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INFLUENCE OF SEX AND PRE-SLAUGHTER WEIGHT OF PIGS ON THEIR CARCASS QUALITY

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Abstract

In order to study the influence of pig sex and pre-slaughter weight on carcass quality, experimental studies were carried out on 120 pigs of Irish origin: 30 gilts with a pre-slaughter weight of 100 kg, 30 gilts with a pre-slaughter weight of 120 kg, 30 barrows with a pre-slaughter weight of 100 kg, 30 barrows with a pre-slaughter weight 120 kg. After fattening the pigs were slaughtered and their carcass qualities were evaluated. The analysis showed the influence of pre-slaughter weight on slaughter yield: in gilts by 1.7%, in barrows – no effect; on chilling losses: in gilts by 44.00%, in barrows by 26.32%; on fat thickness above the 6-7 thoracic vertebrae: in gilts by 21.19%, in barrows by 24.76%; on fat thickness in buttocks: in gilts by 22.65 %, in barrows – no effect; on fat thickness in withers: in gilts by 13.47%, in barrows by 14.9%; on carcass length: in gilts by 8.28%, in barrows by 4.62% and on the Loin eye area MLT: in gilts by 6.0%, in barrows by 13.50%.

Key words*: carcass length, fat thickness, meat content, carcass, slaughter yield.*

INTRODUCTION

In meat production, pig farming plays a significant role as one of the most important branches of animal husbandry. The modern development of industrial pig farming is directly related to the high consumer demand for lean pork (McOrist et al., 2011). About 40% of the world's meat production is pork. At the same time, pigs are the only animal that can meet our needs for fats of animal origin. Pork lard contains all essential amino acids: lysine, tryptophan, methionine, as well as vitamins and essential fatty acids. Pork is therefore a biologically complete food (Gan et al., 2020; Ma et al., 2020). Pigs of different breeds and their combinations produce carcasses with different meat, fat, and bone content, which requires detailed study of meat productivity and quality of pigs of different genotypes sent for processing to determine their industrial suitability (Khanal et al., 2019). Price of pork, and thus the competitiveness of the whole production, depends on the ratio between muscle and fat tissue in a pig carcass. Therefore, the selection of the most promising genotypes and genotype combinations and the determination of their optimal slaughter conditions provides the opportunity to increase production, improve the quality of pork and utilize it appropriately, which will contribute to the successful development of both the pig farming and processing industries (Lebret & Čandek-Potokar, 2022; Mihaila et al., 2023; Moreira et al., 2022). According to studies conducted not long ago, the quality of pork is significantly influenced by the rearing and fattening conditions of the animals, their age, live weight, feeding, transport and slaughter characteristics, as well as genetic predisposition and sex (Lozada-Soto 2022; Soares et al., 2022). In most cases, these factors can serve as effective methods for targeted management of quality development of swine carcasses and meat (Xia et al., 2023). In recent years, both in Ukraine and abroad, the meatiness of pigs has increased significantly, which makes it possible to obtain carcasses with a higher weight before slaughter (Clop-Gallart et al.,

2021). An increase in pig carcass weight is observed in most countries with developed pig farming, such as Italy (150-165 kg), USA (120-130 kg), Canada (115-125 kg), Netherlands (110-120 kg), and France (110-120 kg). That is, increasing the weight of animals before slaughter is an important reserve for increasing pork production. However, the question of the optimal condition of pigs for slaughter has not yet been fully resolved (Boyle et al., 2022; Kušec et al., 2022; Ritchie et al., 2017).

