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THE QUALITY OF PORK HAM - TISSUE YIELD DEPENDING ON INDIVIDUAL FACTORS

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Original scientific paper

Abstract: The study included the progeny of three boar-sires breeds (SL - Swedish Landrace; LW – Large White and P - Pietrain). A total of 201 progeny of both sexes (93 female and 108 male castrated animals), originating from 16 boar-sires, were tested. The study included the progeny of 10 SL boar-sires (sires nuRWer: 1, 2, 3, 7, 8, 9, 15, 16, 17 and 18), progeny of 3 LW sires (sires nuRWer: 4, 5 and 6) and 3 P boar-sires (sires nuRWer 14, 19 and 20), born in four seasons (winter, spring, summer and autumn). Studies have shown that, with an mean weight of a warm carcass side of 81.20 kg, the highest mean values for ham weight (RW; 10.456 kg), mass of intermuscular fatty tissue (RINT; 0.477 kg), ham bone (RB; 0.837 kg) and muscle tissue RMT, 7,939 kg) have progeny of the sires of Pietrain breed (P) compared to SL and LW sires. In comparison to animals sired by SL and LW boars, the progeny of P sires had less skin and subcutaneous fat tissue (RSFT) by 30 and 549 grams. Studies have shown that we have progeny of sires 7 and 9 of SL breed which have the lowest LSMean values for the yield of skin and subcutaneous fat tissue (869 and 876 g), which is below the mean for breed by 364 and 357 g. In addition, when it comes to intermuscular fatty tissue, the lowest established value was recorded in the progeny of sire no. 8 of SL breed (182 g), which is by 220 g less than the general mean and by 132 g below the mean of the sire breed. The animals originating from sires n. 19 and 20 showed the highest weight of muscle tissue (RMT) (8.489 and 8.118 kg) in the ham, which is by 2.853 and 2.482 kg more meat compared to the progeny of sire no. 5 of LW breed. The total weight of the ham and the ham muscle yield were influenced by (P <0.01 and P <0.001) sire breed, sires within the breed, gender and season of birth. A very significant (P <0.001) influence of the weight of warm carcass sides on the ham weight and tissue yield was determined.

Key words: breed, sire, sex, birth, progeny

Introduction

The quality traits of pig carcass sides and pig meat varied under the influence of a large number of factors. The influence of genetic and non-genetic factors (genotype of sire, sire, sex, and farm) on quality of carcass side was investigated by *Petrović et al. (2006).* They have found, in two examined farms, that the sire, sex and the weight of the warm carcass side affected (P <0.01) the thickness of the bacon, the yield and the proportion of muscle tissue in the carcass sides. Pigs, of all species of domestic farm animals, have the highest level of accumulation of fat in the carcass. In the newborn piglets, the content of fat tissue in the carcass is only about 2% and its share in the carcass increases with the increase of the age of the animal. In the course of life, pigs mostly accumulate subcutaneous fat tissue, which on mean accounts for 60 to 70% of the total fatty tissue in the body, the fat tissue of the body cavities makes up 10 to 15%, and intermuscularl fat 20 to 35%. The content of intramuscular fat tissue in most industrial pig genotypes is between 2.5 and 3.5% (*Karolyi, 2007*). Selection may influence the content of intramuscular fatty tissue, or the content of fat in meat (*Dević and Stamenković, 2004*). Statistically significant differences (P <0.001) for intramuscular fat content in ML (2.31: 3.32%) between the progeny of the Landrace and Duroc sires have been found in the study by *Mason et al. (2005)*. In regard to the effect of sex on the quantity of fat tissue in the pig carcasse, *Čepin and Žgur (2003)* state that uncastrated male animals, compared to females, have a much lower percentage of fat under the same diet regime. They also state that the selection is a powerful tool for reducing fat content, and that adequate animal nutrition provides the ability to reduce fat content and fatty acid changes. Observing the share of certain tissues in the four primary parts of the carcass side (ham, loin, the shoulder and the rib part) in gilts and castrates, *Kušec et al. (2006)* have found that the highest proportion of muscle tissue is in the ham, with the highest proportion of fatty tissue in the rib part of the carcass, while the highest share of the bone tissue is found in the loin. By comparing the share of the main tissues of the basic carcass parts in the examined pigs, statistically significant differences between the sexes were not determined (*Kušec et al., 2006*). Distribution of fatty tissue, as well as the total amount of fat in the carcass, varies considerably between pigs of different breeds. For example, there is a clear difference in the content of intramuscular fat between different pig genotypes. It is generally higher in pig of Duroc breed than in Landrace or Large White pigs, although differences in the content of subcutaneous and abdominal fat tissue between pigs of different genotypes may be small. Distribution of the fat tissue in the pig carcass can be changed relatively easily through selection. Variations in energy intake through diet are the decisive factor in the distribution of fatty tissue, as well as the total amount of fat in the pig carcass within the appropriate genotype (*de Lange et al., 2003*). In animals intended for meat production, the estimated heritability for fat content is relatively high (between 0.3 and 0.6). This means that the selection is a powerful tool for reducing fat content. An even better option for reducing the fat content and changing fatty acids is adequate nutrition, especially in non-ruminants, as these animals absorb fatty acids in unchanged form (*Čepin and Žgur, 2003).*

