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Evaluation of beef carcass quality using the muscle eye area *M. longissimus dorsi*

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ABSTRACT

In Japan, Korea, the USA, and Australia, the area of the "muscle eye" (cross-section of the *M. longissimus dorsi* during the division of the half-carcass between the 12th and 13th rib into the front and rear parts) is used to assess the quality of cattle carcasses. The correlation between this feature and the slaughter and quality characteristics of carcasses in 20-22-month-old crossbred bulls (Ukrainian Black-and-White Dairy × Holstein) has been studied. The area of the "muscle eye" in bulls was determined before slaughter by an ultrasound analyzer Emperor 860. After slaughter, it was calculated by the length and depth of the "muscle eye". The colour of muscle and adipose tissue, carcass conformation, development, and subcutaneous fat thickness have been examined. The correlation between the size of the "muscle eye" and carcasses' quantitative and qualitative characteristics has been determined. The area of the "muscle eye" has a positive relationship (r = 0.612; p >0.999) with live weight after fasting, carcass weight (r = 0.598; p >0.999), flesh weight (r = 0.498; p >0.99), including the highest (r = 0.745; p >0.999), and first grade (r = 0.662; p >0.99), the amount of adipose tissue (r = 0.491; p >0.99) and tendons and ligaments (r = 0.435; p >0.99). With its increase, there is a tendency to an inverse relationship with the content of second-grade flesh in the carcass (r = 0.303), carcass conformation (r = 0.147), fat-irrigation thickness (r = 0.125), and marbling (r = 0.340). The area of the "muscle eye" is inversely correlated with the development of subcutaneous fat (r = -0.389; p >0.95) and the saturated colour of muscle tissue (r = -0.309). The correlation coefficients between the area of the "muscle eye" determined by ultrasound and quantitative and qualitative characteristics of carcasses are significantly higher than those obtained by post-slaughter calculation of the area of the muscle eye by measuring the length and depth. The data's practical significance is obtaining knowledge that allows beef to be sorted based on the correlation between the muscle eye area and the quality of carcasses and beef.

Keywords: marbling of beef, carcass weight, carcass yield, meat colour, fat colour, fatness, carcass conformation

INTRODUCTION

The evaluation of cattle carcasses in Ukraine and in developed countries is different. According to DSTU 4673-2006 "Cattle for slaughter. Technical specifications" **[1]**, beef is evaluated by pre-slaughter live weight, fatness, and carcass weight. In the European Union, beef carcasses are classified according to the EUROP system **[2]**. According to this system, the conformation (meatiness) of carcasses (grades E, U, R, O, P) and the development of adipose tissue (5 main grades) are determined. DSTU 4673:2006 **[1]** and the EUROP system **[2]** do not take into account the area of the "muscle eye" (the cross-section of the *M. longissimus dorsi* between the 12th and 13th rib during carcass cutting). The above-mentioned regulations only assess the quantitative characteristics of beef, but not its nutritional quality. In the world, the production of meat from cattle is adapted to the consumer's taste. It is selected for its sensory characteristics- the most important signs of nutritional value

- tenderness, juiciness, taste, and aroma. To establish the quality grade of carcasses and make a decision on the use of a particular cut by the consumer, the area of the "muscle eye" is considered the main feature by the standards of Japan **[3]**, Korea **[4]**, the United States **[5]** and Australia **[6]**. Therefore, the justification for the need to include the area of the "muscle eye" in Ukraine's regulatory documents on the classification of cattle carcasses is relevant to the livestock economy.

Analysis of recent research and publications. In Ukraine, beef is produced from dairy, combined, and beef cattle breeds and crossbreeds obtained from their crossbreeding. The largest share of cattle is Ukrainian Black-and-White and its crossbreeds with Holstein. A significant diversity of breeds is associated with differences in the quality and quantity of beef yield **[7]**, so there is a need to assess the characteristics of meat of each genetic group of animals. The features of quantitative and qualitative characteristics of meat from cattle with different areas of the "muscle eye" are not sufficiently disclosed. The area of the "muscle eye" significantly depends on the direction of breed productivity **[8]** and the breed of animals **[9]**. Thus, in 22-month-old bulls of the Ukrainian beef breed, the size is 133.5 cm^2, which is 30% more (p >0.999) than in their peers of the Ukrainian Black-and-White dairy breed **[8]**. In 30-month-old Hanvoo bulls, the average area of the "muscle eye" is 87.4 cm^2 **[10]**.

