

Amino acid composition of pig meat in relation to live weight and sex

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ABSTRACT: The objective of this study was to find out the amino acid composition of pig meat in relation to live weight and sex. In total 80 (40 barrows/40 gilts) finishing pigs of the final hybrid kept in the Czech Republic [(CL × CLW) × (D × PN)] = [(Czech Landrace × Czech Large White) × (Duroc × Pietrain)] were used in this experiment. The pigs were slaughtered at the average age of 168–171 days after birth, at the average live weight of 112.2 kg. The samples of meat were taken from the *musculus longissimus lumborum et thoracis* (MLLT) 24 hours *post mortem* and subsequently subjected to the chemical analysis. As for the essential and semi-essential amino acids (EAA/SEAA), the highest content was found out in lysine, leucine and arginine. Among the nonessential amino acids (NEAA) glutamic and aspartic acid were present. The highest values of threonine (6.81%), isoleucine (6.13%), leucine (9.21%), lysine (10.54%), arginine (7.88%), serine (6.13%), glutamic acid (15.65%), glycine (6.04%) and alanine (6.25%) were found out in gilts, of valine (6.36%) and proline (5.56%) in the group of barrows with the highest live weight, i.e. 115.1 kg and more. The highest value of phenylalanine (1.34%) was measured in the group with the lowest live weight. The indirect dependence between the content of amino acids and live weight was determined only for valine in gilts. The influence of live weight was found in proline and the influence of sex as statistically significant on the probability level $P \leq 0.05$ was found in lysine. The highest/lowest values of water content in barrows as well as in gilts were measured in the group of 115.1 kg and more/105.1–115 kg live weight. A decreasing tendency of the content of intramuscular fat (IMF) was recorded with the increasing live weight. The values of water content, IMF and ash content were found to be significant on the probability level $P \leq 0.05$ and $P \leq 0.01$. In barrows with the growth of live weight the content of crude proteins also increased. In gilts the content of crude proteins reached the point of inflexion already in the group of 105.1–115 kg live weight. In the values of crude protein content the influence of live weight was not significant. With the growth of live weight the content of ash also slightly increased.

Keywords: pig; meat; chemical analysis; slaughter weight; sex

Changing consumers' preferences influence the conception of ideal composition and properties of the end product to a great extent (Šubrt et al., 2002).

According to the importance for human nutrition the amino acids are divided into essential: valine (Val), leucine (Leu), isoleucine (Ile), threonine (Thr), methionine (Met), lysine (Lys), phenylalanine (Phe) and tryptophan (Trp); semi-essential: arginine (Arg) and histidine (His); and nonessential ones: glycine (Gly), alanine (Ala), serine (Ser),

cysteine (Cys), aspartic acid (Asp), asparagine (Asn), glutamic acid (Glu), glutamine (Gln), tyrosine (Tyr) and proline (Pro) (Belitz et al., 2001).

Passi and de Luca (1998) stated that in the human nutrition it is possible to consider only 10 amino acids as principal, i.e. essential nutrients, which the humans must obtain from various diets. The remaining amino acids may be synthesized from the products of metabolism and of essential amino acids.

Cornet and Bousset (1999) studied the free amino acids and dipeptides in pigs namely in the red (*masseter*), white (*trapezius*) and inter-medial (*longissimus dorsi*) muscles. The highest content of aspartic acid, glutamine and taurine was in the muscle *masseter*. The muscle *longissimus dorsi* showed the highest content of β -alanine and carnosin. The muscle *trapezius* had the medium content of the above-mentioned amino acids.

Aristoy and Toldrá (1998) also evaluated the free amino acids and dipeptides in pig meat, namely in the muscles of diverse metabolic types (*masseter*, *trapezius*, *semimembranosus* and *longissimus dorsi*).

According to Ruan, Chen (1997) the content of water in meat substantially influences the characteristic sensory properties of meat (texture, smell, taste, colour) as well as its stability during storage, immunity against microbial disorders and enzyme/non-enzyme reactions, taking place during processing and storage.

The proteins of meat and their high benefits to the organism have an eminent biological value. From the nutritional aspect they are rightly regarded as the most valuable components of meat. They are “fully-valuable” – containing all essential amino acids.

According to Šubrt et al. (2002) also the fat has to be considered as an indispensable part of nutrition that cannot be replaced by any other component. According to Kempster et al. (1982) in the body and body cavities of animals there is a very variable quantity of fat in the form of intracellular, intercellular and extracellular fat.

