstrated that feeding polyunsaturated fat sources reduce belly firmness and increase the IV of belly fat (*Apple et al., 2007*; *Jackson et al., 2009)*. However, *White et al. (2009)* concluded that IV was not a good measure of belly firmness because of variations in the fatty acid composition and calculated IV within the belly. Results from the current study (Table 4) support their conclusion and indicated considerable variation in fatty acid composition and IV, which was somwhat higher in females (64.36) compared to male fatteners (63.00), however no statistical significance between groups was established. *Benz et al. (2010)* find that barrows had significantly decreased IV in jowl fat and back fat compared with gilts. On the contrary of these findings,

Marcoux et al. (2007) did not observe any difference in the fatty acid profile of bellies between gender of pigs when comparing the same fat content.

Table 4. Chemical composition and iodine value of the belly fati tisue

Parameters	Male castrated fatteners			Female castrated fatteners			Effect of gender[1]
	$\overline{X}$	Sd	Cv	$\overline{X}$	Sd	Cv	
Water (%)	10.96	0.72	6.56	9.45	0.93	9.86	ns
Fat (%)	86.60	0.61	0.71	88.18	1.38	1.56	ns
PUFA (%)	16.00	0.79	5.02	19.12	1.36	7.12	ns
MUFA (%)	42.18	1.87	4.43	43.09	2.97	6.88	ns
SFA (%)	41.46	1.26	3.04	37.23	1.38	3.71	*
PUFA:SFA	0.39	0.02	4.12	0.51	0.02	3.39	*
IV	63.00	3.74	5.93	64.36	3.60	5.58	ns

[1] * – $P<0.05$; ns – non-significant

Fresh bellies with IV greater than 70 to 75 are typically considered soft *(Madsen et al., 1992)*. In the trial carried out by *Barton-Gade (1987)*, the critical IV of 70 was reached at 8 and 11 g PUFA/kg feed in the outer backfat layer for respectively gilts and barrows. Share of PUFA in soybean oil used in this trial was 60.72 % (Table 2), which would mean that animals received approx. 7.59 g PUFA/kg of food, and IV of belly fat in both pig groups was lower than stated limit (Table 4). *Warnants et al. (1998)* stated that the threshold for feed and backfat PUFA can be as high as, respectively, 18 g PUFA/kg feed and 22% PUFA in backfat, without deterioration of fresh and frozen backfat. However, same authors state that from the aspect of processing and technological quality of meat products, these limits should be considerably lower.

Conclusion

Composition of belly part of the carcass obtained from fatteners showed significant differences between genders. Female fatteners had statistically significantly higher share of muscle tissue, whereas in male fatteners higher share of intermuscular and total fat tissue was determined.

Adding of soybena oil influences significant increase of non-saturation of fatty acids and based on results obtained in this research, it can be concluded that in regard to the nutritional quality, belly part from female animals may provide a balanced fatty acid intake for consumers (PUFA:SFA>0.4). The belly fat from female fatteners, is more unsaturated, compared to male fatteners, but it is more prone to rancidity during storage leading to a potentially reduced bacon shelf-life.

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Uticaj pola na karakteristike trbušno-rebarnog dela svinja hranjenih sa dodatkom sojinog ulja

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Rezime

Ukupno 40 kastriranih tovljenika rase švedski landras, podeljenih u dve grupe u zavisnosti od pola (po 20 svinja u grupi), je iskorišćeno za utvrđivanje uticaja pola na udeo tkiva i hemisjki sastav masti trbušno-rebarnog dela. Sve svinje su hranjene sa dodatkom 1,25% sojinog ulja. Pol životinja nije značajno uticao na težinu trbušno-rebarnog dela, međutim, utvrđeno je da su ženska grla imala veći udeo mišićnog tkiva ($P<0,05$), dok su muška imala veći udeo intermuskularnog i ukupnog masnog tkiva ($P<0,01$). Dodatak sojinog ulja, koje ima visok udeo PUFA, u ishranu svinja, može značajno da utiče na povećanje nezasićenosti masti. Ženski tovljenici su imali više ekstrahovane masti u masnom tkivu i veći sadržaj PUFA, međutim statistički značajna razlika je utvrđena samo u udelu SFA, koji je bio značajno niži ($P<0,05$) u odnosu na muška grla. Kao posledica toga, odnos PUFA:SFA je bio značajno veći kod ženskih grla (0,51) u odnosu na muška (0,39). Jodni broj masti se kretao od 63,00 kod muških do 64,36 kod ženskih životinja i nije se statistički značajno razlikovao.

Na osnovu dobijenih rezultata može se zaključiti da je, u pogledu nutritivnog kvaliteta, trbušno-rebarni deo ženskih tovljenika kvalitetniji u pogledu masno-kiselinskog sastava (PUFA:SFA>0.4). Međutim, u pogledu tehnološkog kvaliteta, slanina dobijena od ženskih životinja bi imala manju održivost, usled brže oksidacije masti, i bila bi lošijeg tehnološkog kvaliteta, zbog mekanog masnog tkiva i otežanog sečenja.

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