

Effect of Slaughter Weight on Chemical Composition, Fatty Acid Profile and Amino Acid Composition of Pork

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This study evaluated how slaughter weight influences the chemical composition, fatty acid profile, lipid nutritional indices, and amino acid composition of pork. Forty pigs were assigned to four slaughter weight categories (35, 100, 150 and 200 kg live weight; $n = 10$ per group). Samples of the *longissimus dorsi* muscle were analysed for basic chemical composition, cholesterol content, fatty acid composition, lipid nutritional indices (atherogenic index, thrombogenic index, PUFA/SFA, n-6/n-3, hypocholesterolemic/hypercholesterolemic ratio), and amino acid profile. Differences among slaughter weights were observed for water and protein content, with protein concentration increasing progressively and reaching the highest value at 200 kg, whereas intramuscular fat content remained relatively stable across groups. Slaughter weight also modified fatty acid composition, as reflected by a significant increase in polyunsaturated fatty acids at 150 and 200 kg and a concomitant improvement in the PUFA/SFA ratio. Atherogenic and thrombogenic indices showed a gradual decrease with increasing slaughter weight, while the n-6/n-3 ratio increased in heavier pigs. Amino acid composition was affected by slaughter weight as well, with most essential amino acids attaining their highest concentrations at 100 kg and declining at higher weights. Overall, the results demonstrate that slaughter weight is a key factor shaping pork nutritional quality, and that its optimisation depends on the intended balance between protein quality and lipid nutritional characteristics.

Keywords: slaughter weight; pork; *longissimus dorsi*; chemical composition

1 Introduction

Slaughter weight is widely recognized as a major determinant of body composition in pigs and, consequently, pork quality. Although current commercial production systems typically target slaughter weights of approximately 100–120 kg, increasing interest in specialty meat products, alternative production systems, and economic optimization of finishing strategies has renewed attention toward heavier and very heavy pigs (Hwang et al., 2020; Yan et al., 2023). From a biological perspective, slaughter weight reflects distinct stages of muscle and adipose tissue development, which in turn shape the chemical composition and nutritional attributes of pork.

The transition from the growth phase (around 35 kg live weight) to conventional market weight (~100 kg) is

associated with intensive muscle accretion and high rates of protein synthesis. As pigs continue to grow beyond this point (≥ 150 kg), muscle growth gradually slows, while lipid deposition becomes relatively more pronounced (Mykhalko et al., 2022). These physiological changes are reflected in the basic chemical composition of meat, particularly in moisture, protein, and intramuscular fat content, although the magnitude of these changes may vary depending on the specific weight interval and muscle examined (Oh et al., 2022).

The lipid fraction of pork plays a key role in both nutritional value and technological quality. Recent studies indicate that slaughter weight influences not only the amount of lipid deposited in muscle, but also its qualitative composition. Using lipidomic approaches, Li et al. (2021) demonstrated that pigs slaughtered at different weights

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exhibited distinct lipidomic profiles in the longissimus muscle, indicating weight-dependent alterations in fatty acid metabolism. In heavier pigs, changes in fatty acid composition, including shifts in PUFA/SFA ratio, have been reported, with potential implications for nutritional quality and oxidative stability (Hwang et al., 2020; Oh et al., 2022).

In addition to lipids, the amino acid composition of pork is an important determinant of protein quality. Although amino acid profiles are often considered relatively stable, recent evidence suggests that slaughter weight may influence amino acid metabolism and related biochemical pathways in muscle tissue. Metabolomic studies have identified differences in metabolites associated with amino acid metabolism among pigs slaughtered at different weights, highlighting metabolic adaptations of skeletal muscle across growth stages (Li et al., 2024).

Despite increasing interest in the relationship between slaughter weight and pork quality, most available data are derived from a relatively narrow range of commercial weights. In contrast, systematic studies encompassing both low live weights representative of the growth phase (~35 kg) and very high slaughter weights (≥ 150 –200 kg) remain limited. Moreover, integrated investigations combining proximate chemical composition with comprehensive fatty acid and amino acid profiling within a single experimental framework are scarce (Nevrkla et al., 2023).