Gonzalez et al. (2001), Tibau et al. (2002) and Zullo et al. (2003) dealt with the chemical composition of pig meat in relation to slaughter weight, sex and genotype. The chemical composition of pig meat was affected in final hybrids slaughtered in the weight range from 25 to 140 kg of live weight.

The objective of this study was to find out the amino acid composition of pig meat in relation to live weight and sex.

MATERIAL AND METHODS

In total 80 finishing pigs of the final hybrids [(CL \times CLW) \times (D \times PN)] kept in the Czech Republic were included in the test. The testing procedures were realized at a test station in Ploskov-Lány. All pigs were penned delivered in couples. The pigs were placed into the test at the average weight of

23.6 kg (the same age and well-balanced sex ratio – barrows/gilts) and at the average age of 65 to 70 days after the date of birth. The pigs received a complete feed mixture (CFM) composed of three components (wheat, barley, soybean meal) according to the feeding scheme (Table 1).

After reaching the total average live weight 112.2 kg at the age of 168–171 days from the birth the pigs were slaughtered and subjected to the carcass analysis.

The right half-carcass was dissected into individual carcass parts. Samples were taken from the *musculus longissimus lumborum et thoracis* (MLLT). The representative samples were homogenized and subjected to chemical analyses to determine selected amino acids (the analysis of the hydrolysis product on an automatic analyzer AAA 400 and evaluation by the ChromuLan programme), water content (it can be determined from a difference in the sample weight before and after drying with sea sand), intramuscular fat (gravimetric determination after extraction with petroleum ether – Soxhlet extraction), crude protein (determination of amino-nitrogen according to Kjeldahl) and ash content (by burning the sample at 550°C until the perfect burning of organic substances).

80 finishing pigs were divided into 3 groups according to the live weight criterion (Table 2).

Table 1. Composition of pig diets and nutrient contents

	P1	P2
Ingredients		
Wheat (%)	50.0	55.0
Barley (%)	25.0	32.0
Soybean meal (%)	21.7	10.5
Premix 1 (%)	3.3	–
Premix 2 (%)	–	2.5
Nutrient content		
Mep (MJ/kg)	12.8	12.8
Crude protein (g/kg)	188.6	150.1
Stock (g/kg)	38.7	36.3
SLYSINp (g/kg)	9.6	7.1
SMETHIOp (g/kg)	2.7	2.1
Sm + Cp (g/kg)	5.7	4.6
STHREONp (g/kg)	6.3	4.8
STRYPTOp (g/kg)	2.0	1.6
Ca (g/kg)	7.5	6.0
P – total (g/kg)	6.4	5.1
P – consumable (g/kg)	3.3	2.3
Na (g/kg)	1.9	1.6

Table 2. Division of pigs according to the classification criteria live weight and sex

Live weight (kg)	Barrows	Gilts	Total
Up to 105	9	15	24
105.1–115	16	17	33
115.1 and more	15	8	23

The test results were evaluated by the statistical programme SAS[®] Proprietary Software Release 6.04, formulated in tables, whereas the differences between the individual traits were tested by GLM procedure on mutual interactions between weight and sex.

RESULTS AND DISCUSSION

Table 3 shows the average live weights of barrows/gilts and in total. From the results of measuring it follows that statistically significant differences were

calculated between the groups and no differences in the classification of differences between the sexes were found to be statistically significant.

Amino acids

The measured values of selected amino acids in the groups with different live weights are shown in Table 4. The highest values in the group of non-essential amino acids were measured in glutamic (13.90–15.65%) and aspartic acid (9.96–10.31%). The lowest values were found out in the amino acids proline (4.53–5.56%), serine (5.47–6.13%), glycine (5.49–6.04%) and alanine (5.58–6.25%). Belitz et al. (2001) also reported alternate values in the framework of monitoring the level of non-essential amino acids, and they found out the values of proline 4.6, serine 4.2, glycine 5.7 and alanine 5.5%.