It has been proved **[8]** that increasing the slaughter age of Ukrainian beef bulls from 20 to 22 months had virtually no effect on the area of the "muscle eye". The cross-section of *M. longissimus dorsi* in bulls tends to increase in diameter when they reach a live weight of 500 kg, after which its growth slows down. The area of the "muscle eye" depends on the growth rate of bulls from birth to slaughter. Thus, its increase by 100 g helps to improve the cross-sectional area by 9%. Thus, increasing the growth rate of young animals, which improves protein deposition in muscle tissue, is one of the main ways to influence the muscle eye area within a breed.

A positive correlation between the area of the "muscle eye" and the pre-slaughter live weight and carcass weight has been found **[10]** in Hanvoo beef bulls. According to our data **[8]**, the area of the "muscle eye" in cattle of the Ukrainian meat breed directly correlates with slaughter weight (r = 0.614; p >0.95) and carcass yield (r = 0.653; p >0.95). This indicates its connection with the growth of muscle tissue. The data on the correlation between the area of the "muscle eye" and quantitative features of beef in specialized meat animals cannot be used as a basis for interpreting them for dairy cattle. Therefore, the study aimed to evaluate the correlation between the area of the muscle eye and quantitative features of beef yield after slaughter and qualitative features of carcasses in crossbred bulls from Ukrainian Black-and-White dairy cows and Holstein bulls.

Scientific Hypothesis

Previous studies on Ukrainian beef bulls have shown that better development of the "muscle eye" area directly correlates with slaughter weight and muscle tissue content in the carcass, particularly in the highest and first grades. No positive correlation has been confirmed with beef quality features, including sensory and processing properties and chemical composition. It is assumed that the "muscle eye" area in animals correlates with other quality features of the carcass – marbling, conformation, development, and thickness of the subcutaneous fat, which affect certain sensory and technological properties of beef. The relationship between the area of the "muscle eye" and the quantitative and qualitative features of beef in crossbred animals from the Ukrainian Black-and-White dairy and Holstein breeds may differ from the general features of their correlation in beef cattle.

MATERIAL AND METHODOLOGY

Samples

The study was conducted at the Zhuravushka farm in Brovary district, Kyiv region. 26 crossbred bulls from Ukrainian Black-and-White dairy (UBW) cows and Holstein (H) bulls were used in the study. From birth to 4 months of age, the bulls were housed in groups and fed dairy feed. During the dairy period, they were fed 547 kg of milk and 182 kg of skim milk. The animals had free access to hay and concentrated feed. The bulls were raised and fattened at the fattening site until they reached 20 to 22 months. The feed needs of the animals were met by the farm's feed base. At the site, bulls were kept in groups based on their age. The animals had free access to concentrated, roughage, juicy feed, and in summer to green fodder and mineral fertilisers, which were fed from self-made troughs by the rations developed on the farm.

During the eye animals lifetime, muscle eye area was determined using Emperor 860 according to the recommendations given in the international methodology of ICAR **[11]**. Animals at the slaughterhouse, after fasting, were fixed in a split, and the hair was cut in the study area to a hair length of no more than 1.5 cm. Before the ultrasound scanning, a gel was applied to the measurement site to ensure maximum contact between the transducer and the skin. To measure the area of the "muscle eye", the device was placed in the area of the *M. longissimus dorsi* between the 12^{th} and 13^{th} ribs. After the ultrasound examination, the bulls were slaughtered in the slaughterhouse of the Zhuravushka farm in the village of Kalynivka. Before slaughter, before and after a 24-hour fast, the live weight of the bulls was determined by weighing. Fasting was carried out with free access to

