Research Article

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Effect of pre-slaughter weight on morphological composition of pig carcasses

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Abstract: To achieve the goals of our study, we investigated the relationship between morphological composition of pig carcasses and their pre-slaughter weight. In this research, 60 pigs were reared for fattening under the identical conditions of keeping and feeding, then slaughtered and sampled with pre-slaughter weight 110 and 120 kg. The content of meat, fat, and bones and their ratio in carcasses were evaluated. The probable influence of the factor of pre-slaughter weight on the share of meat in certain parts of the carcass is established 61.96% for the cervical-scapular third, 62.21% for the lumbosacral third, and 96.57% for the pelvic-femoral thirds. It has been found that in pigs at slaughter weight 120 kg for each additional increase in fat content by 1.0 kg, the meat content was proportionally insufficient by 0.43 kg in the cervical-scapular third and by 0.39 kg in the pelvic-femoral third of the carcass. In peers weighing 110 kg, each additional 1 kg of fat did not allow to gain 0.72 kg of meat in the cervical-scapular third of the carcass. The study shows that pigs fattening up to 110 kg of its carcass is more sensitive (44.99%) to changes in meat–fat ratios in the cervical-scapular third, which allows more targeted formation of the characteristics of semi-finished products of this part at this stage. Slaughter weight management can improve the quality of pork.

Keywords: slaughter yield, meat content, fat content, bone content, pig carcasses

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1 Introduction

Meat is one of the most important human protein foods. The universality and uniqueness of pig muscle tissue include high energy consumption, balanced amino acid composition of proteins, and biologically active substances. Together, it ensures a normal physiological state and absorption of nutrients by the human body. Meat contains all the substances necessary for human nutrition [1].

Nowadays, due to growing demand for pork, the research studies are particularly directed on increase in production of pork by industrial high-intensive technologies [2–4]. At the same time, pig farming is dominated by a tendency to increase the production of lean pork with increasing pre-slaughter weight of pigs [5–8]. However, as the pre-slaughter weight of pigs in their carcasses often increases, so does the meat and bone content and the amount of fat [9]. With increasing fattening time, there is a decrease in the proportion of muscle tissue, increase in connective tissue, and deterioration of the ratio of intramuscular fat. Some studies reported an increase in the percentage of lean meat in those studies that used a higher starting body weight than other studies [10].

A similar statement [11] indicates that when the carcass weight of pigs increased, the bone content in the carcass relatively decreased, and the fat content increased. There was no clear trend in this study regarding the dependence of meat content on pre-slaughter weight. The

published article indicates that during the growth of carcass weight and weight of all its anatomical components there was a deterioration in the ratio of muscle, bone and fat in the morphological structure of the carcass [12].

Previous studies [13] have shown a tendency to a gradual proportional increase in the weight of all parts of pig carcasses in parallel with the increase in pre-slaughter weight of animals. These studies [13] also showed that all other semi-finished products with increasing pre-slaughter weight of animals also increased in weight, and the composition of pig carcasses depends more on pre-slaughter weight than on other factors. Other publications have reported that the slaughter of pigs with a pre-slaughter weight of 120 kg showed a significant reduction in the meat content of their carcasses compared with carcasses of pigs slaughtered weighing 100 and 110 kg [14]. Our recent studies have shown a significant dependence of carcass quality, meat, adipose tissue, and bone content on pig pre-slaughter weight [15].

The report demonstrates [16] slight differences in the effect of pigs sex, no genotype influence, and a significant effect of pre-slaughter weight on the morphological composition of pig carcasses and noted that the absolute yield of boneless meat increased, whereas its percentage decreased with increasing carcass weight. up to 160 kg. Backfat depth, carcass length, ham, and shoulder weights increased ($p < 0.001$) as pre-slaughter weight increased from 116 to 133 kg [17].

The pig sex did not have a significant effect on the morphological composition of the carcass, and the increase in pre-slaughter weight increased the fat content and decreased the content of bones and meat [18].

However, a study [19] comparing the effect of the breed and the level of feeding at the same pre-slaughter weight showed that the meat content of the carcass depends more on the breed.

Some researchers [20] found that the slaughter of overweight pigs resulted in a decrease in the proportion of skin, whereas the proportion of muscle, fat, and bone tissue remained relatively constant.

According to studies [21], it was found that to increase the meat content piglets should not be allowed to overfeed for fattening, as this reduces the slaughter yield and increases the thickness of the lard. Contrary to her findings, other researchers [22] did not establish a statistical relationship between meat and pre-slaughter weight of pigs in 100, 115, 130, and 145 kg, but found that its growth increased slaughter yield, but decreased feed digestion rate, resulting in increase in the cost of production.

Another study [23] concluded that pigs do not reach the weight threshold when they become constantly fatter or more muscular, due to a weak or negative correlation between fat depth and predicted muscle tissue yield, as well as between muscle depth and the predicted yield of muscle mass. Known publications [24] pointed out the lack of significant effect of pre-slaughter weight on the fat content in the carcass.

A more in-depth study of the effect of pre-slaughter weight on the morphological composition of pig carcasses is an urgent problem of the general vector of research to improve the efficiency of pork production, especially in modern conditions of widespread use of different pig genotypes at industrial farms.

The purpose of this study is to research the degree of influence of pre-slaughter weight of fattening young animals on fluctuations in the morphological composition of pig carcasses.

2 Materials and methods

2.1 Experimental site

To achieve the goal of this research, we conducted an experiment to study the relationship between the morphological composition of pig carcasses and their pre-slaughter weight on the basis of the fattening farm of Globinsky Pig Complex LLC, Poltava region, Ukraine.

2.2 Experimental establishment

2.2.1 Animals

Pigs obtained from hybrid sows (F_1) from a cross between Irish Ladras and Yorkshire, which were inseminated with boar semen from the Max Gro synthetic terminal line, were taken. A group of 300 pigs with an equal number of gilts and barrows was formed from the selected animals and put to fattening at the age of 70 days.

Ethical approval: We used adequate methods and everything possible during the experiment to reduce pain or suffering in the experimental pigs. Research was conducted in compliance with the European animal ethics' recommendations [27]. All used experimental methods were agreed by the Sumy National Agrarian University Bioethics Commission "For animal care and use in scientific (Experimental) research" (No BT-21-1027-01). Animals were treated during the experiment in accordance with the

requirements of the Ukraine's Law No 3447- IV, 2006, on protecting animals from brutal treatment [28].

2.2.2 Rearing conditions and feeding

During the fattening period, the population of 60 pigs were raised in identical conditions in group pens of 40 m^2 each, on a completely slotted concrete floor with a liquid type of feeding with complete rations. During fattening, pigs used liquid-type feed of two recipes (Table 1). Pigs weighing 110 kg were kept in the amount of 60 heads per pen. From this number, 30 animals were selected for slaughter. In the group with a slaughter weight of 110 kg, there were 30 pigs, of which 15 were gilts and 15 were barrows. Pigs weighing 120 kg were kept in the amount of 60 heads per pen. From this number, 30 animals were selected for slaughter. There were 30 pigs in the group with a slaughter weight of 120 kg, of which 15 were gilts and 15 were barrows.