Table 3. Live weight and sex ($\bar{x} \pm SD$)

Live weight (kg)	Barrows	Gilts	Total
Up to 105	101.8 ^{Aa} \pm 1.78	101.6 ^{CD} \pm 1.04	101.7 ^{FG} \pm 0.99
105.1 – 115	109.4 ^{Ba} \pm 1.33	110.8 ^{CE} \pm 0.97	110.1 ^{FH} \pm 0.84
115.1 and more	126.6 ^{AB} \pm 1.38	121.6 ^{DE} \pm 1.43	124.8 ^{GH} \pm 1.00

ABCDEF^{GH} $P \leq 0.001$; ^a $P \leq 0.01$; \bar{x} = mean; SD = standard error of the mean

Table 4. Contents of amino acids in MLLT ($\bar{x} \pm SD$)

Live weight (kg)	Up to 105		105.1–115		115.1 and more	
	barrows	gilts	barrows	gilts	barrows	gilts
Essential and semi-essential amino acids (%)						
Threonine	6.36 \pm 0.33	6.35 \pm 0.25	6.29 \pm 0.29	6.27 \pm 0.35	6.56 \pm 0.44	6.81 \pm 0.30
Valine	5.96 \pm 0.28	6.13 \pm 0.22	6.09 \pm 0.26	6.02 \pm 0.34	6.36 \pm 0.44	5.99 \pm 0.81
Isoleucine	5.54 \pm 0.32	5.56 \pm 0.21	5.60 \pm 0.25	5.50 \pm 0.30	6.09 \pm 0.55	6.13 \pm 0.38
Leucine	8.31 \pm 0.24	8.34 \pm 0.16	8.54 \pm 0.83	8.18 \pm 0.64	8.54 \pm 0.43	9.21 \pm 0.49
Phenylalanine	1.34 \pm 0.10	1.30 \pm 0.05	1.31 \pm 0.06	1.22 \pm 0.09	1.32 \pm 0.09	1.29 \pm 0.20
Lysine	9.71 \pm 0.44	9.85 \pm 0.44	10.01 \pm 0.30	9.99 \pm 0.24	9.76 ^a \pm 0.49	10.54 ^a \pm 0.75
Arginine	7.32 \pm 0.05	7.28 \pm 0.16	7.45 \pm 0.28	7.56 \pm 0.79	7.48 \pm 0.52	7.88 \pm 0.24
Nonessential amino acids (%)						
Aspartic acid	10.23 \pm 0.84	10.18 \pm 0.73	10.31 \pm 0.46	9.99 \pm 0.54	9.96 \pm 0.41	10.12 \pm 0.15
Serine	5.47 \pm 0.33	5.69 \pm 0.20	5.78 \pm 0.24	5.64 \pm 0.31	5.99 \pm 0.37	6.13 \pm 0.28
Glutamic acid	14.20 \pm 0.51	14.26 \pm 0.38	14.55 \pm 0.61	14.38 \pm 0.87	13.90 \pm 0.32	15.65 \pm 0.89
Proline	4.60 \pm 0.44	5.27 \pm 0.35	4.53 ^a \pm 0.29	5.25 \pm 0.31	5.56 ^a \pm 0.38	5.44 \pm 0.44
Glycine	5.49 \pm 0.30	5.69 \pm 0.23	5.69 \pm 0.26	5.66 \pm 0.30	5.71 \pm 0.19	6.04 \pm 0.34
Alanine	5.64 \pm 0.58	5.85 \pm 0.14	5.94 \pm 0.22	5.58 \pm 0.55	5.76 \pm 0.39	6.25 \pm 0.84

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

Table 5. Chemical composition of MLLT ($\bar{x} \pm SD$)

Live weight (kg)	Up to 105		105.1–115		115.1 and more	
	barrows	gilts	barrows	gilts	barrows	gilts
Water (%)	72.19 ^a ± 0.21	72.30 ^b ± 0.25	72.01 ^{ay} ± 0.28	72.05 ^{bδ} ± 0.14	72.73 ^{yδ} ± 0.15	73.09 ^{abaβ} ± 0.17
IMF (%)	2.00 ^{aba} ± 0.16	1.53 ^a ± 0.11	1.77 ^{by} ± 0.11	1.41 ^{aβ} ± 0.10	1.65 ± 0.10	1.31 ^{by} ± 0.16
Crude proteins (%)	23.18 ± 0.23	23.52 ± 0.17	23.38 ± 0.15	23.64 ± 0.20	23.61 ± 0.21	23.38 ± 0.38
Ash (%)	1.30 ^a ± 0.03	1.35 ^a ± 0.02	1.34 ^b ± 0.03	1.38 ± 0.02	1.46 ^{aba} ± 0.03	1.38 ± 0.03

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

The highest content of essential and semi-essential amino acids was determined in lysine (9.71 to 10.54%), leucine (8.18–9.21%) and arginine (7.28 to 7.88%). However, Belitz et al. (2001) reported the value 7.8–8.1% for lysine and 7.5–7.6% for leucine. The lowest content among the essential amino acids was measured in phenylalanine (1.22–1.34%), whereas Belitz et al. (2001) mentioned the phenylalanine content higher by 3%. The content of isoleucine was in the range of 5.50–6.13%, valine 5.96–6.36% and threonine 6.27–6.81%.