Materials and Methods

The study included the progeny of three breeds of sires (SL - Swedish Landrace, LW – Large White and P - Pietrain). A total of 201 progeny of both sexes (93 female and 108 male castrated animals) originating from 16 boar-sires, were tested. The test included the progeny of 10 SL sires (sires number 1, 2, 3, 7, 8, 9, 15, 16, 17 and 18), 3 LW sires (sires number: 4.5 and 6) and 3 P sires (sires number 14, 19 and 20). The minimum number of progeny per sire was 9. The examined animals were born in four seasons (winter, spring, summer and autumn). The ham was separated from the loin (loin-rump section) part and the belly part with a right angle cut in relation to the longitudinal axis between the 5th and 6th lumbal vertebrae and from the lower leg by a flat cut through the knee joint.
The cutting and separation of individual tissues of the ham is shown in Figure 1.

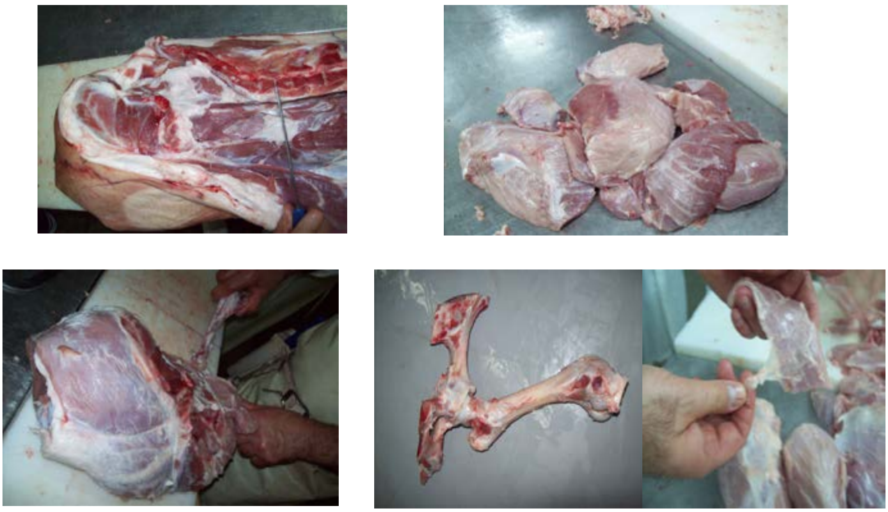

Figure 1. Separation and dissection of the ham (Photo: Č. Radović)

The tissues were separated by a knife, as precisely as possible. Removing the subcutaneous surface fatty tissue with the skin implied removing the entire fatty tissue over the outer muscle layers. After the subcutaneous fatty tissue was separated, the bone and cartilage parts were extracted and the smallest parts of the soft tissue were removed from them (with a knife). Fases, aponeuroses (tendons) were separated together with muscle tissue. In the intermuscle areas there is a lower or higher content of intermuscular fatty tissue. Intermuscular fatty tissue was removed by separation of muscle parts and individual muscles with the greatest possible precision. According to the set goal, the research was carried out on the farm, experimental slaughterhouse and in the laboratory of the Institute for Animal Husbandry, Zemun-Belgrade. Data was processed by applying the adequate software package "LSMLMW and MIXMDL, PC-2 VERSION" (Harvey, 1990), i.e. by using the procedure of the Least Square Method in order to determine the significance ($P<0.05$) of systematic influences on traits of meat quality. Model included: sire breed, sires within the breed, gender, gender within the breed, birth season of progeny and carcass side mass (linear effect).

$$Y_{ijklm} = \mu + R_i + O_{j:i} + P_k + P_{k:i} + S_l + b_3 (x_3 - \bar{x}_3) + \varepsilon_{ijklm}$$

where: Y_{ijklm} - expression of trait of *m* individual animal, of *i* boar breed, of *j* sire within *i* breed, of *k* sex and *l* birth season; μ = general population average, R_i – effect of sire breed (i=1, 2, 5); $O_{j:i}$ – effect of sire within the breed ($j:i_1$ =1, 2, 3, 7, 8, 9, 15, 16, 17, 18; $j:i_2$ =4, 5, 6; $j:i_3$=14, 19, 20); P_k – effect of sex/gender (k =1,2); $P_{k:i}$ – effect of sex/gender within the breed; S_l – effect of offspring birth season (l =1, 2, 3, 4); b_3 – linear regression effect of the warm carcass side weight (x_3); ε_{ijklm} – random error (residue).