2.2.3 Sampling

When the animals reached an average weight of 110 and 120 kg, they were weighed individually. According to the results of this weighing, 60 heads were selected for control slaughter with a weight of 110 and 120 kg. All procedures followed [25] the protection of animals used in research and other scientific endeavors. After 24 h of fasting, the control slaughter was carried out according to the generally accepted method in the slaughterhouse of the Globinsky Meat Factory LLC, Poltava region, Ukraine. During slaughter, the carcass was divided into three parts according to the appropriate anatomical scheme:

(1) Cervical-scapular third of the carcass – incision from the first cervical vertebra to a straight line between the fifth and sixth thoracic vertebrae, crossing the ribs behind the scapula;
(2) Dorsal-lumbar third of the carcass – incision from the line of separation of the anterior part to the straight line passing between the last and penultimate lumbar vertebrae directly in front of the pelvis;
(3) Pelvic-femoral third of the carcass – incision along the line of separation of the middle part to the line of separation of the shin. The weight of each part of the carcass was determined by weighing, and after their deboning, the mass of morphological components: meat, fat, and bones; their percentage and ratio were calculated.

After slaughter, the carcasses were cooled for 24 h at a temperature of 2.0–4.0°C. When deboning the carcasses, the morphological composition of carcasses, yield of meat, lard, bones, and their ratio to each other and to the weight of the carcass were determined in accordance with international standard [26].

Table 1: Nutritional value of feed for the first and second stages of fattening

Indicator	The first period of fattening: 30–60 kg	The second period of fattening: 60–130 kg
Assimilable energy (MJ/kg)	14	13.5
Protein (%)	18	17
Lysine (%)	1.15	1
Oil (%)	2.95	2.7
Fiber (%)	4.0	4.5
Calcium (%)	0.68	0.65
Assimilable phosphorus (%)	0.33	0.3
Total phosphorus (%)	0.58	0.55
Vitamin A (IU/kg)	10,000	10,000
Vitamin D (IU/kg)	2,000	2,000
Vitamin E (IU/kg)	100	100
Biotin (μg/kg)	100	100
The ratio of water to feed	2.8:1	3:1

2.3 Statistical analysis

The obtained results were analyzed statistically (Excel 2010) on the grounds of generally accepted statistical methods with single-factor variance analysis. When using the method of one-factor analysis of variance, we took into account the influence of the slaughter weight factor. Factors that did not fall within the scope of our research were considered not taken into account in accordance with the calculation methodology. These are microclimatic indicators in the room, seasonal factors, age of animals, method of castration, sex, technological features of feeding equipment, method of feeding, parameters of holding machines, method of manure removal and others. The dissemblance significance ($p \leq 0.05$, $p \leq 0.01$) between the indicators of morphological composition of carcasses ($n = 60$) was analyzed by Student's t-test. In addition, a linear least squares mathematical model was used to estimate the correlation between the actual features and the dependent parameters of the carcass.

3 Results

The results of the study (Table 2) suggest that the meat content in the cervical-scapular third of the carcass was 2.20 kg or 11.61% ($p < 0.001$) higher in pigs with a pre-slaughter weight of 120 kg compared with analogues slaughtered for a weight of 110 kg. No significant difference in the content of fat and bones in the carcasses of animals of the experimental groups was found.

Animals weighing 120 kg also outperformed their analogues with 110 kg carcass weight in the proportion of meat in the cervical-scapular third of the carcass by 1.10% ($p < 0.001$). No probable divergence was obtained in the proportion of fat and bones between animals of the groups.

The composition of the dorsal-lumbar third of the carcasses (Table 3) was marked by significantly higher values of meat, fat, and bones in animals slaughtered at a pre-slaughter weight of 120 kg than their counterparts at a slaughter weight of 110 kg by 2.9 kg or 17.37% ($p < 0.001$), 0.5 kg or 13.16% ($p < 0.05$), and 0.3 kg or 7.32% ($p < 0.01$), respectively.

The livestock of the control group I, which was sent for slaughter at 110 kg, was probably inferior to the analogues of the experimental group II in terms of the share of meat by 1.5% ($p < 0.001$) in the dorsal-lumbar third of the carcass. At the same time, statistically significant differences between animals of both groups were not found in terms of the proportion of fat and the proportion of bones in this third of carcasses.

Pigs fattened to a weight of 120 kg had a higher meat content by 1.5 kg or 8.02% ($p < 0.001$) and a higher bone content by 0.40 kg or 14.81% ($p < 0.001$) in the pelvic-femoral third of the carcass compared to analogues fattened to a weight of 110 kg. According to the indicator of fat content in the carcasses of animals of the control and experimental groups, there was no significant difference (Table 4).

A study of the ratio of fat to bone in the pelvic-femoral third of the carcasses did not reveal a significant difference between the carcasses of animals with different pre-slaughter weight in terms of meat and bones. However, the proportion of fat was probably higher by 0.5 kg or 7.81% ($p < 0.05$) in this third of the carcasses of pigs slaughtered at 120 kg relative to the other pigs slaughtered at 110 kg.

The performed one-factor analysis of variance revealed a significant influence of factors on the morphological composition of the thirds of pig carcasses (Figure 1). The influence of pre-slaughter weight factor on the share of meat, fat, and bones in the cervical-scapular third of carcasses was set at: 61.96% on the share of meat in carcasses, 96.32% on the share of fat in carcasses, and 94.29% on the proportion of

Table 3: Distribution of morphological composition of the dorsal-lumbar third of the carcass of pigs of the experimental groups ($n = 60$)

Indicators	Group I (110 kg)	Group II (120 kg)	*p*-value
Meat content (kg)	16.7 ± 0.23	19.6 ± 0.50	***
Fat content (kg)	3.8 ± 0.14	4.3 ± 0.19	*
Bone content (kg)	4.1 ± 0.08	4.4 ± 0.10	**
Proportion of meat in carcass (%)	21.1 ± 0.26	22.6 ± 0.39	***
The proportion of fat in carcass (%)	4.8 ± 0.16	5.1 ± 0.27	NS
The proportion of bones in carcass (%)	5.1 ± 0.11	5.1 ± 0.13	NS

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$, NS – not significant.

Table 2: Distribution of morphological composition of the cervical-scapular third of the carcass of pigs of the experimental groups ($n = 60$)

Indicators	Group I (110 kg)	Group II (120 kg)	*p*-value
Meat content (kg)	13.7 ± 0.22	15.9 ± 0.24	***
Fat content (kg)	7.3 ± 0.22	7.7 ± 0.27	NS
Bone content (kg)	3.8 ± 0.06	3.9 ± 0.08	NS
Proportion of meat in carcass (%)	17.3 ± 0.26	18.4 ± 0.20	***
The proportion of fat in carcass (%)	9.1 ± 0.27	8.9 ± 0.29	NS
The proportion of bones in carcass (%)	4.7 ± 0.08	4.6 ± 0.11	NS

***$p < 0.001$, NS – not significant.

Table 4: Distribution of morphological composition in the pelvic-femoral third of the carcass of pigs of the experimental groups ($n = 60$)

Indicators	Group I (110 kg)	Group II (120 kg)	*p*-value
Meat content (kg)	18.7 ± 0.20	20.2 ± 0.42	***
Fat content (kg)	5.1 ± 0.12	5.2 ± 0.19	NS
Bone content (kg)	2.7 ± 0.04	3.1 ± 0.08	***
Proportion of meat in carcass (%)	23.6 ± 0.21	23.2 ± 0.38	NS
The proportion of fat in carcass (%)	6.4 ± 0.14	6.9 ± 0.18	*
The proportion of bones in carcass (%)	3.4 ± 0.05	3.5 ± 0.11	NS

*$p < 0.05$, ***$p < 0.001$, NS – not significant.

