

Effect of Lean Meat Proportion on the Chemical Composition of Pork

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Abstract:

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The objective of this work was to verify the effect of the lean meat proportion on the chemical composition of the meaty parts (loin and ham) of pork. A total of 116 finishing hybrid pigs commonly used in the Czech Republic were fattened for this purpose. The pigs were divided according to the lean meat proportion criterion into 3 groups, i.e. more than 60.0%, 55.0–59.9% and 50.0–54.9%. Representative muscle samples were taken from the right halves of these pigs. They were then homogenised and submitted to chemical analysis. The results of the measuring showed that the values of the water content, intramuscular fat (IMF), crude proteins, and ash matter ranged in the loin between 72.50–72.80%, 1.56–1.96%, 23.20–23.40%, and 1.37–1.40%, respectively, and in the ham between 70.43–71.59%, 3.52–4.26%, 21.67–21.95%, and 1.42–1.56%, respectively. The ascertained values of the water content and crude proteins with regard to the increasing lean meat proportion in the carcasses did not show any developmental tendencies. As for the content of IMF, it was determined that the higher was the lean meat proportion, the lower was the IMF content. Concerned of sensoric quality traits it means that pork meat from supermeaty hybrid pigs shows lower quality. Concerning the content of ash matter, it was observed that the ash content increased with an increasing lean meat proportion. In the carcass part of the *musculus longissimus lumborum et thoracis* (MLLT), it was demonstrated that the higher was the lean meat proportion, the lower was the content of amino acids – threonine, isoleucine, lysine, aspartic acid, serine, and proline. From point of the production of exceedingly meaty pigs (over 60%), it can be expected a worse nutritional pork meat value. In the carcass portion of the *musculus semimembranosus* (MS), the contents of valine, isoleucine, phenylalanine, lysine, serine, proline, and glycine increased with an increasing lean meat proportion. Within the framework of statistical evaluation of differences between the groups, the values of IMF ($P \leq 0.01$) in MLLT, water content, IMF, ash matter, threonine, valine, phenylalanine, lysine, aspartic acid, serine, glycine, and alanine in MS were highly significant ($P \leq 0.05$; $P \leq 0.01$ and $P \leq 0.001$).

Keywords: pig; meat; lean meat; chemical composition

Meat quality has assumed great significance in recent years mainly due to the importance of quantitative and qualitative carcass value relationships. As pigs were becoming progressively leaner, more

complaints were received from the food industry claiming that the quality of meat had declined (WOOD 2001). The importance of the pig in the meat industry according to the lean meat propor-

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tion (lean meat percentage – LMP) was studied by BRANSCHIED *et al.* (1987). KOUCKÝ *et al.* (1993) observed the influence of the sex (boars, barrows, and gilts) on the index of carcass value. The weight of the right half in the observed groups was 48.0, 47.8 and 45.8 kg, respectively. The percentage of lean meat was 50.04%, 44.33%, and 49.12%, respectively. In the dry matter of the meat and in the protein content no statistically significant differences between sexes were observed.

An important factor influencing the qualitative aspect of pig meat is the proportion of intramuscular fat (IMF). Several studies involving consumers and trained panels revealed that IMF content is one of the important traits which influence the quality characteristics such as meat tenderness, juiciness, and taste (VERBEKE *et al.* 1999).

The IMF content of porcine meat is the optimum trait with regard to the influence on the meat tenderness (HOVENIER *et al.* 1993). An IMF content below the recommended optimum range of 2.5–3% diminishes the quality, whereas a higher IMF content will not further improve this parameter and will instead have adverse effects on the consumer acceptability due to the increased visibility of fat in the meat.

ŠEVČÍKOVÁ *et al.* (2002) determined in gilts (LW × L) an IMF content at the level of 1.918%, water loss by drainage – 3.07%, remission – 19.67%, and pH₂₄ – 5.51. MIKULE (2005) found an IMF content of 0.71% in the LW breed and 0.85% in the L breed, respectively. OLIVER *et al.* (2003) recorded the highest IMF content in the Duroc breed – 2.89%.