The results of studies conducted recently have shown that fattening pigs up to a high weight (120-130 kg) leads to salinization of the animals and consequently to an increase in feed costs per unit of growth, which causes an increase in the cost price of pork. Increasing the live-finish weight during fattening from 100 to 125 kg, and especially to 150 kg, is associated with a natural increase in time and a noticeable increase in feed costs and other means per unit of growth (Birta et al., 2023). Slaughtering pigs at a lower weight helps to reduce feed costs and increase carcass production. Economically, this is more justified, especially with intensive technologies for reproduction of young animals (Malgwi et al., 2022). Most farms sell 105-110 kg pigs. The producer chooses the slaughter weight considering the profitability of the farm. Two factors are critical: space availability and cost. To fatten pigs in more difficult conditions, more space is needed; if this is not available, the farm is forced to sell low-weight animals (Čobanović et al., 2016). It must be taken into account that pigs of different sexes and their combinations start fattening at different weights (Durkin et al., 2012), so the study of carcass performance of pigs of different genetic combinations at different weights before slaughter is a current issue and requires a complex production concept and implementation of the necessary carcass evaluation system (Oh et al., 2022). With this in mind, the objective of our study was to determine the influence of weight and sex of pigs before slaughter on the quality of their carcasses.

MATERIALS AND METHODS

The experiment was carried out under production conditions using Irish origin pigs, which were selected from sows F_1 (Irish Landrace x Yorkshir) and terminal boars Max Gro and kept in the fattening branch of LCC "Globinsky Pigs Complex", Poltava region, Ukraine. At the beginning of the experiment, four hundred pigs, including 200 barrows and 200 gilts, were fattened at the age of seventy days. Before the start of fattening, all pigs were pre-weighed individually. Each weighed animal was marked with a tag with individual numbers. On the next step of experiment, the fattening process involved placing pigs in technologically identical conditions in pens of 40 m^2 with 50 animals in each. Every pen had a completely slotted concrete floor.

Barrows and gilts were kept separately. At the same time, feed was distributed with a frequency of 8-10 times within 24 hours. Liquid fodder mixtures were used for feeding, which were grown at the enterprise and prepared in possession of the equipment of the Austrian company Weda. The ratio of dry fodder to liquid fraction was 1 to 3. Pig feeding was based on a diet whose structure included components produced on the enterprise's experimental fields (Table 1).

Table 1. The structure of the feed ration

Ingredient	Value
Maize grain kibbled, %	19.0
Wheat grain, %	35.9
Soybean seeds meal solvent extracted, %	13.3
Sunflower seeds meal mechanical extracted, %	8.8
Sorghum grain, %	12.0
Wheat bran, %	1.0
Cereals, screenings, %	10.0

The nutritional value of the diet was adequate and contained the necessary vitamins and micro- and macroelements required for normal fattening pigs (Table 2).

Table 2. Nutritional value of feed for pigs fattening

Indicator	Value
Protein content, %	18.0
Lysine content, %	1.0
Oil content, %	2.8
Fiber content, %	4.3
Calcium content, %	0.63
Assimilable phosphorus content, %	0.29
Total phosphorus content, %	0.57
Vitamin A content, IU / kg	10000
Vitamin D content, IU / kg	2000
Vitamin E content, IU / kg	100
Biotin content, μg / kg	100
Assimilable energy, MJ / kg	13.65

The fattening continued until the pigs reached an average weight of close to 120 kg. The weight of each barrow and each gilt was determined by individual weighing, as a result of which every animal was marked with a colored spray indicating their weight on their back.

The purpose of this weighing was to separate 30 pigs from the general group for control slaughter with a live weight of 100 and 120 kg. Thus, four groups were formed for slaughter: two groups of barrows of 100 and 120 kg and two groups of gilts of 100 and 120 kg.

Before slaughter, the pigs were transported to LLC "Globinsky meat processing plant", Poltava region, Ukraine, where they were kept for 24 hours without food, but with free access to water. After 24 hours of keeping at the slaughterhouse, animals from each group were weighed again. After control weighing, the pigs were slaughtered by stunning, followed by crushing their carcasses. In the process of preparing the carcasses for chilling, their slaughter qualities were measured. When the slaughter was completed, the carcasses were re-weighed and chilled for 24 hours in a refrigerator at a temperature of -4ºC. After chilling, the carcasses were finally deboned into meat cuts in the deboning department, which made it possible to estimate the yield of meat and measure the Loin eye area MLT.