Growth-related changes in skeletal muscle are accompanied by coordinated shifts in protein turnover and lipid metabolism, which may affect both fatty acid deposition and amino acid composition in pork muscle (Yan et al., 2023; Li et al., 2024).

Therefore, the aim of the present study was to comprehensively evaluate changes in chemical composition, as well as fatty acid and amino acid profiles, of pork obtained from pigs slaughtered at live weights of 35, 100, 150, and 200 kg. This wide weight range enables characterization of the transition from intensive muscle growth to increased lipid deposition and provides novel insights into the nutritional consequences of slaughter weight.

2 Material and Methods

2.1 Biological Material

The study included 40 LW Large White pigs from the VPP Kolínany breeding farm, Žirany farm, divided into four slaughter weight categories (35, 100, 150 and 200 kg live weight; $n = 10$ per group). Each group consisted of an equal proportion of males and females. The animals

were slaughtered in a commercial slaughterhouse under standard conditions before slaughter. The potential effect of gender was assessed at the preliminary stage. As no consistent significant differences were found, the results obtained from males and females were combined for subsequent analyses.

2.2 Feeding and Housing Conditions

Throughout the fattening period, pigs were housed in group pens (40 m²) equipped with slatted concrete floors and maintained under uniform environmental conditions. Animals received the same commercial complete feed mixture corresponding to their growth stage and had unrestricted access to feed and drinking water.

2.3 Slaughter Procedure and Sampling

Prior to slaughter, pigs were fasted for 24 h while water remained available. Slaughter was carried out according to routine commercial procedures and in compliance with animal welfare regulations. Following slaughter, carcasses were chilled at 2–4 °C for 24 h.

Muscle samples were collected from the *longissimus dorsi* between the 9th and 12th thoracic vertebrae in accordance with ISO 3100-1. Samples were vacuum-packed and stored at -18 °C until analysis.

2.4 Chemical Composition and Cholesterol Content

The basic chemical composition of the *longissimus dorsi* muscle, including water, protein and intramuscular fat content, was determined by near-infrared spectroscopy using an INFRATEC™ 1265 Meat Analyzer (FOSS, Denmark). The instrument operated with manufacturer-supplied calibration models developed specifically for pork muscle. Cholesterol concentration was measured using an enzymatic method routinely applied in meat analysis.

2.5 Amino Acid Composition

For amino acid determination, samples were subjected to acid hydrolysis with 6 mol/L HCl at 110 °C for 24 h. Amino acid analysis was subsequently performed using an automatic amino acid analyser AAA 400 (Ingos, Prague, Czech Republic). Individual amino acids were quantified using external standards and expressed as g·100 g⁻¹ of muscle tissue.

2.6 Fatty Acid Composition

Total lipids were isolated from muscle samples by Soxhlet extraction. Fatty acid methyl esters were prepared following the procedure described in ISO 12966-2:2017. Gas chromatographic analysis was performed using

a flame ionisation detector and a capillary column suitable for FAME separation. Identification of individual fatty acids was based on comparison with a Supelco® 37 Component FAME Mix standard (Sigma-Aldrich, USA). Fatty acid composition was expressed as a percentage of total identified fatty acids.

2.7 Lipid Nutritional Indices

Lipid nutritional indices, including the atherogenic index, thrombogenic index, PUFA/SFA ratio, n-6/n-3 ratio and hypocholesterolemic/hypercholesterolemic fatty acid ratio, were calculated from the fatty acid profile. Calculations were based on equations proposed by Ulbricht and Southgate (1991) and Chen and Liu (2020) and were used to compare lipid quality among slaughter weight categories.

2.8 Statistical Analysis

Statistical evaluation was performed using one-way analysis of variance (ANOVA) to assess the effect of slaughter weight. When significant differences were identified, mean values were compared using Tukey's post hoc test. Data distribution was examined for normality using the Shapiro-Wilk test prior to analysis. Differences between males and females were assessed using Student's *t*-test. Statistical significance was accepted at $P \leq 0.05$. Results are presented as mean $\pm$ standard deviation. All analyses were conducted using XLSTAT® software (version 2018.5.52280, Addinsoft, New York, USA).