A number of authors have dealt with the evaluation of the qualitative indicators depending on the lean meat proportion: BABATUDE *et al.* (1966), FEWSON *et al.* (1990), BRUWE *et al.* (1991), BAHILKA *et al.* (2006), CORREA *et al.* (2006), and others.

The objective of this study was to determine the influence of the attained lean meat proportion on the chemical composition of pork which influences the eating quality.

MATERIAL AND METHODS

116 slaughter pigs of a final hybrid combination bred in the Czech Republic were used in the experiments which were performed at the Ploskov teststation, Lány. All of the pigs were penned pairs and divided according to sex (gilts, barrows). The pigs were placed in the experiment at an average live weight of 23.6 kg (the same age and well-balanced sex ratio – barrows/gilts) and at an average age of 65 to 70 days after the date of birth. Feeding was provided by means of a full feed mixture (FFM) which contained three components (wheat, barley, soybean extracted meal) and feeding premix. The pigs were slaughtered and subjected to carcass analysis after reaching an overall average live weight of 111.6 kg at the age of 168–171 days after birth. The pigs were then commercialised in a slaughterhouse by the SEUROP system. The lean meat proportion of the pigs was evaluated by the ZP method (PULKRÁBEK 2001; PULKRÁBEK *et al.* 2004) and further subjected to carcass analysis.

The right half-carcass was dissected into individual parts. Samples were taken from the *musculus longissimus lumborum et thoracis* (MLLT) and *musculus semimembranosus* (MS). The representative ones were homogenised and subjected to chemical analyses to determine the content of water (from the difference of the sample weight before and after drying with sea sand), IMF (by gravimetric determination after extraction with petrolether), crude protein (determination of amino nitrogen according to Kjeldahl), ash (by burning the sample at 550°C until the burning of organic substances was complete) and selected amino acids (analysis of the hydrolysis product with an automatic analyzer AAA 400 and evaluation by the ChromuLan programme).

116 finishing pigs were divided into 3 groups according to their lean meat proportion (Table 1).

The test results obtained were evaluated by the statistical programme SAS® Propriety Software Release 6.04, formulated in tables, whereas the

Table 1. Pig frequency according to lean meat classification criteria

Class quality	Lean meat (%)	Total
S	more than 60.0	35
E	55.0–59.9	51
U	50.0–54.9	30

differences between the individual traits were tested by the GLM procedure on the basis of mutual interactions between lean muscles.

The following parameters were used to evaluate the appropriateness of the allometric models: $Y_i = \mu + (LM)_i + e_i$ – analysis of a single class (lean meat).

RESULTS AND DISCUSSION

The grading criteria together with the fundamental statistical characteristics and the results of variation analyses for the selected characteristics of the chemical composition are shown in Tables 2–3.

As is evident from Table 2, the total water content in the MLLT was in the range of 72.50–72.80%, where the highest water content was found in the group with 55.0–59.9% of lean meat and the lowest content in the group with 60.0% or more of lean meat. From the values of IMF in the muscle MLLT it results that with the growth of lean muscle the content of IMF declined, i.e., in the group with the highest lean meat proportion the values of 1.56%, further 1.61% and 1.96%, were estimated. MATOUŠEK *et al.* (1997) found the proportion of IMF content in a hybrids pig population to be 2.39%. The highest total value of crude proteins, 23.40%, was ascertained in the group with the lowest lean meat proportion. On the contrary, the lowest value of crude proteins, 23.20%, was shown in the group with 55.0–59.9% of lean meat. The content of ash matter demonstrated an evolutionary tendency when, with an increase in the muscle proportion, the ash content also increased. In the group with 50.0–54.9% of muscle, a value of 1.37% was ascertained; in the group with 55.0–59.9% the proportion of 1.39% was demonstrated, and in the group over 60.0% a value of 1.40% was observed.

CORREA *et al.* (2006) determined that with the presence of 61.32%, 61.13% and 60.80% of lean meat in the carcass in the MLLT, 73.9, 73.9 and 73.8% of water, 2.05, 1.75 and 1.90% of IMF, and 23.45, 23.75, and 23.70% of proteins, respectively were measured. NADĚJE *et al.* (2000) testing pigs with an average carcass weight of 104 kg found in the MLLT 73.95% of water, 1.86% of IMF and 26.05% of proteins.