Results and Discussion

Table 1 shows the variations in the total weight of the ham and the yield of individual tissues in it under the influence of the sire breed and sire within the breed. By correcting the total ham weight (RW) to the mean weight of the warm carcass side (WCSW = 81.20 kg), the progeny of (P) sires had the highest mean values for this trait (10,456 kg) compared to other sires. They also had the highest mean weight of intermuscular fatty tissue (RINT; 0.477 kg), of bones in the ham (RB; 0.837 kg) and muscle tissue (RMT; 7.939 kg). In relation to the animals originating from Swedish landras (SL) and Large White (LW) sires, progeny of (P) sires had less skins and subcutaneous fat tissue (RSFT) by 30 and 549 grams. The lowest LSMean values for the yield of skin and subcutaneous fat tissue (RSFT) were recorded for the progeny of sires no. 7 and 9, of the SL breed (869 and 876 g), which is less in relation to the breed mean by 364 and 357 g. In addition, when it comes to intermuscular fatty tissue, the lowest established value was recorded for progeny of sire no. 8 of SL breed (182 g), which is by 220 g less than the general mean and 132 g less than the mean for the sire breed. The animals originating from sires n. 19 and 20 had the highest amount of muscular tissue (RMT) (8.489 and 8.118 kg) in the ham, which is by 2.853 and 2.482 kg more meat compared to the progeny of sire no. 5 of breed LW. A very significant (P <0.001) influence of the weight of warm carcass sides on the weight of the ham and tissue yield was determined.

Table 1. The influence of the sire breed and sire within the breed on the quality of the ham/leg in progeny (LSMean ± S.E.)

Source of variation		RW[2)]. kg	RSFT. kg	RINT. kg	RB. kg	RMT.kg
μ ± S.E.		9.519±0.06	1.396±0.04	0.402±0.01	0.780±0.01	6.940±0.07
SB[1)]	Sire no.					
Swedish Landrace	1	9.054±0.12	1.520±0.08	0.392±0.03	0.742±0.02	6.401±0.16
	2	8.911±0.13	1.183±0.09	0.383±0.03	0.753±0.02	6.592±0.17
	3	8.654±0.13	1.472±0.09	0.447±0.03	0.756±0.02	5.979±0.17
	7	9.101±0.17	0.869±0.11	0.266±0.04	0.708±0.03	7.258±0.21
	8	9.189±0.16	1.187±0.10	0.182±0.04	0.730±0.03	7.089±0.20
	9	9.274±0.17	0.876±0.11	0.233±0.04	0.717±0.03	7.448±0.22
	15	9.227±0.16	1.406±0.10	0.388±0.04	0.831±0.03	6.602±0.20
	16	9.341±0.15	1.347±0.10	0.302±0.04	0.796±0.02	6.896±0.19
	17	9.400±0.15	1.123±0.10	0.279±0.03	0.802±0.02	7.196±0.19
	18	9.303±0.14	1.344±0.09	0.272±0.03	0.817±0.02	6.869±0.18
	Mean	9.145±0.07	1.233±0.05	0.314±0.02	0.765±0.01	6.833±0.09
Large White	4	9.065±0.14	1.506±0.09	0.388±0.03	0.753±0.02	6.418±0.17
	5	8.876±0.14	2.060±0.09	0.433±0.03	0.747±0.02	5.636±0.17
	6	8.925±0.13	1.691±0.09	0.423±0.03	0.717±0.02	6.094±0.17
	Mean	8.955±0.09	1.752±0.06	0.415±0.02	0.739±0.01	6.049±0.11
Pietrain	14	9.550±0.10	1.230±0.06	0.312±0.02	0.801±0.02	7.208±0.12
	19	10.937±0.18	0.975±0.12	0.579±0.04	0.894±0.03	8.489±0.23
	20	10.880±0.18	1.405±0.12	0.539±0.04	0.817±0.03	8.118±0.23
	Mean	10.456±0.11	1.203±0.07	0.477±0.03	0.837±0.02	7.939±0.14
WCSW (b)		0.111***	0.027***	0.004***	0.007***	0.074***