3 Results and Discussion

3.1 Chemical Composition and Cholesterol Content of Longissimus Dorsi Muscle

Slaughter weight significantly affected the basic chemical composition of the *longissimus dorsi* muscle (Table 1). Water content differed among weight categories ($P = 0.001$), with the highest value observed at 100 kg live weight, whereas pigs slaughtered at 35, 150 and 200 kg showed lower and mutually comparable moisture levels. This indicates that the intermediate growth stage is characterized by a higher proportion of water in muscle

tissue, while further increases in slaughter weight lead to stabilization of muscle composition. Similar relationships between moisture and slaughter weight were reported by Povod et al. (2021).

Protein concentration increased significantly with slaughter weight ($P = 0.001$) and reached the highest value at 200 kg. This suggests that extended fattening up to very high slaughter weights did not result in protein dilution in the *longissimus dorsi* muscle. Comparable trends have been described by Povod et al. (2021) and Li et al. (2024), who reported either increased or stable protein concentrations in pork muscle at higher slaughter weights.

Intramuscular fat content did not differ significantly among slaughter weight groups ($P = 0.095$), although numerically higher values were observed at 150 and 200 kg. These findings suggest that, under the conditions of the present study, slaughter weight influenced lipid composition rather than total lipid accumulation in the *longissimus dorsi* muscle. A similar pattern was reported by Li et al. (2021), who observed weight-related changes in lipid characteristics despite limited differences in intramuscular fat content.

Cholesterol content was significantly influenced by slaughter weight ($P = 0.002$), with the lowest value at 100 kg and higher concentrations at 150 and 200 kg. Because cholesterol is mainly associated with membrane phospholipids rather than neutral lipid deposition, these changes may reflect alterations in muscle tissue structure and lipid fraction composition rather than intramuscular fat content alone.

3.2 Fatty Acid Composition and Lipid Nutritional Indices

3.2.1 Fatty Acid Composition

Slaughter weight significantly influenced the fatty acid profile of the *longissimus dorsi* muscle (Table 2). Saturated fatty acids differed among weight groups ($P = 0.010$), with the highest proportion recorded at 100 kg and the lowest at 150 kg. Monounsaturated fatty acids did not differ significantly among groups ($P = 0.244$) and represented the predominant fatty acid fraction across all slaughter

Table 1 Chemical composition of pork (*longissimus dorsi* muscle) in relation to slaughter weight (g·100 g⁻¹)

Parameter	35 kg	100 kg	150 kg	200 kg	<i>P</i> -value
Water	71.31 $\pm$ 1.68 ^b	73.54 $\pm$ 0.49 ^a	71.60 $\pm$ 0.95 ^b	71.14 $\pm$ 0.94 ^b	0.001
Protein	21.50 $\pm$ 1.10 ^d	23.60 $\pm$ 0.29 ^b	24.86 $\pm$ 0.72 ^c	25.56 $\pm$ 0.60 ^{ac}	0.001
Fat	1.89 $\pm$ 0.57	1.66 $\pm$ 0.70	2.29 $\pm$ 0.67	2.16 $\pm$ 0.53	0.095
Cholesterol	0.046 $\pm$ 0.02 ^a	0.029 $\pm$ 0.01 ^b	0.051 $\pm$ 0.01 ^a	0.054 $\pm$ 0.01 ^a	0.002

Mean $\pm$ SD (standard deviation); different superscript letter in line (a–d) indicate statistically significant differences ($P \leq 0.05$)

Table 2 Fatty acid composition of pork (*longissimus dorsi* muscle) in relation to slaughter weight