In addition to monitoring in the groups of pigs with different lean meat we can mention the values of the water content, IMF, crude proteins and ash matter (Table 2).

The the water contents ranged between 72.50% to 72.80%, the highest/lowest values having been found in the group with lean meat of 55.0–59.9%/more than 60.0%. The content of IMF showed an evolutionary tendency when, with the growth of the muscle proportion, the IMF content also declined. In the group with 50.0–54.9% of muscle, a value of 4.26% was recorded; in the group with 55.0–59.9%, a proportion of 3.65% was demonstrated; and in the group over 60.0%, a value of 3.52% was ascertained. As above mentioned values could be considered positive concerned sensorial point of view, there is question how high increase lean meat share with respect to gustative traits. Concerned of others traits characterised pork meat quality, the contents of crude proteins (further, CP) were very well-balanced (21.67–21.95%) in the groups, whereas the differences between the groups were not significant. From the results of the ash content it can be stated that with an increase in lean meat, the ash content also increases. The highest values (1.56%) were shown in the group with lean meat over 60.0% and more, the lowest (1.42%) with lean meat of up to 50.0%.

The total values of the selected aminoacids in the loin (MLLT) of the monitored groups with dif-

Table 2. MLLT and MS chemical composition ($\bar{x} \pm \text{SD}$)

	MLLT			MS		
	lean meat (%)					
	60.0 and more	55.0–59.9	50.0– 54.9	60.0 and more	55.0–59.9	50.0–54.9
Water (%)	72.50 $\pm$ 0.19	72.80 $\pm$ 0.16	72.58 $\pm$ 0.32	70.43 ^{Aa} $\pm$ 0.26	71.59 ^A $\pm$ 0.18	71.50 ^a $\pm$ 0.26
IMF (%)	1.56 ^a $\pm$ 0.08	1.61 ^b $\pm$ 0.07	1.96 ^{ab} $\pm$ 0.09	3.52 ^a $\pm$ 0.17	3.65 ^a $\pm$ 0.14	4.26 ^{aa} $\pm$ 0.24
Crude proteins (%)	23.28 $\pm$ 0.13	23.20 $\pm$ 0.12	23.40 $\pm$ 0.17	21.94 $\pm$ 0.14	21.95 $\pm$ 0.13	21.67 $\pm$ 0.15
Ash (%)	1.40 $\pm$ 0.03	1.39 $\pm$ 0.02	1.37 $\pm$ 0.02	1.56 ^{aβ} $\pm$ 0.04	1.44 ^β $\pm$ 0.03	1.42 ^a $\pm$ 0.04

^{ab} $P \leq 0.01$; ^{aβ} $P \leq 0.05$; ^a $P \leq 0.01$; ^A $P \leq 0.001$; $\bar{x}$ = mean; SD = standard error from the mean

ferent lean meat proportions are shown in Table 3. It is demonstrated in this table that the highest values in the essential and semi-essential amino acids were monitored with lysine (9.86–10.59%), arginine (9.16–9.61%), and leucine (8.41–8.90%). However BELITZ *et al.* (2001) presented the values 7.8–8.1% of lysine and 7.5–7.6% of leucine. The absolute minimum was measured for phenylalanine (1.23–1.41%), whereas (BELITZ *et al.* 2001) mention 3% higher representation of phenylalanine. The highest values were shown with glutamic acid (12.04–12.35%), aspartic acid (11.46–12.13%), and alanine (7.75–7.81%), and the lowest values of the non-essential amino acids with proline (4.67–5.45%), serine (5.70–5.92%), and glycine (5.64–5.73%). BELITZ *et al.* (2001) also showed alternative values within the framework of monitoring the levels of the non-essential amino acids. They found almost consistent the values of proline 4.6%, serine 4.2%, glycine 5.7%, and alanine 5.5%.