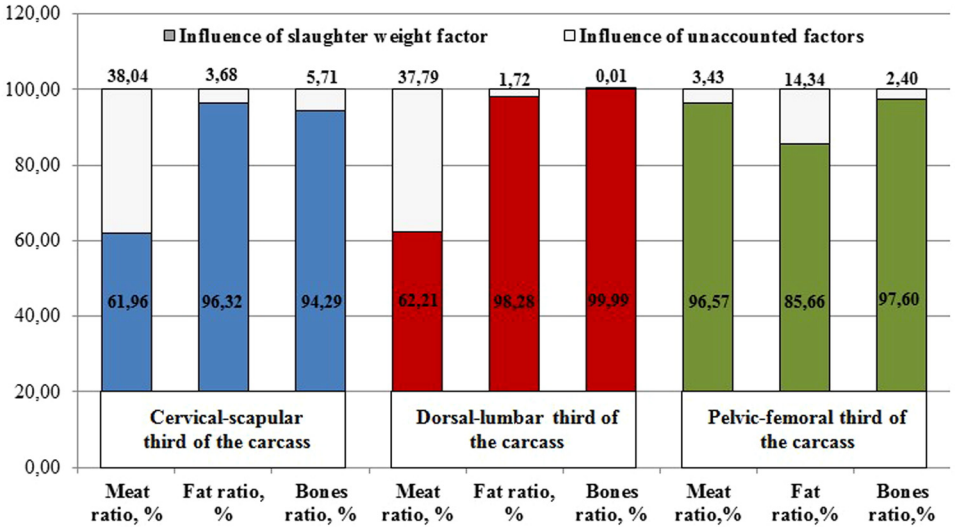


Figure 1: The strength of the influence of slaughter weight factor on the morphological composition of pig carcasses (source is own calculations).

bones in carcasses. The probable influence of unaccounted factors on the proportion of meat in the carcass was also found to be 38.04%, whereas the other proportions of fat and bones were not significantly affected by these factors.

The probable influence of carcass weight on the change of indicators of the dorsal-lumbar third of the carcasses is established. The share of meat in the dorsal-lumbar part of the carcass probably depended on both the pre-slaughter weight by 62.21% and unaccounted for factors by 37.79%. Although the share of fat and bones in the carcass was not affected by unaccounted factors, the carcass weight affected these indicators with a strength of 98.28 and 99.99%, respectively.

The study found a significant effect of weight categories on the shares of meat, fat, and bones at 96.57, 85.66, and 97.60%, respectively, in the pelvic-femoral third of the carcass. At the same time, the proportion of fat in this third of the carcass in parallel had a probable effect and unaccounted for factors at the level of 14.34%.

The study found that pigs slaughtered at a weight 120 kg had a higher meat content in the carcass by 6.6 kg or 13.44% ($p < 0.001$) compared to analogues slaughtered at a weight of 110 kg. But according to the indicators of the amount of fat and bones in their carcasses, no difference was found (Table 5).

The share of meat in pig carcasses was higher in the carcasses of the experimental animals compared with control analogues by 2.3 kg or 3.72% ($p < 0.01$). At the same time, in the carcasses of pigs slaughtered weighing 120 and 110 kg, there was no significant difference in the proportion of fat and the proportion of bones in them.

The study of the ratio of morphological components of pig carcasses showed in animals at pre-slaughter weight of 110 kg: higher meat yield per 1 kg of lard, higher bone yield per 1 kg of meat, and higher bone yield per 1 kg of lard (Table 6) compared with the carcasses of animals slaughtered at 120 kg.

Table 5: Body composition of pig carcasses of experimental groups ($n = 60$)

Indicators	Group I (110 kg)	Group II (120 kg)	*p*-value
Meat content (kg)	49.1 ± 0.41	55.7 ± 1.01	***
Fat content (kg)	16.3 ± 0.38	17.3 ± 0.61	NS
Bone content (kg)	10.5 ± 0.16	11.0 ± 0.43	NS
Proportion of meat in carcass (%)	61.9 ± 0.36	64.2 ± 0.68	**
The proportion of fat in carcass (%)	21.0 ± 0.44	21.9 ± 0.68	NS
The proportion of bones in carcass (%)	13.3 ± 0.23	12.9 ± 0.44	NS

**$p < 0.01$, ***$p < 0.001$, NS – not significant.

Table 6: The ratio of morphological components of pig carcasses (kg) ($n = 60$)

Indicators	Group I (110 kg)	Group II (120 kg)
Meat/1 kg of fat	0.33:1	0.31:1
Meat/1 kg of bones	4.67:1	4.79:1
Fat/1 kg of meat	3.01:1	3.21:1
Fat/1 kg of bones	1.55:1	1.57:1
Bones/1 kg of meat	0.21:1	0.19:1
Bones/1 kg of fat	0.64:1	0.63:1

At the same time, animals at a pre-slaughter weight of 120 kg predominated in the ratio: meat per 1 kg of bones, fat per 1 kg of meat, and fat per 1 kg of bones in the carcasses of analogues slaughtered at a weight 110 kg.

We established the nature of the relationship between meat and fat content in the cervical-scapular third of the carcass of pigs slaughtered at a weight of 120 kg using the statistical method of constructing a two-dimensional linear mathematical least squares model (Table 7). As a result, the pairwise correlation coefficient showed a moderate ($0.3 < r_{xy120} < 0.5$), inverse ($r_{xy120} < 0$) and statistically significant ($F_{120} > F_{crit120}$) relationship between meat and fat content in the cervical-scapular third of the carcass of pigs slaughtered at a weight of 120 kg. This indicates that as the content of meat increases in the cervical-scapular third of the carcass, the fat content in it moderately decreases.

At the same time, the relationship between the meat content and the fat content of the cervical-scapular third of the carcass of animals slaughtered at a weight of 110 kg was high ($0.7 < r_{xy110} < 0.9$), inverse ($r_{xy110} < 0$), and statistically significant ($F_{110} > F_{crit110}$). The strong feedback between indicators shows that when the average live weight of 110 kg is reached, gaining weight because of the increase in the fat content in the carcass reduces the potential meat component more intensively and *vice versa*.

The analysis suggests a potentially weak ($0.1 < r_{xy120} < 0.3$) and statistically insignificant ($F_{120} < F_{crit120}$) correlation between muscle tissue content and fat content in the dorsal-lumbar third of pig carcasses slaughtered at 120 kg. The closeness of the linear relationship between these indicators of the dorsal-lumbar third of the carcass for animals with pre-slaughter weight 110 kg was moderate ($0.3 < r_{xy120} < 0.5$), but also did not gain statistical significance ($F_{110} < F_{crit110}$).

The study found a reliable ($F_{120} > F_{crit120}$), high ($0.7 < r_{xy120} < 0.9$), inverse ($r_{xy120} < 0$) relationship between indicators of meat and fat content in the pelvic-femoral third in the carcass of pigs slaughtered at a weight 120 kg. The structure of the pelvic-femoral third of the carcass of the 120 kg weight category of animals is more sensitive to the factors that stimulate the intensive growth of salinity, and also, the manifestation of this direction of carcass development is characterized by a high simultaneous decrease in its meat content. At the same time, the relationship between meat content and fat content in the pelvic-femoral third of the carcass of animals slaughtered at 110 kg was weak ($0.1 < r_{xy110} < 0.3$), inverse ($r_{xy110} < 0$), and not statistically significant ($F_{110} < F_{crit110}$).