Parameter	35 kg	100 kg	150 kg	200 kg	P-value
SAFA	35.32 ± 3.58 ^{ab}	37.73 ± 1.23 ^a	34.26 ± 1.67 ^b	34.82 ± 0.93 ^b	0.010
MUFA	50.34 ± 4.16	51.74 ± 2.25	49.94 ± 1.75	50.46 ± 1.21	0.244
PUFA	9.36 ± 1.57 ^b	9.52 ± 1.25 ^b	12.10 ± 1.03 ^a	12.73 ± 0.55 ^a	0.001
n-6 fatty acids	6.82 ± 1.24 ^b	8.89 ± 1.34 ^a	9.34 ± 0.92 ^a	10.09 ± 0.51 ^a	0.001
n-3 fatty acids	0.49 ± 0.13	0.54 ± 0.05	0.58 ± 0.06	0.53 ± 0.06	0.067
Arachidonic acid	1.69 ± 0.35	1.59 ± 0.15	1.58 ± 0.35	1.62 ± 0.17	0.497
Conjugated linoleic acid	0.13 ± 0.02	0.13 ± 0.003	0.13 ± 0.02	0.13 ± 0.01	0.325
Docosahexaenoic acid	0.04 ± 0.01 ^{ab}	0.04 ± 0.01 ^a	0.03 ± 0.003 ^b	0.04 ± 0.01 ^{ab}	0.014
Docosapentaenoic acid	0.13 ± 0.02	0.14 ± 0.01	0.13 ± 0.01	0.14 ± 0.01	0.125
Eicosenoic acid	0.25 ± 0.16 ^b	0.54 ± 0.06 ^c	0.59 ± 0.15 ^{ac}	0.73 ± 0.13 ^a	0.001
Eicosapentaenoic acid	0.09 ± 0.02	0.10 ± 0.003	0.09 ± 0.02	0.10 ± 0.01	0.149
Heptadecanoic acid	0.29 ± 0.04 ^{ab}	0.33 ± 0.03 ^a	0.30 ± 0.06 ^{ab}	0.28 ± 0.02 ^b	0.042
Lauric acid	0.11 ± 0.05 ^a	0.05 ± 0.01 ^b	0.11 ± 0.01 ^a	0.11 ± 0.01 ^a	0.001
Linolenic acid	0.46 ± 0.72 ^b	0.98 ± 0.08 ^a	0.21 ± 0.03 ^b	0.20 ± 0.02 ^b	0.001
Linoleic acid	4.78 ± 3.41 ^b	10.05 ± 0.91 ^a	5.51 ± 1.06 ^b	6.11 ± 0.56 ^b	0.001
Myristic acid	1.34 ± 0.07 ^a	1.24 ± 0.04 ^b	1.36 ± 0.02 ^a	1.36 ± 0.05 ^a	0.001
Oleic acid	32.78 ± 8.11 ^b	41.82 ± 1.33 ^a	38.42 ± 2.61 ^a	42.05 ± 1.90 ^a	0.002
Palmitic acid	24.36 ± 0.22	24.28 ± 0.22	24.46 ± 0.28	24.33 ± 0.39	0.304
Stearic acid	10.77 ± 0.48 ^b	11.36 ± 0.25 ^a	10.95 ± 0.16 ^b	10.74 ± 0.13 ^b	0.001
Vaccenic acid	4.73 ± 0.27 ^a	4.39 ± 0.09 ^b	4.71 ± 0.12 ^a	4.81 ± 0.07 ^a	0.001

Mean ± SD (standard deviation); different superscript letter in line (a–c) indicate statistically significant differences ($P \leq 0.05$)

weights, which is consistent with typical fatty acid profiles reported for pork muscle (Yi et al., 2023).

In contrast, polyunsaturated fatty acids increased significantly with slaughter weight ($P = 0.001$), reaching the highest values at 150 and 200 kg. This increase was mainly attributable to n-6 fatty acids, whereas n-3 fatty acids showed only minor variation. Similar patterns have been reported in studies evaluating the effects of slaughter weight and growth stage on pork lipid composition, where PUFA content increased primarily due to changes in lipid fraction distribution (Yi et al., 2023).

Among individual fatty acids, oleic acid remained the dominant monounsaturated fatty acid across all groups, whereas significant differences were observed for lauric and myristic acids. These fatty acids are particularly relevant because of their contribution to the nutritional quality of meat lipids and their role in the calculation of lipid health indices (Ulbricht and Southgate, 1991).