water. The slaughter of animals was carried out by the European Regulation No. 1099/2009 "On the protection of animals at the time of killing" **[12]**. After the slaughtering process was completed, paired bull carcasses were weighed and visually assessed for conformation and fatness according to the EUROP (2008) system **[2]**. The conformation of carcasses was evaluated on a scale of five grades (from 1 = thin to 5 = very fat), 15 subgrades from E+ (very high muscle development) to P- (very low muscle development). For statistical analysis, a numerical transformation was performed on a scale from 1 (corresponding to P-) to 15 (corresponding to E+). The carcasses were cooled and stored at 2 °C for 24 hours. Chilled half-carcasses were cut into quarters between the 12^{th} and 13^{th} rib. The thickness of subcutaneous fat was assessed in the area of the 12^{th}-13^{th} rib using a ruler, and the length and depth of the "muscle eye" were measured on the cross-section of the *M. longissimus dorsi*, at the point where the carcass was divided into front and back parts, according to the scheme shown in Figure 1. The uniformity of colour of muscle and adipose tissue was determined on a scale from 1 to 7 according to the methods described in JMGA **[3]**.

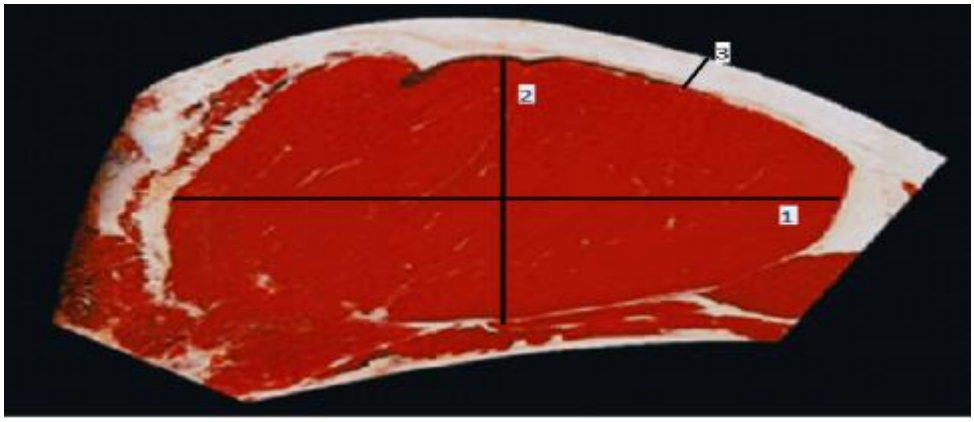


Figure 1 Length (1), depth (2) of the "muscle eye", (3) thickness of subcutaneous fat.

The area of the "muscle eye" was calculated according to (formula 1) under the order of the Ministry of Agriculture of Ukraine No. 290 of 06 August 2004 **[13]**:

$$S = 1 \times 2 \times 0.8 \quad (1)$$

Where:
S is the area of the "muscle eye", cm^2; 1 is the length of the "muscle eye", cm; 2 – depth of the "muscle eye", cm; 0.8 – coefficient.

According to the EUROP (2008) system **[2]**, the subcutaneous fat coverage of carcasses was assessed visually and divided into five grades (from 1 = thin to 5 = very fat). The marbling of meat was determined using a 12-point scale according to the JMGA (2000) **[3]**. All qualitative characteristics of the carcasses were evaluated by the "Rules for Slaughter Veterinary Examination of Animals and Veterinary and Sanitary Examination of Meat and Meat Products" (2002) **[14]**.

Chemicals

Gel for ultrasound examination (Himlaborreactiv LLC, Ukraine).

Animals, Plants and Biological Materials

Carcasses of crossbred bulls from Ukrainian Black-and-White dairy cows and Holstein bulls belonging to the Zhuravushka farm in Brovary district, Kyiv region.