Table 7: Statistical data of a two-dimensional linear mathematical model by the method of least squares

Indicators	Cervical-scapular third of the carcass		Dorsal-lumbar third of the carcass		Pelvic-femoral third of the carcass	
	Group I (110 kg)	Group II (120 kg)	Group I (110 kg)	Group II (120 kg)	Group I (110 kg)	Group II (120 kg)
F critical	0.3145	0.3145	3.1788	3.1788	3.1788	3.1788
F	0.9356	0.4709	2.5193	1.9966	2.1671	7.0841
Pairwise correlation coefficient, $r_{x,y}$	−0.7031	−0.2949	−0.3726	−0.1186	−0.1031	−0.6853
Coefficient of determination, R^2	0.4944	0.0870	0.1389	0.0141	0.0106	0.4696

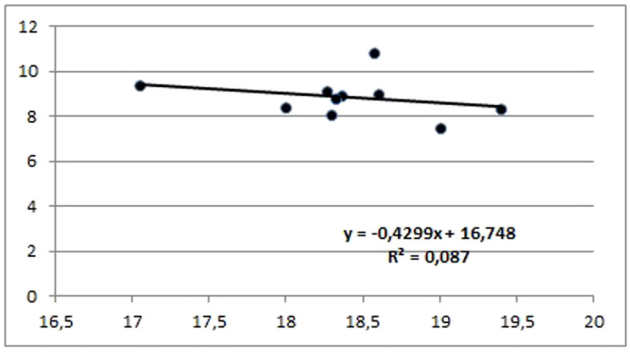


Figure 2: Linear approximation of the dependence of meat content on fat content in the cervical-scapular third of the carcass at a pre-slaughter weight of 120 kg.

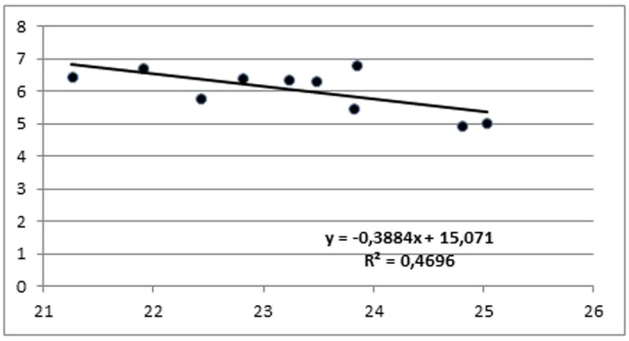


Figure 4: Linear approximation of the dependence of meat content on fat content in the pelvic-femoral third of the carcass at a slaughter weight of 120 kg.

Estimation of the coefficient of determination by the established inverse dependence shows that 8.70% of the variance of the effective trait of meat content is due to a change in the factor fat content in the cervical-scapular third of carcass for pigs with a pre-slaughter weight of 120 kg, and the rest caused by random factors (Figure 2).

The inverse linear regression coefficient shows that for each increase in the fat content in the cervical-scapular third of the carcass at a pre-slaughter weight of 120 kg per 1.0 kg, the meat content will decrease proportionally by 0.43 kg (Figure 2). In the dorsal-lumbar part of the carcass, the value of the coefficient of determination was statistically incredible (Figure 3).

A study of the coefficient of determination with a confirmed inverse relationship suggests that 46.96% of the change in meat content is caused by a change in the content of fat in the pelvic-femoral third of the carcasses of animals slaughtered at 120 kg. Analysis of the mathematical expression of the relationship between these indicators of pig meat shows that with an increase in fat content by 1 kg, the meat content will decrease in the hip third of the carcass by 0.39 kg (Figure 4).

The value of the coefficient of determination with the established inverse relationship shows that the change in meat content is due to changes in the fat content in the cervical-scapular third of the carcass for pigs with slaughter weight 110 kg by 49.44%, and the rest is caused by random factors (Figure 5).

In the dorsal-lumbar and pelvic-femoral parts of the carcass, no reliable value of the coefficient of determination has been established (Figures 6 and 7).

The parameters of the inverse linear regression equation show that for each increase in the fat content in the cervical-scapular third of the carcass at a pre-slaughter weight of 110 kg per 1.0 kg, the meat content of animal carcasses will decrease proportionally by 0.72 kg (Figure 7).

The carcass weight significantly affected the meat content in the cervical-scapular third of the carcass by 61.9%, where the correlation was lineal, inverse, and weak (–0.33), and the meat content decreased by 0.44% with an increase in pre-slaughter weight by 1% (Figure 8).

In the dorsal-lumbar third of the carcass, the meat content significantly depended on the pre-slaughter

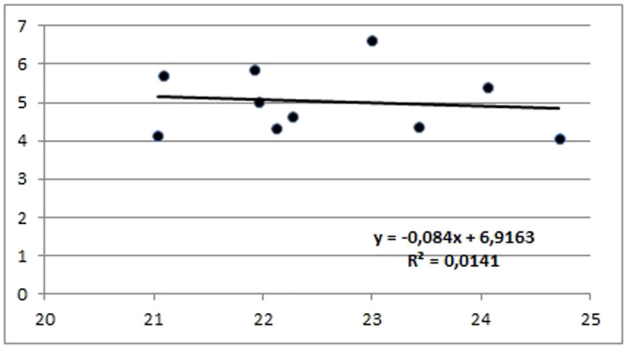
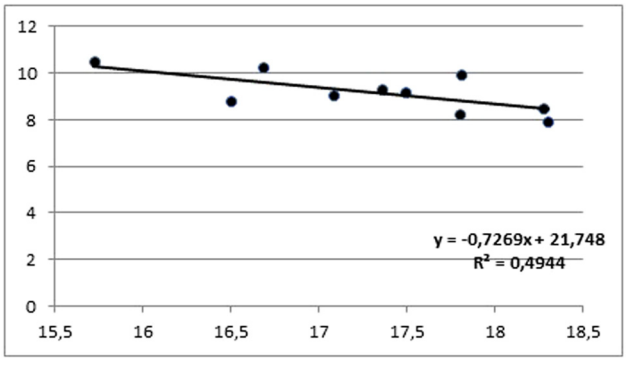


Figure 3: Linear approximation of the dependence of the meat content on the fat content in the dorsal-lumbar third of the carcass at a slaughter weight of 120 kg.



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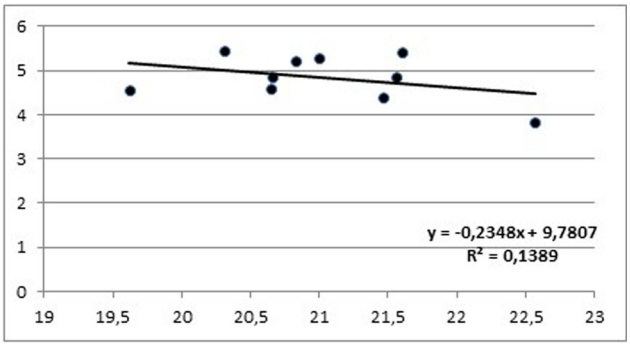

Figure 6: Linear approximation of the dependence of the meat content on the fat content in the dorsal-lumbar third of the carcass at a slaughter weight 110 kg.

weight by 62.2%, and the correlation was lineal, direct, and weak (0.37); the meat content increased by 0.24% with an increase in slaughter weight by 1% (Figure 9).