Based on the evaluation of the influence of the attained live weight on the profile of amino acids in pig meat it is possible to state that in the case of valine, isoleucine, arginine, serine, proline and glycine in barrows and lysine, arginine and glutamic acid in gilts there was an indistinctive tendency of increases in the values in relation to the growing slaughter weight. On the contrary, the indirect dependence between the content of the amino acid and the slaughter weight was noticeable in valine in gilts.

In the course of the mathematical and statistical processing of the resulting data of amino acids, statistically significant differences in the averages of the groups were found only in proline.

As for the evaluation of the influence of sex a statistically significant difference was recorded only in lysine in the group with the live weight 115.1 kg and more.

In the groups of pigs with different live weight we also examined the values of water content, IMF, proteins and ash content (Table 5).

Water content

The values of water content in barrows/gilts were in the range of 72.01–72.73/ 72.05–73.09%. The highest values of water content were found in the group of gilts with the live weight of 115.1 kg

and more. It is evident from Table 5 that the gilts in all groups had higher water content than barrows. Ševčíková et al. (2002) reported an interval of 73.58% and 74.27% in the hybrid combination LW × L and NL × L with the average live weight of 114 kg. Correa et al. (2006) also presented water content in the interval of 73.60–74.00% in pigs divided according to live weight.

Fat

The IMF proportion in barrows ranged from 1.65 to 2.00%, in gilts it was in the range of 1.31–1.53%. The evaluation of the influence of slaughter weight on the content of IMF did not confirm the fact that with the growing weight the IMF proportion increases (Table 5). As for the influence of sex, the barrows in all groups showed higher values of IMF proportion than the gilts. Armero et al. (2002) and Oliver et al. (2003) documented the highest content of IMF – 2.89% in Duroc breed. Jandásek et al. (2004) found out even 3.34% IMF in the hybrid combination (LW_D × L) × D and 3.01% in the hybrid combination (LW_D × L) × LW_S. On the contrary, Mikule et al. (2001) reported the IMF content 0.71/0.85% in the breed LW/L. However, Naděje et al. (2000) presented 1.86% of IMF in barrows.

Crude proteins

The content of crude proteins (CP) was very well-balanced in the groups (23.18–23.64%), whereas the differences between the groups were not significant. In barrows the tendency of moderate growth of CP content was shown with the growing live weight. In gilts the inflexion point of CP content was reached already in the group of gilts with the live weight 105.1–115 kg. From Table 5 it is also evident that only in the group of barrows with live

weight over 115.1 kg the values of CP content were higher than in the gilts. In this regard Correa et al. (2006) obtained similar results of CP content, in the range of 23.30–23.80%, when the highest values were in the group of animals with the average live weight 115 kg. Ševčíková et al. (2002) also reported 23.11% and 22.71% of crude proteins.

Ash content

The values of ash content demonstrate that with the growing live weight the ash content also increases. The highest values (1.46%) were measured in the group of barrows with the live weight over 115 kg, the lowest (1.30%) in barrows with the live weight up to 105 kg. In the group of animals up to 105 kg and 105.1–115 kg of live weight the gilts had a higher proportion of ash content than the barrows, in the group 115.1 kg of live weight and more it was on the contrary. According to Wagner et al. (1999), the pedigree breeds of pigs reached the values of ash content 0.80–4.52%. Zullo et al. (2003) reported 4.8–5.3% of ash in company products of the genetic type Casertana and Casertana × Duroc.

Statistical evaluation of differences between the groups showed that the values of water content, IMF and ash content were highly significant ($P \leq 0.05$ and $P \leq 0.01$).

CONCLUSION

Based on the monitoring of amino acid contents it is possible to state that the selected amino acids showed only insignificant statistically evidential dependences, i.e. without expressive evolutionary tendencies. In the amino acid valine in gilts an indirect dependence between the amino acid content and live weight was determined. A statistically significant difference between sexes (group 115.1 kg and more) was recorded only in lysine.

As for the above-mentioned additional values it is possible to state that the highest/lowest values of water content were in the group 115.1 kg and more/105.1–115 kg of live weight.

In the values of IMF it was confirmed that with the growth of live weight the IMF content declined.

Only in barrows with the growth of live weight the content of crude proteins increased. In gilts the content of crude proteins reached the point

of inflexion already at the live weight of 105.1 to 115 kg.

With the growth of live weight the ash content also slightly increased.

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