Warm carcass weight was measured as unchilled carcass weight after slaughter and removal of the head, skin, digestive tract and internal organs.

Carcass yield was calculated as the percentage of carcass weight, head, legs and visceral fat in the live weight of the pig before slaughter.

Chilled carcass weight was measured as the weight of the carcass excluding head, tail, internal fat, genitalia, internal organs and their contents after 24 hours of chilling.

Chilling losses were calculated as the difference between the weight of the warm carcass and that of the chilled carcass.

Fat thickness was measured with a millimetre ruler on the warm half of the carcass in a hanging vertical position, including the thickness of the skin.

Carcass length was measured in centimetres with a ruler hanging vertically along the centre of the cut from the anterior edge of the pubic bone to the anterior surface of the first cervical vertebra.

The length of the bacon half was measured with a centimeter ruler, in the hanging vertical position of the carcass, along the middle of the cut from the anterior edge of the pubic bone to the middle of the first rib.

The Loin eye area MLT was measured on a transverse section between the last thoracic (or 12th) and first lumbar vertebrae (or 13th). The contour of the cut of the longest muscle of the back was transferred to a transparent film and scanned from the film to an electronic medium using a scanner. Next, we used ImageJ 1.53e software capabilities. The downloaded cut image was calibrated for size using a photo millimeter scale ruler and converted to 8-bit expansion. Next, using the shape selection function and the area analysis function, we measured the area of the cut image. Cut image area measured using this software corresponds to the Loin eye area MLT.

Meat content was calculated as the ratio between the total mass of striped red muscle and the mass of the carcass excluding the head and forelimbs.

The impact of sex and pre-slaughter weight on the slaughter quality of pigs was evaluated using the data analyses Anova: two-factor statistical method. The calculation of the Anova method was carried out in MS Excel 2016. The data obtained were analysed using MS Excel 2016. First, the t-test was used to determine the variance between two average values of one carcass quality indicator.. Then, significance was determined by the t-test, which was: [1] – $P < 0.05$; [2] - $P < 0.01$; [3] – $P < 0.001$.

Experimental pigs were kept in compliance with generally accepted rules of humane treatment, which involves the avoidance of pain, discomfort and suffering.

RESULTS AND DISCUSSIONS

The analysis of slaughter performance of pigs revealed differences between experimental animals. In particular, it was established that the thickness of fat over 6-7 thoracic vertebrae was greater in the group of barrows weighing 100 kg than in gilts with a similar weight by 28 mm or 13.21% ($P < 0.001$) (Table 3).

Table 3. Slaughter qualities of barrows and gilts with different pre-slaughter weight, (n=120)

Indicators	Pre-slaughter weight 100 kg	
	Group I – gilts	Group II – barrows
Slaughter weight, kg	68.9±0.46	70.2±0.53
Slaughter yield, %	74.7±0.15	75.2±1.12
Weight of chilled carcass, kg	67.5±0.47	68.7±0.52
Chilling losses, kg	1.4±0.01	1.4±0.06
Chilling losses, %	2.0±0.03	2.0±0.08
Fat thickness:		
over 6-7 thoracic vertebrae, mm	21.2±0.30	24.0±0.50^{a3}
in the buttocks, mm	14.0±0.51	19.3±0.59 ^{a3}
in withers, mm	39.2±0.28	41.7±0.44 ^{a3}
Carcass length, cm	90.8±0.77	90.8±0.48
Loin eye area MLT, cm^2	48.6±0.68 ^{a2}	45.5±0.83
Meat content,%	61.6±0.30 ^{a1b1}	60.6±0.35
Indicators	Pre-slaughter weight 120 kg	
	Group I – gilts	Group II – barrows
Slaughter weight, kg	88.9±0.43 ^{a3b3}	85.8±0.40^{b3}
Slaughter yield, %	76.4±0.27 ^{a1b3}	75.5±0.27
Weight of chilled carcass, kg	86.6±0.43 ^{a3b3}	83.8±0.38
Chilling losses, kg	2.3±0.07 ^{a3b3}	1.9±0.06 ^{b3}
Chilling losses, %	2.5±0.08^{b3}	2.3±0.07 ^{b2}
Fat thickness:		
over 6-7 thoracic vertebrae, mm	26.9±0.74^{b3}	31.9±1.8$^{a1\ b3}$
in the buttocks, mm	18.1±0.82^{b3}	20.6±0.48^{a1}
in withers, mm	45.3±1.21^{b3}	49.0±1.47^{b3}
Carcass length, cm	99.0±0.28^{b3}	95.2±0.51^{b3}
Loin eye area MLT, cm^2	51.7±1.00^{b1}	52.6±0.85^{b3}
Meat content,%	59.7±0.73	60.7±0.52