Instruments

Static scales 4BDU-15X-P (Axis, Ukraine).
Weighing unit >0.5 kg, weighing range from 10 to 1,500 kg.
Weighing bulls monthly and before slaughter.
Machine for fixing animals.
Ruler.

Laboratory Methods

Scales from 1 to 7 are used to determine muscle (Figure 2), adipose tissue (Figure 3), marbling (Figure 4), conformation (Figure 5), and subcutaneous fat (Figure 6).

Figure 2 Scales for assessing muscle tissue colour according to the methodology (JMGA) **[3]**.

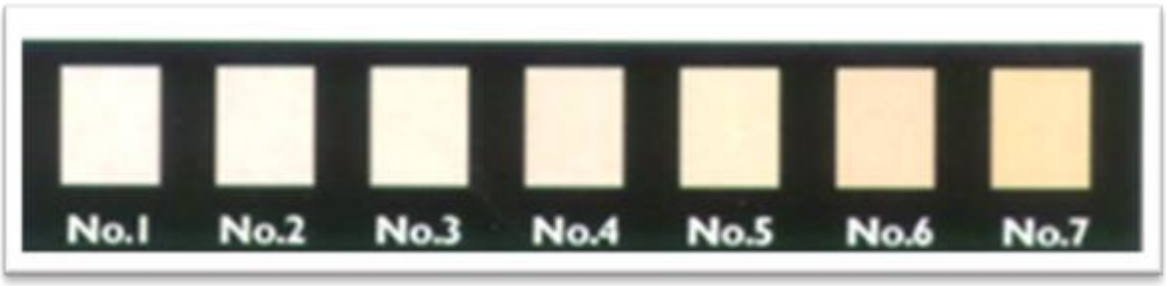


Figure 3 Scales for assessing the colour of adipose tissue according to the methodology (JMGA) **[3]**.