In the pelvic-femoral third of carcass, the carcass weight affected the meat content by 96.6%, and the correlation was lineal, inverse, and weak (–0.36); the meat content decreased by 0.20% with an increase in the carcass weight per 1% (Figure 10).

4 Discussion

The results of our research confirmed the conclusions of other authors [9,17] on the increase in the amount of fat with increasing pre-slaughter weight, confirmed the previously published judgment [9,11] on the reduction of the proportion of bones at higher slaughter weight, and confirmed previous arguments [14,16] on the significant dependence of the morphological composition of pig

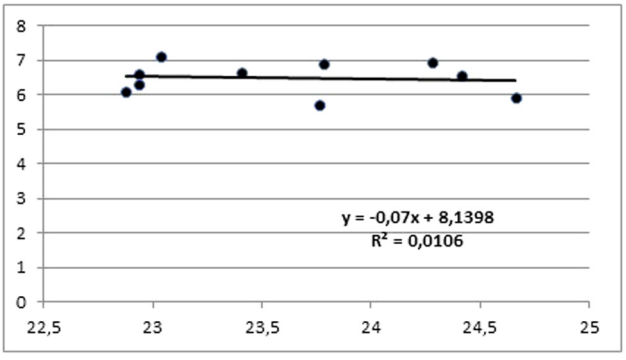

Figure 7: Linear approximation of the dependence of meat content on fat content in the pelvic-femoral third of the carcass at a slaughter weight of 110 kg.

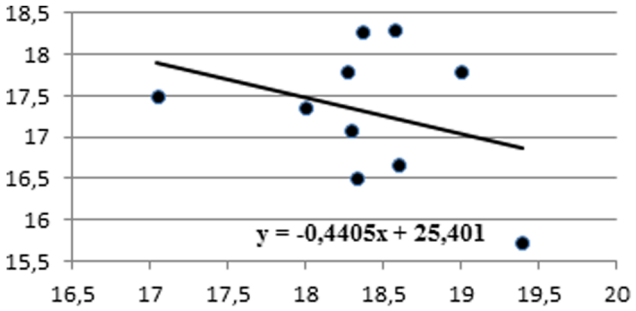

Figure 8: Linear approximation of the dependence of meat content on pre-slaughter weight in the cervical-scapular third of the carcass.

carcasses on pre-slaughter weight compared with other factors.

However, our results contradict the reported scientific arguments [9] on the reduction of meat content with increasing pre-slaughter weight, contradict the announced research data [11] on the lack of reliable dependence of meat content on live weight of pigs before slaughter, contradict the reported conclusions [14] about a significant reduction in the meat content of 120 kg pigs compared to the meat content of analogues weighing 110 kg, and contradict the scientific report [19] on the reliable dependence of pig carcass meat on the breed than on the pre-slaughter weight.

Slaughter weight of pigs had a significant ($p < 0.05$) effect on the characteristics of carcasses [29], accounting for most of the observed differences in the experiments [30]. In particular, scientists [31] found that because of the increase in carcass weight, the carcass yield also increased ($p < 0.001$), but the meat yield decreased ($p < 0.05$). At the same time, scientific studies [32] reported about a decrease in lean meat yield by 0.16% for every 1 kg increase in carcass weight from 110 to 140 kg, which does not coincide with our increase in meat content by 0.37% for each 1 kg increase in pre-slaughter weight

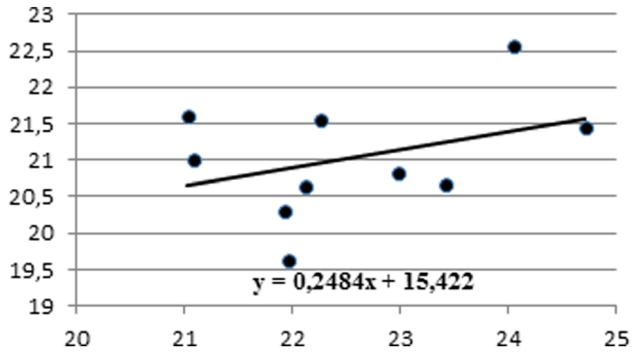

Figure 9: Linear approximation of the dependence of meat content on pre-slaughter weight in the dorsal-lumbar third of the carcass.

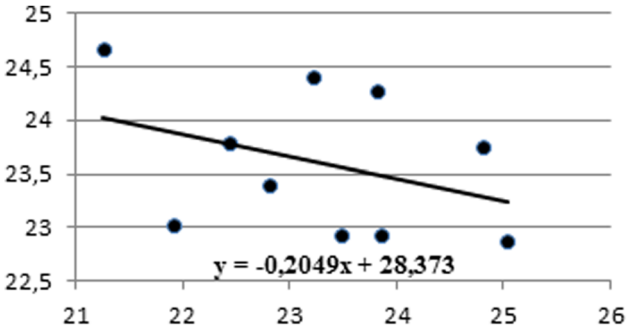

Figure 10: Linear approximation of the dependence of meat content on pre-slaughter weight in the pelvic-femoral third of the carcass.

from 110 to 120 kg. In addition, other authors indicate that the percentage of meat yield to the total carcass weight increased by 0.37% for every 10 kg of live weight with an increase in pre-slaughter weight ($p < 0.001$), which is much lower than our results [33].

Published research [11] noted the practical equality of the output of meat from the carcasses of animals weighing 100 and 110 kg. But at a higher weight of 120 kg, the meat content of carcasses decreased by 1.4% with an increase in fat yield by 2.9%. We found that the meat content in pig carcasses increased by 3.72% with increasing pre-slaughter weight to 120 kg. This coincides with other scientific work [34], which states that the mass of all tissues increased ($p < 0.01$) when the pre-slaughter weight grew. Reported studies [34] coincide with our conclusions on that the level of muscle content in the lumbosacral third and in pelvic third of the carcass climbed up with increasing carcass weight from 110 to 120 kg.

In some experiments [35,36], it was found that when the carcass weight increased to 125 kg, the specific weight of bones in carcasses decreased in all experimental pig groups by 0.3–0.6%. The authors also noted a decrease in the ratio of lard to meat in the range of 0.46–0.61 at slaughter of 100 kg and 0.49–0.70 at slaughter of 125 kg. However, we did not establish a relationship between bone content and pre-slaughter weight, and the tendency to decrease the ratio of lard to meat with increasing pre-slaughter weight was not confirmed and the ratio was increasing in our experiment.

According to published articles [37], the proportions of meat and fat in the cervical-scapular third of the carcass decreased linearly ($p < 0.001$), and in the lumbar third of the carcass, it increased linearly ($p < 0.001$) with increasing slaughter weight. In our experiment, we found a linear increase in meat content and a decrease in fat content in the cervical-scapular third of the carcass, and in the lumbosacral third of the carcass, we had a linear increase in their content as mentioned by other researchers. Moreover, as found by many scientists [37], linear decrease ($p < 0.001$) of carcass, bone, and skin muscles, as well as a linear increase ($p < 0.05$) of carcass fat, when the slaughter weight increased to 113.6 kg was not observed in our results.