In the group of 60.0% and more of lean meat, minimum values were found with threonine, valine, isoleucine, lysine, aspartic acid, serine, and

proline. On the contrary, the maximum values were shown with phenylalanine, glycine, and alanine. In the group with 55.0–59.9% of lean meat, the minimum/maximum values were estimated in the contents of phenylalanine and glycine/valine, leucine, arginine, glutamic acid and alanine. In the group with 50.0–54.9% of lean meat, the minimum values occurred with leucine, arginine, glutamic acid, and alanine. On the contrary, the values of threonine, isoleucine, lysine, aspartic acid, serine, and proline were the highest in this group.

The contents of amino acids – threonine, isoleucine, lysine, aspartic acid, serine, and proline – declined with the increasing proportion of lean meat.

Generally one could say that the higher lean meat share in MLLT, the lower amino acid spectrum and thereby lower pork meat nutritional value.

Table 3 documents the amino acids contents in the ham (MS). The highest contents of essential and semi-essential amino acids were shown with lysine (10.12–10.96%) and leucine (9.05–9.56%). On the contrary, phenylalanine revealed the ab-

Table 3. MLLT and MS amino acid contents ($\bar{x} \pm \text{SD}$)

	MLLT			MS		
	lean meat (%)					
	60.0 and more	55.0–59.9	50.0–54.9	60.0 and more	55.0–59.9	50.0–54.9
Essential and semi-essential amino acids (%)						
Threonine	6.32 $\pm$ 0.27	6.34 $\pm$ 0.15	6.55 $\pm$ 0.38	7.17 ^a $\pm$ 0.40	6.06 ^b $\pm$ 0.22	6.07 ^{ab} $\pm$ 0.43
Valine	6.00 $\pm$ 0.27	6.16 $\pm$ 0.14	6.08 $\pm$ 0.45	6.66 ^a $\pm$ 0.38	6.10 $\pm$ 0.19	5.79 ^a $\pm$ 0.32
Isoleucine	5.46 $\pm$ 0.25	5.68 $\pm$ 0.14	5.97 $\pm$ 0.44	5.90 $\pm$ 0.35	5.56 $\pm$ 0.16	5.27 $\pm$ 0.28
Leucine	8.80 $\pm$ 0.46	8.90 $\pm$ 0.26	8.41 $\pm$ 0.41	9.05 $\pm$ 0.62	9.56 $\pm$ 0.31	9.27 $\pm$ 0.48
Phenylalanine	1.41 $\pm$ 0.07	1.23 $\pm$ 0.05	1.30 $\pm$ 0.09	1.84 ^a $\pm$ 0.14	1.42 ^b $\pm$ 0.07	1.34 ^{ab} $\pm$ 0.09
Lysine	9.86 $\pm$ 0.51	10.21 $\pm$ 0.35	10.59 $\pm$ 0.46	10.96 ^a $\pm$ 0.66	10.42 $\pm$ 0.35	10.12 ^a $\pm$ 0.42
Arginine	9.48 $\pm$ 0.45	9.61 $\pm$ 0.25	9.16 $\pm$ 0.53	8.26 $\pm$ 0.68	8.82 $\pm$ 0.41	8.74 $\pm$ 0.54
Nonessential amino acids (%)						
Aspartic acid	11.46 $\pm$ 0.59	12.05 $\pm$ 0.27	12.13 $\pm$ 0.44	10.64 ^a $\pm$ 0.74	10.12 ^a $\pm$ 0.36	10.35 $\pm$ 0.85
Serine	5.70 $\pm$ 0.24	5.71 $\pm$ 0.14	5.92 $\pm$ 0.33	6.26 ^a $\pm$ 0.35	5.52 ^b $\pm$ 0.19	5.34 ^{ab} $\pm$ 0.31
Glutamic acid	12.27 $\pm$ 0.74	12.35 $\pm$ 0.45	12.04 $\pm$ 0.60	11.23 $\pm$ 1.37	12.53 $\pm$ 0.60	11.52 $\pm$ 1.38
Proline	4.67 $\pm$ 0.28	5.16 $\pm$ 0.22	5.45 $\pm$ 0.30	5.39 $\pm$ 0.32	5.24 $\pm$ 0.20	4.83 $\pm$ 0.26
Glycine	5.73 $\pm$ 0.26	5.64 $\pm$ 0.13	5.72 $\pm$ 0.23	6.71 ^a $\pm$ 0.36	5.83 ^b $\pm$ 0.19	5.78 ^{ab} $\pm$ 0.34
Alanine	7.81 $\pm$ 0.33	7.81 $\pm$ 0.19	7.75 $\pm$ 0.28	8.97 ^a $\pm$ 0.49	7.69 ^b $\pm$ 0.24	7.71 ^{ab} $\pm$ 0.51