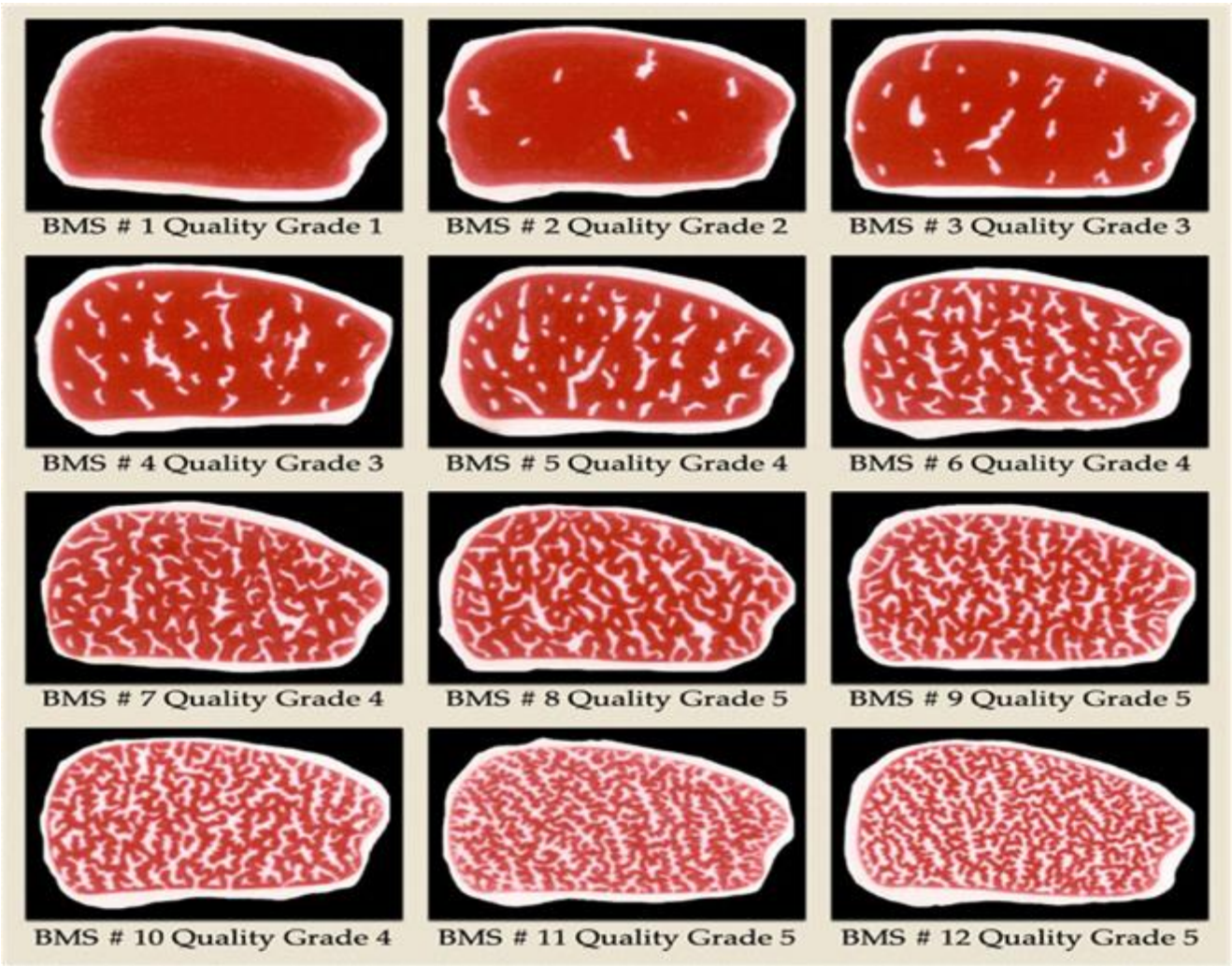
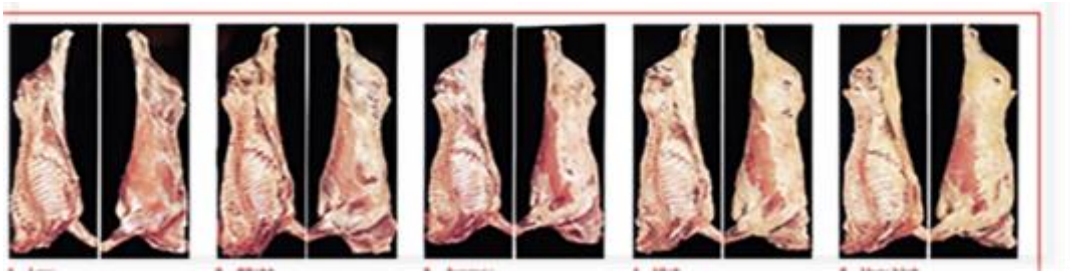


Figure 4 Scales for assessing the marbling of *M. longissimus dorsi* (JMGA) **[3]**.

(E) (U) (R) (O) (P)

Figure 5 Scales for assessing the conformation of carcasses (EUROP) **[2]**.



1 2 3 4 5

Figure 6 Scales for assessing the development of subcutaneous fat according to the EUROP system **[2]**.

Portable ultrasound scanner Emperor 860 (manufactured by Shenzhen Emperor Electronic Technology, China).

Description of the Experiment

Sample preparation: There are European Regulation No. 1099/2009 of 24 September 2009 "On the protection of animals at the time of killing" **[12]** and the Rules for Slaughter and Pre-Slaughter Veterinary Examination of Animals and Veterinary and Sanitary Examination of Meat and Meat Products (2002) **[14]**.

Animal preparation: Before slaughter, animals were fasted for 24 hours with free access to water. After slaughter, the conformation of the carcasses and the development of subcutaneous adipose tissue were visually examined. After 24 hours of storage at 2 °C in a refrigerator, the thickness of the subcutaneous fat, muscle marbling, and the length and depth of the "muscle eye" were determined.

Number of samples analyzed: in the experiment, one sample from each animal was used to analyse the qualitative characteristics of 26 carcasses of *M. longissimus dorsi* of the left half of them.