Note: Comparison between lines: ^{a1} – P <0.05; ^{a2} - P <0.01; ^{a3} - P <0.001; Comparison between columns: ^{b1} – P <0.05; ^{b2} – P <0.01; ^{b3} – P <0.001.

Also, barrows (100 kg) had thicker fat compared to gilts (100 kg) in buttocks by 53 mm or 37.86% (P <0.001) and in withers by 25 mm or 6.38% (P <0.001). Gilts with a pre-slaughter weight of 100 kg outweighed barrows with a similar weight in terms of Loin eye area MLT by 3.1 cm^2 or 6.38% (P <0.01) and in terms of the yield of meat from the carcass by 1.0% (P <0.05).

At the same time, heavier gilts with a pre-slaughter weight of 120 kg compared to barrows weighing 120 kg had a higher slaughter weight by 3.1 kg or 3.49% (P <0.001), a higher slaughter yield by 0.90% (P <0.05), higher weight of the chilled carcass by 2.8 kg or 3.23% (P <0.001), higher chilling losses by 0.40 kg or 17.39% (P <0.001).

Barrows that reached a pre-slaughter weight of 120 kg differed from heavy 120 kg gilts by a greater fat thickness above the 6-7 thoracic vertebra by 50 mm or 18.59% (P <0.05), by a greater fat thickness in the buttocks by 25 mm or 13.81% (P <0.05).

Gilts with a pre-slaughter weight of 120 kg prevailed over lighter gilts with a pre-slaughter weight of 100 kg in terms of slaughter weight by 20.0 kg or 29.03% (P <0.001), in terms of slaughter yield by 1.7% (P <0.001), according to the chilled carcass by 19.1 kg or 22.06% (P <0.001), according to the losses during chilling by 1.1 kg or 44.00% (P <0.001), according to the fat thickness over 6-7 thoracic vertebrae by 57 mm or 21.19% (P <0.001), by the indicator of fat thickness in the buttocks by 41 mm or 22.65% (P <0.001), by the indicator of fat thickness in the withers by 61 mm or 13.47% (P <0.001), according to the carcass length indicator by 8.2 cm or 8.28% (P <0.001), according to the Loin eye area MLT by 3.1 cm^2 or 6.0% (P <0.05). However, heavy gilts (120 kg) were inferior to light peers (100 kg) in terms of meat content by 1.9% (P <0.05).

Also, barrows with a higher weight condition (120 kg) compared to their counterparts with a lower pre-slaughter weight (100 kg) had a higher slaughter weight by 16.6 kg or 18.18% (P <0.001), a higher weight of the chilled carcass by 15.1 kg or 18.02% (P <0.001), greater losses during chilling by 0.5 kg or 26.32% (P <0.001), greater fat thickness over the 6-7 thoracic vertebrae by 79 mm or 24.76% (P <0.001), greater fat thickness in the withers by 73 mm or 14.9% (P <0.001), greater carcass length by 44 mm or 4.62% (P <0.001), greater Loin eye area MLT by 7.1 cm^2 or 13.50% (P <0.001).