^a $P \leq 0.05$; ^{ab} $P \leq 0.01$; $\bar{x}$ = mean; SD = standard error from the mean

solutely lowest value (1.34–1.84%). Among the nonessential amino acids, the highest values were measured for glutamic acid (11.23–12.53%) and aspartic acid (10.12–10.64%). The lowest value was shown for proline (4.83–5.39%).

In the group of 60.0% and more of lean muscle, the minimum values were found for leucine, arginine, and glutamic acid whereas the maximum values were shown for threonine, valine, isoleucine, phenylalanine, lysine, aspartic acid, serine, proline, glycine, and alanine. In the group with 55.0–59.9% of lean meat, the minimum/maximum values were found with threonine, aspartic acid, and alanine/leucine, arginine, and glutamic acid. In the group with 50.0–54.9% of lean meat, the minimum values occurred with valine, isoleucine, phenylalanine, lysine, serine, proline, and glycine.

The contents of the amino acids valine, isoleucine, phenylalanine, lysine, serine, proline, and glycine increased with the increasing proportion of lean meat.

From obtained values of the amino acid spectrum concerning of lean meat share, it can be stated, that MS demonstrate other tendency than MLLT. This fact can be caused by more higher metabolism intensity in the MLLT than in the MS. This findings correlated with results of MORA *et al.* (2008). They determined significantly higher content of creatine, creatinine and carnosine and showed that this could be due to the highest dependence of glycolytic muscles on anaerobic metabolism. The amount of carnosine increases with glycolytic activities of the muscle, also creatine and creatinine contents increase in this type of metabolism. ARISTOY and TOLDRA (1998) evaluated free amino acid and dipeptides in pig meat, too. Statistically highest value of carnosine and serine was recorded in muscles with glycolytic activity.

Concerning the statistical evaluation of the differences between the groups, the values of IMF ($P \leq 0.01$) in MLLT, the water content, IMF, ash matter, threonine, valine, phenylalanine, lysine, aspartic acid, serine, glycine, and alanine in MS were highly significant ($P \leq 0.05$; $P \leq 0.01$ and $P \leq 0.001$).

CONCLUSION

On the basis of the results obtained by measuring, it can be demonstrated that the values of the water content, IMF, crude proteins, and ash matter in the loin ranged between 72.50–72.80%, 1.56–1.96%, 23.20–23.40%, and 1.37–1.40%, respectively, whereas

the values of the water content, IMF, crude proteins, and ash matter in the ham were lower and ranged between 70.43–71.59%, 3.52–4.26%, 21.67–21.95%, and 1.42–1.56%, respectively. No developmental tendencies in the contents of water and crude proteins in meat with respect to the increasing lean meat proportion in the carcass were found. In our study, the IMF content declined with the increasing lean meat proportion while the ash matter content increased with the increasing lean meat proportion. Our findings indicated that the aminoacids contents in MLLT (threonine, isoleucine, lysine, aspartic acid, serine, proline) declined with the increase of the lean meat proportion, whereas in MS the amino acids (valine, isoleucine, phenylalanine, lysine, serine, proline and glycine) increased with the increase of the lean meat proportion. Based on the comparison of the total chemical composition in the dependence on the lean meat proportion in the carcass, the best appears to be the MLLT/MS group with 50.0–54.9%/60.0% lean meat proportion and more.

It can be stated, that pig breeding towards to high lean meat share leads to lower IMF content, then flavour and in some important carcass parts to lower pork meat nutritional value as well.

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