However, our results on the increase in meat content with increasing slaughter weight do not coincide with the found reports [38] where it is stated that the yield of lean meat did not change, as muscle depth increased with increasing slaughter weight from 95 to 105 kg ($p < 0.05$).

Recent data have also been published, which are in complete agreement with our findings that the increase in pre-slaughter weight of animals was accompanied by an increase in carcass weight of the carcass, shoulder fat thickness, and total carcass weight [39].

A number of studies have reported the correlation between the pre-slaughter live weight of pigs and the parameters of leanness of their carcasses. Data from some of them indicate that the percentage of lean meat depends not only on the ratio of tissues, but also on the slaughter yield. Increasing the slaughter yield by 1% increases the average yield of muscle tissue by 0.84 kg. Whereas an increase of 1% in the content of lean meat in the carcass of slaughter animals increases the content of muscle tissue by 0.52 kg [40]. In other scientific works, the positive correlation of a high degree between live weight of animals before slaughter and the maintenance of both meat and fat in carcasses of young growth is established [41]. Similarly, in our study, the carcass weight significantly affected the meat content in the cervical-scapular third of the carcass by 61.9%, where the correlation was lineal, inverse, and weak (−0.33), and the meat content decreased by 0.44% with an increase in pre-slaughter weight by 1%.

In most scientific studies, the increased growth rate, which results in a higher pre-slaughter weight, strongly correlates with the content of fat and meat. Some authors suggest that selection to increase the rate of growth at fattening increases both the thickness of fat and muscle depth [41–43].

But it is clear that the correlation coefficients between growth rate and fat and meat content show a certain range of unpredictability. It is thought that this may be due to the method of measurement, the influence of technology, differences in breed and sampling errors [44].

In general, many authors suggest that the slaughter weight of pigs of 125 and 135 kg may be optimal for production without compromising the quality of meat [45]. The discrepancy in the reported effects of pre-slaughter weight among the studies can be explained by genetics

and (or) age of pigs at slaughter [46], but this contradicts our results, because the experiment used pigs of the same genetics of the equal age.

Slaughter of animals of increased weight condition (over 120 kg) will increase the slaughter yield by 3.72%, which is even more than in our previous study, where we found a higher meat content of 1.8 and 1.6% in pigs and castrates, respectively, at higher pre-slaughter weight of pigs [47].

The assumption that an increase in carcass weight will lead to an increase in fat content was not confirmed in our studies, which correlates with the findings [48], which say that the fat content in carcasses increased to a weight of 100 kg, and then remained stable and depended more on pig gender and genotype than on pre-slaughter weight [49]. Moreover, the low content of fat within 1.5% is the optimal indicator, which does not worsen the consumer preferences [50,51].

5 Conclusions

(1) Animals of the highest weight condition of 120 kg significantly prevailed in absolute and relative terms of meat content as in the section of thirds of their carcasses: cervical-scapular by 16.06 and 1.10%, dorsal-lumbar by 17.37 and 1.50%, pelvic-femoral by 8.02%, and in general by 13.44 and 3.72%, respectively.

(2) There is no significant difference in fat and bone content between animals at pre-slaughter weights of 110 and 120 kg. The study found higher values of fat content by 13.16% and bone content by 23.39% for the dorsal-lumbar third of the carcass and higher values of bone content by 14.81% and fat content by 7.81% for the pelvic-femoral third of the carcasses for pigs slaughtered at a weight 120 kg.

(3) The probable influence of the factor of pre-slaughter weight on the share of meat in certain parts of the carcass is established: 61.96% for the cervical-scapular third, 62.21% for the dorsal-lumbar third, and 96.57% for the pelvic-femoral thirds. The proportion of fat and the proportion of bones under the action of the pre-slaughter weight factor varied from 85.66 to 98.28% and from 94.29 to 99.99%, respectively, depending on the part of the pigs carcass.

(4) Significant inverse relationship between meat content and fat content in the cervical-scapular third of the carcass was moderate in animals raised up to 120 kg and was high in analogues weighing 110 kg. In the dorsal-lumbar third of pigs carcass of both weight conditions, no probable relationship between meat and fat content has been established. In the pelvic-femoral third of the carcass, the correlation between muscle tissue content and adipose tissue content was significant, but weak in 120 kg pigs, and its presence has not been confirmed in analogues.

(5) In animals fattened until 120 kg, changes in meat content caused by changes in adipose tissue content were at the level of 46.96% in the pelvic-femoral third and at the level of 8.70% in the cervical-scapular third of the carcass. In 110 kg analogues, the interdependence between changes in meat content and fat content was formed at 49.44% only for the cervical-scapular third of the carcass.

(6) It has been proved that in pigs at a pre-slaughter weight of 120 kg for each additional increase in fat content by 1.0 kg, the meat content was proportionally insufficient by 0.43 kg in the cervical-scapular third and by 0.39 kg in the pelvic-femoral third of the carcass. In peers weighing 110 kg, each additional 1 kg of fat did not allow to gain 0.72 kg of meat in the cervical-scapular third of the carcass.

(7) The study shows that pig carcass during fattening up to 110 kg is more sensitive (44.99%) to changes in meat–fat ratios in the cervical-scapular third, which allows more targeted formation of the characteristics of semi-finished products of this part at this stage. The dependence of the content of meat, fat and bones in the cervical-scapular third of the carcass is reduced by the impact of growth intensity by 8.7% when pigs are slaughtered weighing 120 kg. The effect of growth intensity of pigs on the interdependence between the ratio of meat to fat content increases by 46.96% in the pelvic-femoral third of the carcass when growing pigs to weight 120 kg. This level of interdependence between the content of meat and lard could affect the quality of semi-finished products.

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Conflict of interest: The authors state no conflict of interest.

Data availability statement: The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

References

[1] Bankovska IB, Voloshchuk VM. Genotype factors and way of animal housing affected on the morphological composition carcasses of pigs. Ukrainian Black Sea Reg Agrarian Sci. 2015;2(84):91–9 (Ukrainian). http://nbuv.gov.ua/UJRN/vanp_2015_2(2)__16.

[2] Nikolaev DV. Evaluation of meat productivity when fattening hybrid gilts to live weight of 100, 110, and 120 kg. Bull Nizhnevolzhsky Agro-university Complex: Sci High Professional Educ. 2014;2(34):129–34 (Russian). https://www.volgau.com/Portals/0/izv_auk/izv_auk_full/izvestiya_2014_34_2.pdf?ver=Lb8Dc2tf0uxpwHUpE4QMyQ%3d%3d.

[3] González E, Carrapiso A, Noguera JL, Ibáñez-Escriche N, Tejeda JF. Effect of genetic and diet on Iberian pig fresh loin (m. Longissimus dorsi). Arch. Zootec. Proceedings IX Simposio Internacional Sobre el Cerdo Mediterráneo. Cordoba, Spain: 2018. p. 185–7. https://riunet.upv.es/bitstream/handle/10251/153355/Gonzalez?sequence=1.

[4] Renaudeau D, Hilaire M, Mourot JA. Comparison of carcass and meat quality characteristics of Creole and Large White pigs slaughtered at 150 days of age. Anim Res. 2005;54(1):43–54. https://hal.archives-ouvertes.fr/hal-00890019/document.