Number of repeated analyses: The value of the qualitative feature of the area of the "muscle eye" in the carcasses of slaughtered bulls was determined once during the animals' lives and once after slaughter.

Number of experiment replication: Each study was carried out five times, and the number of samples was three, resulting in fifteen repeated analyses.

Design of the experiment: In the first stage, 26 crossbred bulls were kept in a group from birth to 4 months of age. Then, the animals were fed with feed produced on the farm at the fattening site. In the second stage, the bulls were slaughtered in the slaughterhouse (Kalynivka village) by the requirements of European Regulation No. 1099/2009 **[12]**. After slaughtering the bulls, the degree of coverage of carcasses with subcutaneous fat was determined, the conformation (muscularity) of carcasses and the thickness of subcutaneous fat, the colour of muscle and adipose tissue, and the marbling of *M. longissimus dorsi* were assessed. At the last stage, the correlation between the area of the "muscle eye" and the quality properties of the carcasses was studied.

Statistical Analysis

The data obtained were statistically processed using Microsoft Excel 2016 and XLSTAT. The studied indicators were evaluated by correlation coefficients calculated according to the appropriate methods **[15]**.

RESULTS AND DISCUSSION

The live weight of bulls after 24 hours of fasting and carcass weight are the main signs of meat productivity, positively and significantly correlated with the area of the "muscle eye" of *M. longissimus dorsi* (Table 1). This indicates that the process of muscle tissue formation is closely correlated with the growth of animals since an increase in their live weight mainly determines the development of muscles. When using the evaluation of the area of the "muscle eye" by ultrasound during the life of 21-month-old animals, a significantly higher positive probable correlation was established. Studies **[16]** also found that the area of the "muscle eye" of *M. longissimus dorsi* significantly correlated with the slaughter weight of experimental animals, depending on their genotype. There was no correlation between the area of the "muscle eye" and the slaughter yield (carcass).

Table 1 Correlation coefficients between the area of the "muscle eye" and slaughter signs of commercial bulls.

Slaughter age	Sign			
	n	live weight after fasting	carcass weight	carcass yield
From 20 to 22 months	26	0.612***	0.598***	0.018
including at 21 months	21	0.613**	0.611**	0.107
including at 21 months for the use of ultrasound	11	0.916***	0.912***	-0.045

Notes: **)p >0.99; ***)p >0.999.

The nutritional value of beef is significantly influenced by muscle and adipose tissue. Connective and bone tissues – no. In our study, a positive significant relationship between the area of the "muscle eye" and the content of muscle tissue in the carcass, in particular of the highest and first grades, was proved (Table 2).

Table 2 Correlation coefficients between the area of the "muscle eye" and the absolute values of the morphological composition of carcasses of crossbred bulls.

Feature	Age		
	20 to 22 months (n = 26)	including at 21 months (n = 21)	including at 21 months (n = 11) for the use of ultrasound
Muscle tissue	0.498**	0.550**	0.931***
in particular of the highest grade	0.745***	0.727***	0.831***
-//- first grade	0.662***	0.718***	0.926***
-//- second grade	-0.303	-0.227	0.958***
Fatty tissue	0.491**	0.579**	0.437
Tendons and ligaments	0.435*	0.593**	-0.023
Bones	0.093	-0.014	0.758**

Notes: *)p >0.95; **) p >0.99; ***) p >0.999.

A significant positive correlation was previously established in animals between the area of the "muscle eye" and the content of premium muscle tissue **[17]**, valuable cuts **[18]**, and the proportion of flesh **[16]**.

A direct significant correlation was found between the area of the "muscle eye" and carcass weight, the amount of muscle tissue, in particular of the highest and first grades, can be explained by the fact that the *M. longissimus dorsi* muscle is located mainly in the thoracic and lumbar regions of the carcass. These are the most valuable cuts, and their muscle tissue makes up a significant proportion. The data presented in Table 2 and obtained in studies **[16]**, and **[17]** indicate that the area of the "muscle eye" of *M. longissimus dorsi* can be used to predict the amount of muscle tissue in carcasses and its belonging to the highest and first grades, which indicates a higher yield of valuable cuts for which the consumer pays the highest price. The conclusion that it is possible to use the data on the area of the "muscle eye" to predict the amount of beef produced and its belonging to a certain grade was also pointed out by other authors **[19]**.