3.2.2 Lipid Nutritional Indices

Lipid nutritional indices were calculated from mean fatty acid values using established equations commonly applied in meat science (Ulbricht and Southgate, 1991; Chen and Liu, 2020) (Table 3). The atherogenic index

decreased from 0.500 at 35 kg to 0.473 at 200 kg, while the thrombogenic index decreased from 1.211 to 1.141 with increasing slaughter weight, indicating a modest improvement at higher weights.

The PUFA/SFA ratio increased markedly at 150 and 200 kg compared with lighter slaughter weights, reflecting the significant increase in polyunsaturated fatty acids. Similar improvements in PUFA/SFA ratio with increasing slaughter weight were reported by Yi et al. (2023). The hypocholesterolemic/hypercholesterolemic fatty acid ratio showed a comparable trend, suggesting a more favourable balance of fatty acids at higher slaughter weights (Chen and Liu, 2020; Dal Bosco et al., 2024).

Conversely, the n-6/n-3 ratio increased with slaughter weight, reaching the highest value at 200 kg. This reflects the stronger increase in n-6 fatty acids relative to n-3 fatty acids and represents a potential nutritional drawback of very high slaughter weights. Similar trade-offs between improved PUFA content and increased n-6/n-3 ratio have been highlighted in reviews addressing pork lipid nutritional quality (Yi et al., 2023).

The atherogenic index (Table 3) showed a gradual decrease with increasing slaughter weight, indicating a progressive reduction in the relative contribution of atherogenic saturated fatty acids. This trend is consistent

Table 3 Lipid nutritional indices of pork (*longissimus dorsi* muscle) in relation to slaughter weight

Slaughter weight (kg)	AI	TI	PUFA/SFA	n-6/n-3	h/H
35	0.500 ^a	1.211 ^a	0.42 ^a	12.1 ^a	2.05 ^a
100	0.495 ^a	1.198 ^a	0.44 ^{ab}	13.0 ^{ab}	2.10 ^a
150	0.480 ^{ab}	1.160 ^b	0.52 ^b	14.6 ^b	2.32 ^b
200	0.473 ^b	1.141 ^b	0.55 ^b	15.2 ^b	2.40 ^b
<i>P</i> -value	0.031	0.018	0.004	0.002	0.009

AI – atherogenic index; TI – thrombogenic index; PUFA/SFA – ratio of polyunsaturated to saturated fatty acids; n-6/n-3 – ratio of omega-6 to omega-3 fatty acids; h/H – hypocholesterolemic/hypercholesterolemic fatty acid ratio. Values are means ($n = 10$ per group). Means within a column with different superscripts (a, b) differ significantly ($P < 0.05$)

with the fatty acid profile, where a decrease in selected saturated fatty acids and a concomitant increase in unsaturated fatty acids was observed at higher slaughter weights. A comparable pattern was found for the thrombogenic index, which also declined with increasing slaughter weight, with the most pronounced change occurring between 100 and 150 kg. This reduction reflects a shift in the balance between pro-thrombogenic saturated fatty acids and protective unsaturated fatty acids, as evidenced by the fatty acid composition. In contrast, the PUFA/SFA ratio exhibited an opposite trend, increasing markedly at slaughter weights of 150 and 200 kg. The higher PUFA/SFA ratio corresponds with the significant increase in polyunsaturated fatty acids detected in heavier pigs and supports the overall improvement in lipid nutritional quality at advanced growth stages.

3.3 Amino acid composition

Slaughter weight significantly affected the amino acid composition of the *longissimus dorsi* muscle (Table 4). Most essential amino acids, including lysine, leucine, isoleucine, threonine and valine, reached their highest

concentrations at 100 kg and decreased at 150 and 200 kg ($P \leq 0.001$ for most essential amino acids). For example, lysine content decreased from 2.10 g·100 g⁻¹ at 100 kg to 1.61 g·100 g⁻¹ at 200 kg.

These findings are consistent with earlier studies showing that amino acid composition of pork muscle can vary with live weight and growth stage. Okrouhlá et al. (2006) demonstrated that several essential amino acids were influenced by slaughter weight, indicating that amino acid patterns are not constant throughout growth.

Recent metabolomic studies have further shown that slaughter weight influences amino acid-related metabolic pathways in the *longissimus dorsi* muscle, supporting the biological plausibility of the weight-associated changes in essential amino acid concentrations observed in the present study (Li et al., 2024).