[1)]SB-sire breed, WCSW (b)- linear effect of the weight of warm carcass side (WCSW=81,20 kg); [2)] RW- the weight of the ham, RSFT– the weight of the skin and subcutaneous fat tissue of the ham, RINT- the weight of the intermuscular fat tissue of the ham, RB- the weight of bones of the ham, RMT- the weight of muscles of the ham

By observing according to sexes (Table 2), it can be seen that higher LSM values were recorded for RW (+ 293g, P <0.001), RB (+35g, P <0.01) and RMT (+568g; P <0.001) in female progeny relative to male animals, while lower values were determined for RSFT (-260 g, P <0.001) and RINT (-48 g, P <0.01). The highest meat yield (RMT) was recorded in animals born in winter and autumn (7.512 and 7.233 kg). These animals also had a higher RW (9.696 and 9.717 kg) compared to animals born in spring and summer. In our study, a higher proportion of muscle in the ham in the pure landrace breed (74.71%) was observed in relation to the value of 64.59% determined by *Kosovac et al. (2009).* In this study of five genotypes, *Kosovac et al. (2009)* have found the highest value of muscular tissue in the progeny crosses sired by Pietrain breed 69.67%. The established proportion of muscle tissue in the ham in our study for the progeny of Pietrain breed sires was significantly higher and amounted to 75.92% of the muscle tissue in the total weight of the ham. Depending on sex, *Kušec et al. (2006)* have found a lower proportion of fatty tissue in the castrated male animals compared to the females (20.44: 21.93%), which is in contrast to our results (subcutaneous fat tissue in castrated males was 16.28%, in females 13.10%). By examining the different levels of threonine, *Barowicz et al. (2009)* have not recorded statistically significant impact on the weight of the ham (8.13 to 9.26 kg) nor on the share of meat in the ham, which was similar in all groups and varied from 72.82 to 73.85%. In our research, the proportion of meat in the ham was 72.91%.

Table 2. The effect of sex and season of birth on the quality of the ham in progeny (LSMean ±S.E.)

Sources of variation		RW[2]. kg	RSFT. kg	RINT. kg	RB. kg	RMT.kg
Sex	M[1]	9.372±0.07	1.526±0.04	0.426±0.02	0.763±0.01	6.656±0.08
	F	9.665±0.07	1.266±0.05	0.378±0.02	0.798±0.01	7.224±0.09
Saeason	Winter	9.696±0.19	1.076±0.13	0.321±0.05	0.787±0.03	7.512±0.24
	Spring	9.196±0.07	1.712±0.05	0.525±0.02	0.759±0.01	6.199±0.09
	Summer	9.466±0.09	1.471±0.06	0.401±0.02	0.776±0.01	6.817±0.11
	Autumn	9.717±0.08	1.325±0.05	0.361±0.02	0.799±0.01	7.233±0.10

[1]M- male castrates, F–females; [2] RW- the weight of the ham, RSFT– the weight of the skin and subcutaneous fat tissue of the ham, RINT- the weight of the intermuscular fat tissue of the ham, RB- the weight of bones of the ham, RMT- the weight of muscles of the ham

Table 3 shows the statistical significance of the factors on the tested properties. The total weight of the ham (RW) was influenced by the (P <0.001) breed of the sire, sires within the breed, sex, and the genotype of the animal, while the season showed significant influence (P <0.01). Other factors did not show significant influence (P> 0.05) on this trait. Factors included in the model (the impact of the sire breed, sires within the breed, sex, season of birth, sex within the breed and the weight of the warm carcass side) explain 93.6% of the variability of the RW trait. All of the included factors showed significant impact on the yield of skin and subcutaneous fatty tissue (RSFT) as well as on muscle (RMT), (P <0.05; P <0.01 and P <0.001), only for the interaction of sex within the sire breed and sex within the genotype no influence was determined (P> 0.05). According to *Renaudau et al., (2005), Renaudeau and Mourot, (2007), Serrano et al., (2007); Radović et al., (2008),* the dependance of presence of muscular and fatty tissue on gender is in accordance with our research.