Based on the results of the analysis of variance Anova: two-factor with replication, the effect of pre-slaughter weight on the slaughter weight of

pigs was established at the level of 91.6% ($F_{1036.7}>F_{crit3.96}$) (Figure 1).

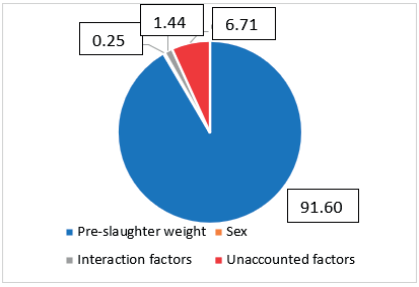

Figure 1. Influence of pre-slaughter weight and sex on the slaughter weight of pigs

The interaction of sex and pre-slaughter weight had an effect on slaughter weight with 1.44% ($F_{16.25}>F_{crit3.96}$). The sex factor had no significant effect on the slaughter weight of pigs. Unaccounted factors had an impact on slaughter weight at the level of 6.71%.

The weight of the chilled carcass was influenced by pre-slaughter weight and the interplay of sex and pre-slaughter weight, which had a significant effect at the level of 91.39% ($F_{980.23}>F_{crit3.96}$) and 1.33% ($F_{14.22}>F_{crit3.96}$), respectively . Sex did not affect the weight of the chilled carcass, and unaccounted factors had an effect on it with a strength of 7.09% (Figure 2).

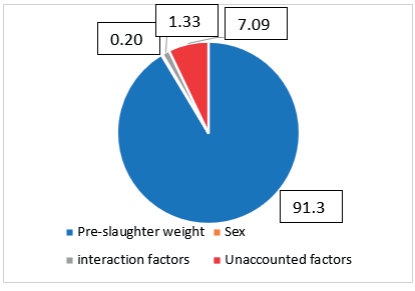

Figure 2. Influence of pre-slaughter weight and sex on the weight of the chilled carcass

The rate chilling losses depended reliably both on the pre-slaughter weight of pigs by 55.72% ($F_{108.36}>F_{crit3.96}$), and on the interplay of sex and pre-slaughter weight by 3.19% ($F_{6.21}>F_{crit3.96}$). The sex factor did not directly have a statistically confirmed effect on chilling losses. At the same time, unaccounted factors had an influence on the specified indicator with a strength of 39.08% (Figure 3).

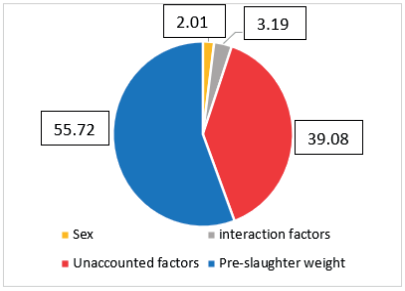

Figure 3. Effect of pre-slaughter weight and sex on chilling losses

Fat thickness over the 6-7 thoracic vertebrae was significantly dependent on the influence of only pre-slaughter weight at the level of 25.75% ($F_{30.05}>F_{crit3.96}$). Sex, the interaction factors had no effect. Other factors had an impact on the thickness of the fat over the 6-7 thoracic vertebrae with a strength of 65.11% (Figure 4).

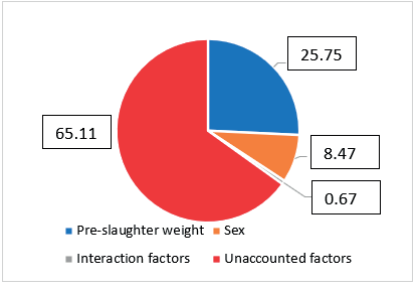

Figure 4. Influence of pre-slaughter weight and sex on the thickness of fat over the 6-7 thoracic vertebrae

Fat thickness in the withers had a probable dependence both on pre-slaughter weight by 27.42% ($F_{31.33}>Fcrit_{3.96}$) and on sex by 5.87% ($F_{6.70}>F_{crit3.96}$) (Figure 5).