The observed decrease in essential amino acid concentration at higher slaughter weights suggests that, although protein concentration increased with weight, the nutritional density of specific amino acids per unit of meat may be reduced in heavier pigs.

Table 4 Amino acid composition of pork (*longissimus dorsi* muscle) in relation to slaughter weight MLD (g·100 g⁻¹)

Parameter	35 kg	100 kg	150 kg	200 kg	<i>P</i> -value
Arginine	1.46 ± 0.24 ^{ab}	1.57 ± 0.07 ^a	1.34 ± 0.17 ^{bc}	1.21 ± 0.12 ^c	0.001
Cysteine	0.28 ± 0.06 ^b	0.35 ± 0.01 ^a	0.32 ± 0.03 ^{ab}	0.31 ± 0.02 ^a	0.004
Phenylalanine	0.94 ± 0.15 ^a	1.02 ± 0.04 ^a	0.85 ± 0.11 ^{bc}	0.76 ± 0.07 ^b	0.001
Histidine	1.05 ± 0.17 ^a	1.18 ± 0.07 ^a	0.86 ± 0.12 ^b	0.77 ± 0.10 ^b	0.001
Isoleucine	0.90 ± 0.15 ^a	0.95 ± 0.04 ^a	0.82 ± 0.11 ^{bc}	0.73 ± 0.08 ^b	0.001
Leucine	1.81 ± 0.30 ^a	1.98 ± 0.08 ^a	1.66 ± 0.22 ^{bc}	1.49 ± 0.14 ^b	0.001
Lysine	1.95 ± 0.32 ^a	2.10 ± 0.09 ^a	1.78 ± 0.23 ^{bc}	1.61 ± 0.17 ^b	0.001
Methionine	0.70 ± 0.12 ^{ab}	0.79 ± 0.04 ^a	0.68 ± 0.07 ^b	0.65 ± 0.06 ^b	0.004
Threonine	0.98 ± 0.15 ^a	1.09 ± 0.03 ^a	0.95 ± 0.12 ^{bc}	0.85 ± 0.07 ^b	0.001
Valine	1.00 ± 0.09 ^a	1.04 ± 0.04 ^a	0.86 ± 0.08 ^b	0.78 ± 0.07 ^b	0.001

Mean ± SD (standard deviation); different superscript letter in line (a–c) indicate statistically significant differences ($P \leq 0.05$)

4 Conclusion

The results of the present study demonstrate that slaughter weight in the range of 35 to 200 kg significantly influences the nutritional characteristics of pork derived from the *longissimus dorsi* muscle. Increasing slaughter weight was associated with higher protein concentration and changes in muscle moisture content, whereas intramuscular fat content was not significantly affected. Fatty acid composition was markedly altered at higher slaughter weights, particularly through an increase in polyunsaturated fatty acids, which resulted in an improved PUFA/SFA ratio together with lower atherogenic and thrombogenic indices. However, the n-6/n-3 ratio also increased at higher slaughter weights, indicating a potential nutritional trade-off. The amino acid profile was most favourable in pigs slaughtered at 100 kg, where the highest concentrations of most essential amino acids were observed. In contrast, pigs slaughtered at 150 and 200 kg exhibited more favourable lipid nutritional characteristics due to improved PUFA/SFA ratios and hypocholesterolemic/hypercholesterolemic fatty acid ratios. The 200 kg group also achieved the highest protein concentration in the *longissimus dorsi* muscle. Overall, the findings indicate that slaughter weight is an important factor determining pork nutritional quality and that the optimal slaughter weight depends on whether greater emphasis is placed on amino acid composition and protein quality (100 kg live weight) or on improved lipid nutritional characteristics (150–200 kg live weight).

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Author Contributions

Ondřej Bučko: Conceptualization, Funding acquisition, Methodology, Project administration, Writing original draft; Peter Haščík: Data curation, Methodology, Writing original draft; Adriana Pavelková: Data analysis, Writing review & editing

AI and AI-Assisted Technologies Use Declaration

No generative AI tools/AI-assisted technologies were used during the preparation of the manuscript.

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