[5] Baranikov VA, Zhivotova TY, Gorlov IF, Nikolaev DV. The use of pigs of different genotypes in fattening to different weight conditions and their impact on meat productivity. Proc Lower Volga Agric Univer Compl Zootechn Veterinary Med. 2013 [cited 2021 Nov 1];3(31):1–6 (Russian). Available from https://cyberleninka.ru/article/n/ispolzovanie-sviney-raznyh-genotipov-pri-otkorme-do-raznyh-vesovyh-konditsiy-i-ih-vliyanie-na-myasnuyu-produktivnost. Subscription required.

[6] Parunović N, Petrović M, Matekalo-Sverak V, Radović Č, Stanišić N. Carcass properties, chemical content and fatty acid composition of the musculus longissimus of different pig genotypes. S Afr J Anim Sci. 2013 [cited 2021 Oct 31];43(2):123–136. http://www.scielo.org.za/scielo.php?script=sci_arttext&pid=S0375-15892013000200002&lng=en. Subscription required.

[7] Ayuso D, González A, Peña F, Hernández-García FI, Izquierdo M. Effect of fattening period length on intramuscular and subcutaneous fatty acid profiles in Iberian pigs finished in the montanera sustainable system. Sustainability. 2020;12(19):7937. doi: 10.3390/su12197937.

[8] García-Gudiño J, Monteiro A, Espagnol S, Blanco-Penedo I, Garcia-Launay F. Life Cycle assessment of Iberian traditional pig production system in Spain. Sustainability. 2020;12(2):627. doi: 10.3390/su12020627.

[9] Khmelnychyi LM, Vecherka VV, Shpetny MB, Bordunova OG, Pavlenko YM, Opara VO. Fattening and slaughter qualities of pigs of different weight categories reared in machines on polymer and concrete floors. Bull Sumy Natl Agrarian Univ Livest. 2020;1(40):1–9 (Ukrainian). doi: 10.32845/bsnau.lvst.2020.1.1.

[10] Wu F, Vierck KR, DeRouchey JM, O'Quinn TG, Tokach MD, Goodband RD, et al. A review of heavy weight market pigs: status of knowledge and future needs assessment. Transl Anim Sci. 2017;1(1):1–15. doi: 10.2527/tas2016.0004.

[11] Nechmilov VM. Optimization of technological methods of rearing hybrid young pigs of Irish selection in terms of industrial technology [dissertation]. Mykolayiv: Mykolayiv National Agrarian University; 2019 (Ukrainian). https://www.mnau.edu.ua/files/spec_vchen_rad/d_38_806_02/dis_nechmolov.pdf.

[12] Samokhina EA, Mykhalko OG. Morphological composition of carcasses of pigs-final hybrids of the Yorkshire x Landrace x Maxgro genotype depending on weight conditions. Breed Genet Anim. 2018;55:124–8 (Ukrainian). http://irbis-nbuv.gov.ua/cgi-bin/irbis_nbuv/cgiirbis_64.exe?C21COM=2&I21DBN=UJRN&P21DBN=UJRN&IMAGE_FILE_DOWNLOAD=1&Image_file_name=PDF/rgt_2018_55_19.pdf.

[13] Peláez FR, González MA, Avilés C, Martínez AL, Peña F. Effects of the rearing system and gender on the performance, carcass traits, and instrumental and sensory quality of meat from the "Criollo negro de la costa ecuatoriana" Pigs. Rev Científica. 2017;XXVII(3):194–202 (Spanish). https://www.redalyc.org/journal/959/95952010009/html/.

[14] Povod MG, Shvachka RP, Mykhalko OG, Yurieva KV. Productive qualities of sows and their offspring depending on the duration of the suckling period. Bull Sumy Natl Agrarian Univ. Livestock. 2019;4(39):72–84 (Ukrainian) doi: 10.32845/bsnau.lvst.2019.4.11.

[15] Povod MG, Mykhalko OG, Vdovichenko YV, Nechmilov VM. Morphological composition of pig carcasses for different types of feeding, duration of rearing and pre-slaughter live weight. Agrarian Sci Food Technol. 2018;3(102):47–56 (Ukrainian). http://repository.vsau.org/getfile.php/19266.pdf.

[16] Cisneros F, Ellis M, McKeith FK, McCaw J, Fernando RL. Influence of slaughter weight on growth and carcass characteristics, commercial cutting and curing yields, and meat quality of barrows and gilts from two genotypes. J Anim Sci. 1996;74:925–33. doi: 10.2527/1996.745925x.

[17] Latorre MA, Lázaro R, Valencia DG, Medel P, Mateos GG. The effects of gender and slaughter weight on the growth performance, carcass traits, and meat quality characteristics of heavy pigs. J Anim Sci. 2004 Feb;82(2):526–33. doi: 10.2527/2004.822526x.

[18] Álvarez-Rodríguez J, Teixeira A. Slaughter weight rather than gender affects carcass cuts and tissue composition of Bisaro pigs. Meat Sci. 2019;154:54–60. doi: 10.1016/j.meatsci.2019.04.012.

[19] Shejko RI, Fedorenkova LA, Zayats VN, Khramchenko NM, Yanovich EA, Pristupa NV, et al. Fattening and meat traits of young pigs bred in Belarus, their variability and correlation. Zootechnical Sci Belarus: Collect Sci Pap. 2013;47(1):202–9 (Russian). https://agris.fao.org/agris-search/search.do?recordID=BY2012001088.

[20] Borah P, Bora JR, Borpuzari RN, Haque A, Bhuyan R, Hazarika S. Effect of age, gender and slaughter weight on productive performance,carcass characteristics and meat quality of crossbred (Hampshire x Assam local) pigs. Indian J Anim Res. 2016;50:601–5. doi: 10.18805/ijar.11250.

[21] Polkovnykova VY. Fattening qualities and meat productivity of pigs of different genotypes. Zootekhniia. 2015 [cited 2021 Nov 1];6(56)151–4. (Russian). https://cyberleninka.ru/article/n/otkormochnye-kachestva-i-myasnaya-produktivnost-svineyraznyh-genotipov, Subscription required.

[22] Oliveira EA, Bertol TM, Coldebela A, Santos Filho JI, Scandolera AJ, Warpechowski MB. Live performance, carcass quality, and economic assessment of over 100 kg slaughtered pigs. Arq Bras Med Vet Zootec. 2015;67(6):1743–50. doi: 10.1590/1678-4162-7632.

[23] Barducci RS, Zhou ZY, Wormsbecher L, Roehrig C, Tulpan D, Bohrer BM. The relationship of pork carcass weight and leanness parameters in the Ontario commercial pork industry. Transl Anim Sci. 2020;4(1):331–8. doi: 10.1093/tas/txz169.

[24] Latorre MA, Olivares A, Callejo A, Rey AI, Pérez-Ciria L, López Bote CJ, et al. A comparison of female and castrate pigs slaughtered at weights above and below 120 kg on carcass traits, intramuscular fat and fatty acid composition of carcasses intended for dry-cured ham and shoulder production. Anim Prod Sci. 2019;59:1923–30. doi: 10.1071/AN18267.

[25] Council of the European Union. Council Directive 86/609/EEC of 24 November 1986 on the approximation of laws, regulations and administrative provisions of the member states regarding the protection of animals used for experimental and other scientific purposes. Off J Eur Commun. 1986;358:1–28.

[26] ISO 3100-1, Meat and meat products – Sampling and preparation of test samples – Part 1: Sampling. International Organization for Standardization, Geneva, Switzerland https://standards.iteh.ai/catalog/standards/iso/173c37dd-6a81-4146-beeb-bb1c6fe94c52/iso-3100-1-1991.