Table 3. Statistical significance (level of significance) of the effect of factors included in the model in the analysis of quality traits of the pork ham

Sources of variation (impact)[1)]	RW[2)]	RSFT	RINT	RB	RMT
RO	***[3)]	***	***	***	***
O:SL	NS	***	***	***	***
O:LW	NS	***	NS	NS	**
O:P	***	**	***	**	***
Pol	***	***	**	**	***
Sezona	**	***	***	NS	***
Pol:RO	NS	NS	NS	NS	NS
WCSW (b)	***	***	***	***	***
R^2	0,936	0,693	0,668	0,658	0,830

[1)]SB-sire breed, S:SL – sires within the breed Swedish Landrace; S:LW – sires within the breed Large White; S:P – sires within the breed Pietrain; Sex:SB-sex of the progeny within the sire breed; [2)] RW- the weight of the ham, RSFT– the weight of the skin and subcutaneous fat tissue of the ham, RINT- the weight of the intermuscular fat tissue of the ham, RB- the weight of bones of the ham, RMT- the weight of muscles of the ham [3)] NS=P>0,05; *=P<0,05; **=P<0,01; ***=P<0,001

Conclusion

With the mean weight of the warm carcass side of 81.20 kg, the highest mean values for the weight of the ham (RW; 10.456 kg), the weight of intermuscular fat tissue (RINT; 0.477 kg), the bones of the ham (RB; 0.837 kg) and muscle tissue (RMT; 7.939 kg) were recorded in the progeny of Pietrain sires (P) in relation to sires of other breeds. In comparison to the animals originating from the Swedish Landrace (SL) and Large White (LW) sires progeny of the (P) sires had less skin and subcutaneous fat tissue (RSFT) by 30 and 549 grams. The study showed that the progeny of SL sires no. 7 and 9, had the lowest LSMean values for the yield of skin and subcutaneous fat (869 and 876 g), which was less than the mean for the breed by 364 and 357 g. In regard to the intermuscular fatty tissue, the lowest established value was recorded in progeny of SL sire no. 8 rase (182 g), which was by 220 g less than the general mean and by 132 g less than the mean for sire breed. The animals originating from sires no. 19 and 20 had the highest amount of muscular tissue (RMT) (8.489 and 8.118 kg) in the ham, which was by 2.853 and 2.482 kg more meat compared to the progeny of LW sire no. 5. The total weight of the ham and the muscle yield of the ham were influenced by (P <0.01 and P <0.001) sire breed, sires within the breed, sex and season of birth. A very significant (P <0.001) influence of the weight of warm carcass sides on the weight of the ham and tissue yield was determined.

Kvalitet buta-prinos tkiva u butu u zavisnosti od pojedinih faktora

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Rezime

Ispitivanjem su bili obuhvaćeni potomci tri rase nerasta-očeva (SL - švedski landras; LW - veliki jorkšir i P - pijetren). Ukupno je ispitano 201 potomak oba pola (93 ženska i 108 muška kastrirana grla) koji su vodili poreklo od 16 očeva-nerasta. Ispitivanjem su bili obuhvaćeni potomci 10 nerasta rase SL (očevi broj: 1, 2, 3, 7, 8, 9, 15, 16, 17 i 18), 3 nerasta rase LW (očevi broj: 4,5 i 6) i 3 nerasta rase P (očevi broj: 14, 19 i 20) rođeni u četiri godišnje sezone (zima, proleće, leto i jesen). Istraživanja su pokazala da, pri prosečnoj masi tople polutke od 81.20 kg, najveće prosečne vrednosti za masu buta (RW; 10,456 kg), masu intermuskularnog masnog tkiva (RINT; 0,477 kg), kostiju buta (RB; 0,837 kg) i mišićnog tkiva (RMT; 7,939 kg) imaju potomci očeva rase pijetren (P) u odnosu na očeve rase SL i LW. U odnosu na grla koja potiču od očeva SL i LW potomci očeva rase P imala su manje kože i potkožnog masnog tkiva (RSFT) za 30 i 549 grama. Istraživanja su pokazala da imamo potomke očeva nerasta br.7 i 9, rase SL koji imaju najmanje LSMean vrednosti za osobinu prinosa kože i potkožnog masnog tkiva (869 i 876 g) što je manje u odnosu za prosek rase za 364 i 357 g. Pri tom, kada je reč o intermuskularnom masnom tkivu najmanju utvrđenu vrednost imali su potomci oca br. 8 rase SL (182 g), što je za 220 g manje od opšteg proseka i za 132 g od proseka rase očeva. Grla koja potiču od očeva br. 19 i 20 imala su najviše mišićnog tkiva (RMT) (8,489 i 8,118 kg) u butu što je za 2,853 i 2,482 kg više mesa u odnosu na potomke nerasta br. 5 rase LW. Na ukupnu masu buta i prinos mišića u butu uticali su (P<0,01 i P<0,001) rasa oca, očevi unutar rasa, pol i sezona rođenja. Utvrđen je vrlo visoko značajan (P<0,001) uticaj mase toplih polutki na masu buta i prinos tkiva.

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