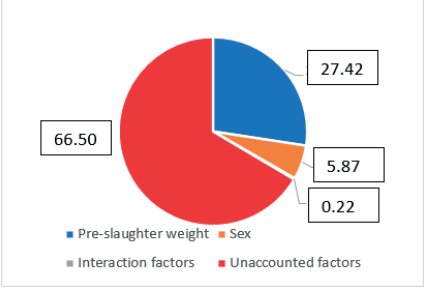

Figure 5. Influence of pre-slaughter weight and sex on the thickness of fat in the withers

The interaction of sex and pre-slaughter weight did not affect the thickness of fat in the withers, unaccounted factors had an effect on it at the level of 66.50%/

Fat thickness in the buttocks also depended reliably on the influence of pre-slaughter weight by 11.42% ($F_{13.81}>F_{crit3.96}$), pig sex by 22.98% ($F_{27.78}>F_{crit3.96}$) and unaccounted factors by 62.85%. The interaction of sex and pre-slaughter weight did not affect the thickness of fat in the sacrum (Figure 6).

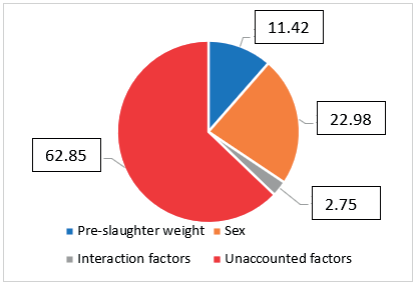

Figure 6. Influence of pre-slaughter weight and sex on fat thickness in buttocks

Pre-slaughter weight influenced carcass length with a strength of 49.92% ($F_{93.69}>F_{crit3.96}$). Sex affected carcass length at the level of 4.77%, and the interaction of factors had an effect on carcass length with a strength of 4.81% ($F_{9.03}>F_{crit3.96}$). Carcass length depended on other factors by 40.50% (Figure 7).

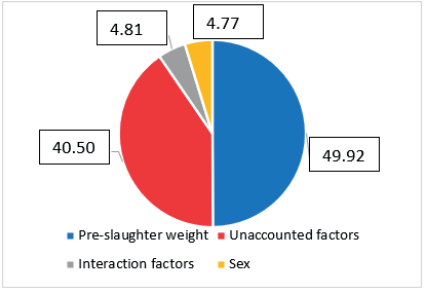

Figure 7. Influence of pre-slaughter weight and sex on carcass length

The indicator of the Loin eye area MLT had a probable dependence only on the indicator of pre-slaughter weight by 23.36% (Figure 8).

Neither sex nor the interaction of sex and pre-slaughter weight had any effect on him. Also, unaccounted factors had an impact on the area of the longest muscle of the back with a power of influence of 71.96%.

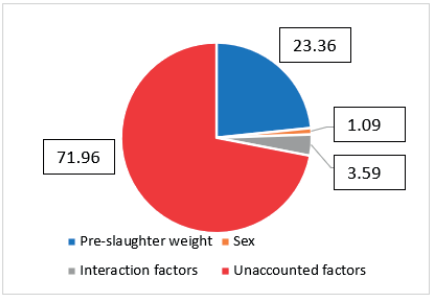

Figure 8. Influence of pre-slaughter weight and sex on the Loin eye area MLT

Variance analysis showed the absence of a probable relationship between the content of meat from the carcass and pre-slaughter weight, sex of animals, interaction of sex and pre-slaughter weight. However, unaccounted factors had an impact on the content of meat from the carcass with a strength of 93.98% (Figure 9).