[27] Directive 2010/63/EU of the European Parliament and of the Council of 22 September 2010 on the protection of animals used for scientific purposes https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32010L0063.

[28] On protection of animals against brutal treatment, Law of Ukraine, No. 3447-IV, adopted on February 21, 2006 (as amended on 14-01-2020) (Ukrainian). https://cis-legislation.com/document.fwx?rgn=18258.

[29] Makaukii AF, Lekule FP. Effect of slaughter weight on characteristics and economics of pig production. Tanzan J Agric Sc. 2000;3(1):55–62. https://www.ajol.info/index.php/tjags/article/view/115911/105460.

[30] Pieterse E, Siebrits F, Gloy E, Polawska E. The effect of slaughter weight on the carcass characteristics of pork with gender type as co-variable. Anim Prod Sci. 2016;56:55–60. doi: 10.1071/AN14183.

[31] Peinado J, Serrano MP, Medel P, Fuentetaja A, Mateos GG. Productive performance, carcass and meat quality of intact and castrated gilts slaughtered at 106 or 122 kg. BW Anim. 2011;5(7):1131–40. doi: 10.1017/S1751731111000061.

[32] Leach LM, Ellis M, Sutton DS, McKeith FK, Wilson ER. The growth performance, carcass characteristics, and meat quality of halothane carrier and negative pigs. J Anim Sci. 1996;74:934–43. doi: 10.2527/1996.745934x.

[33] Jeong JY, Park BC, Ha DM, Park MJ, Joo ST, Lee CY. Effects of increasing slaughter weight on production efficiency and carcass quality of finishing gilts and barrow. Food Sci Anim Resour. 2010;30(2b):206–15. doi: 10.5851/kosfa.2010.30.2.206.

[34] Wiseman TG, Mahan DC, Peters JC, Fastinger ND, Ching S, Kim YY. Tissue weights and body composition of two genetic lines of barrows and gilts from twenty to one hundred twenty-five kilograms of body weight. J Anim Sci. 2007;85(7):1825–35. doi: 10.2527/jas.2006-407.

[35] Birta HO, Burhu YH, Floka LV, Khmelnytska YV, Rachynska ZP. Morphological composition and meat and fat qualities of pig carcasses. Bull Sumy Natl Agrarian Univ Livest. 2020;4:27–32 (Ukrainian). http://nbuv.gov.ua/UJRN/Vsna_tvar_2020_4_5.

[36] JinLiang X, Gary D, James E. Pettigrew, performance, carcass, and meat quality advantages of boars over barrows: A literature review. Swine Health Prod. 1997;5(1):21–8. https://www.aasv.org/shap/issues/v5n1/v5n1p21.pdf.

[37] Apple JK, Maxwell CV, Galloway DL, Hamilton CR, Yancey JW. Interactive effects of dietary fat source and slaughter weight in growing-finishing swine: III. Carcass and fatty acid compositions. J Anim Sci. 2009;87(4):1441–54. doi: 10.2527/jas.2008-1455.

[38] Conte S, Boyle L, O'Connell N, Lynch P, Lawlor P. Effect of target slaughter weight on production efficiency, carcass traits and behaviour of restrictively-fed gilts and intact male finisher pigs. Livest Sci. 2011;136:169–74. doi: 10.1016/j.livsci.2010.08.018.

[39] Więcek J, Skomiał J, Rekiel A, Florowski T, Dasiewicz K, Kosińska M. Fattening and slaughter parameters in the first period of fattening of pigs fed restrictive or semi ad libitum-diets. Pol J Food Nutr Sci. 2008;58(3):325–9. http://journal.pan.olsztyn.pl/pdf-98144-30858?filename=FATTENING%20AND%20SLAUGHTER.pdf.

[40] Mykhailov NV, Sviatohorov NA. Selection of pigs for meat qualities. Sci J Kuban State Agrarian Univ. 2011 [cited 2021 Nov 1];70:1–11 (Russian). https://cyberleninka.ru/article/n/selektsiya-sviney-na-myasnye-kachestva. Subscription required.

[41] Doilydov VA, Volkova EM. Productive qualities of purebred and local young pigs with different pre-slaughter weight. Actual Probl Intensive Dev Anim Husb. 2014 [cited 2021 Nov 1];17(1):203–213 (Russian). https://cyberleninka.ru/article/n/produktivnye-kachestva-chistoporodnogo-i-pomesnogo-molodnyaka-sviney-s-raznoy-preduboynoy-massoy-1 Subscription required.

[42] Miar Y, Plastow G, Bruce H, Moore S, Manafiazar G, Kemp R, et al. Genetic and phenotypic correlations between performance traits with meat quality and carcass characteristics in commercial crossbred pigs. PLoS One. 2014;9(10):e110105. doi: 10.1371/journal.pone.0110105.

[43] Khalak VI. The effectiveness of using some methods of complex selection to assess young pigs for fattening and meat qualities. Bioresources and nature management. Zootechnics. 2015;7(556):25–31, https://journals.indexcopernicus.com/api/file/viewByFileId/67951.pdf.

[44] Zhou ZY, Bohrer BM. Defining pig sort loss with a simulation of various marketing options of pigs with the assumption that marketing cuts improve variation in carcass weight and leanness. Can J Anim Sci. 2018;99(3):542–52. doi: 10.1139/cjas-2018-0195.

[45] Park BC, Lee CY. Feasibility of increasing the slaughter weight of finishing pigs. J Anim Sci Technol. 2011;53(3):211–22. doi: 10.5187/JAST.2011.53.3.211.
[46] Virgili R, Degni M, Schivazappa C, Faeti V, Poletti E, Marchetto G, et al. Effect of age at slaughter on carcass traits and meat quality of Italian heavy pigs. J Anim Sci. 2003;81:2448–56. doi: 10.2527/2003.81102448x.
[47] Povod M, Kravchenko O, Getya A, Zhmailov V, Mykhalko O, Korzh O, et al. Influence of pre-killing living weight on the quality of carcases of hybrid pigs in the conditions of industrial pork production in Ukraine. J Sci Pap Ser Manag Econom Eng Agr Rural Dev. 2020;20(4):431–7, http://managementjournal.usamv.ro/pdf/vol.20_4/Art49.pdf.
[48] Franco D, Vazquez JA, Lorenzo JM. Growth performance, carcass and meat quality of the Celta pig crossbred with Duroc and Landrance geno-types. Meat Sci. 2014;96(1):195–202. doi: 10.1016/j.meatsci.2013.06.024.
[49] Carabús A, Sainz RD, Oltjen JW, Gispert M, Font-i-Furnols M. Growth of total fat and lean and of primal cuts is affected by the gender type. Animal. 2017;11:1321–9. doi: 10.1017/S1751731117000039.
[50] Fortin A, Robertson WM, Tong AKW. The eating quality of Canadian pork and its relationship with intramuscular fat. Meat Sci. 2005;69:297–305. doi: 10.1016/j.meatsci.2004.07.011.
[51] Fernández-Dueñas DM, Myers AJ, Scramlin SM, Parks CW, Carr SN, Killefer J, et al. Carcass, meat quality, and sensory characteristics of heavy body weight pigs fed ractopamine hydrochloride (Paylean). J Anim Sci. 2008;86(12):3544–50. doi: 10.2527/jas.2008-0899.