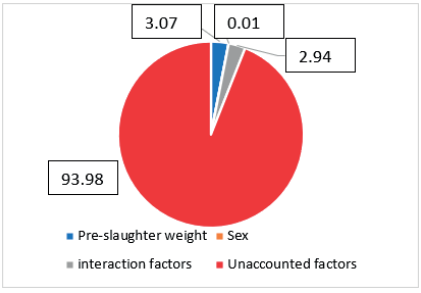

Figure 9. Influence of pre-slaughter weight and sex on meat content

We have found in our studies that, when the slaughter weight increases to 120 kg, the fat thickness increases in different parts of the carcass of gilts, as other authors have also found, namely especially on the abdomen (Correa et al., 2008), on the back (Kim et al., 2005) and on the buttocks (Hwang et al., 2020; Liu et al., 2021). However, this could not be confirmed for barrows in our studies. In contrast to the report (Hwang et al., 2020), we did not observe an increase in buttock fat thickness with increasing weight in barrows with increasing pre-slaughter weight. The common data (Correa et al., 2008) about the increase in the Loin eye area MLT

with an increase in the pre-slaughter weight of pigs were also confirmed in our experiment in both gilts and barrows. However, we could not find any influence of sex on the Loin eye area MLT in heavy (120 kg) and light (100 kg) gilts and barrows as reported by other researchers (Povod et al., 2022). According to popular opinion (Povod & Khramkova, 2018), an increase in the pre-slaughter weight of pigs before slaughter leads to an increase in losses during chilling because the surface area of the carcass increases, thus increasing the area for moisture evaporation and weight loss. We found a similar trend in our study - chilling losses increased with pre-slaughter weight. However, sex had no effect on the increase in chilling losses. A number of researchers (Wu et al., 2017) confirm an increase in slaughter yield with an increase in pre-slaughter weight of pigs by 0.41% per 10 kg increase in weight. In our experiment, we were also able to confirm such a tendency towards an increase in the indicator for slaughter yield with increasing weight. However, we found that the increase in carcass yield was more significant, in particular it was 4.45% per 10 kg in gilts. However, the increase in weight before slaughter in barrows did not lead to an increase in carcass yield.

The effect of weight before slaughter on meat content was absent in barrows, which agrees with the data (Shevchuk, 2019), but completely contradicts the report (Mykhalko et al., 2022), where an almost synchronous increase in meat content with pre-slaughter weight was found. However, it can be noted that similar to the data (Wu et al., 2017), an increase in pre-slaughter weight in gilts resulted in a decrease in meat content, which is in contrast to the other reports (Peinado et al., 2012), which spoke of the same meat yield regardless of sex in both gilts and in barrows during the increase in pre-slaughter weight.

An increase in pre-slaughter weight resulted in an increase in carcass length, as reported by other authors (Wu et al., 2017), and sex had no effect on this indicator, as reported by other researchers (Overholt et al., 2016; Xie et al., 2022).

CONCLUSIONS

The study showed a probable influence of slaughter weight and sex of pigs on most of their slaughter quality, except for meat content. In particular, pre-slaughter weight caused an increase in slaughter weight, slaughter yield, chilling losses, fat thickness in three points of the carcass, carcass length and Loin eye area MLT in both gilts and barrows. However, pre-slaughter weight had no effect on meat content, on slaughter yield and chilled carcass weight in barrows.

Sex increased fat thickness above the 6-7th thoracic vertebrae, fat thickness in the buttocks and fat thickness in the withers, the Loin eye area MLT, the meat content of 100 kg of pigs. In 120 kg pigs, sex increased slaughter weight, slaughter yield, chilling losses, fat thickness above the 6-7 thoracic vertebrae, fat thickness in buttocks.

Thus, the use of gilts with a pre-slaughter weight of 100 kg is recommended for obtaining a higher meat yield and producing the longest back muscle with a larger area. Increasing the pre-slaughter weight of gilts up to 120 kg improves the slaughter yield without increasing the thickness of fat in different parts of the carcass compared to increasing the pre-slaughter weight of barrows, and therefore it allows to obtain leaner pork.

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