A positive correlation was found between the area of the muscle eye and the total fat content of the carcass. A similar correlation between the area of the "muscle eye" and the fat content of the carcass was also found in other studies **[20]**. There was also a direct correlation between the cross-sectional area of *M. longissimus dorsi* and the content of tendons and ligaments in the carcass. There is practically no correlation between the number of bones in the carcasses of slaughtered animals and the area of the "muscle eye". This can be explained by the fact that

the growth of muscle tissue (including *M. longissimus dorsi*) and adipose tissue in the ontogeny of cattle is relatively faster bone growth is slower, and the correlation between the area of the "muscle eye" of the muscle under study and the bone content is much smaller. There is an inverse correlation between the cross-sectional area of *M. longissimus dorsi* and the amount of second-grade beef contains a significant amount of fat not separated from the muscle during deboning.

Statistical analysis was used in the following aspects of the research described above:

- comparative analysis: the quality of beef carcasses was compared between different groups of animals according to the indicators of the "muscle eye" zone, and the average size and structure of muscle fibers were compared.
- correlation analysis: relationships between various quality parameters of the beef carcass and indicators of the "muscle eye" zone, such as muscle mass, fat content, and moisture, were established.
- analysis of changes over time: studies are conducted in dynamics, and changes in the quality of the beef carcass and its "muscle eye" zone over time (for example, changes in the diet and physical activity of animals) have been studied.
- factor analysis: the influence of various factors on the quality of beef carcass was established through the analysis of the "muscle eye" zone.

The purposeful use of statistical analysis in this context was the collection of objective data, their analysis to identify dependencies and regularities, as well as support decision-making in the field of beef production with maximum quality indicators.

Evaluating the correlation between the area of the “muscle eye” and the quality characteristics of carcasses by international standards established a tendency for correlation with carcass conformation, the thickness of subcutaneous fat, and the colour of muscle and adipose tissue (Table 3).

Table 3 Correlations between the area of the “muscle eye” and the quality features of bull carcasses.

Age	Features					
	carcass conformation	**development of subcutaneous fat**	**thickness of subcutaneous fat**	**marbling of beef**	**colour of muscle tissue**	**colour of adipose tissue**
From 20 to 22 months (n = 26)	-0.147	-0.389*	-0.125	-0.340	-0.309	0.126
In particular. at 21 months (n = 21)	-0.185	-0.382	-0.183	-0.441*	-0.369	0.041
In particular. at 21 months for the use of ultrasound (n = 11)	0.018	-0.202	-0.033	0.136	-0.311	-0.100

Note: *) $p > 0.95$.

There was a correlation ($p > 0.95$) between the area of the “muscle eye” and the development of subcutaneous fat. This indicates that *M. longissimus dorsi* develops better with poorer carcass fatness. In their research **[20]**, they also proved that carcass yield and the proportion of edible parts of muscle tissue decrease in the presence of a significant amount of subcutaneous fat. That is, better development of subcutaneous fat and carcass fatness, in particular, antagonizes the area of the “muscle eye” and simultaneously reduces the amount of valuable edible parts in the carcass. Studies **[38]** have also found a significant correlation between the area of the muscle eye and carcass fatness, depending on the genotype of the animals. In addition, we **[21]** proved that the better development of adipose tissue under the skin did not correlate with the sensory characteristics of cooked beef and beef broth, as well as water retention, penetration, and marbling. Animals with better subcutaneous adipose tissue development consume more feed for growth **[22]**. This reduces the fat content in the middle of the muscles **[23]** and does not improve beef quality **[24]**. The development of adipose tissue depends on inbreeding **[22]** and positively affects the expression of meat forms **[25]**. Since subcutaneous fat has a low commercial value, it is considered **[26]** a waste, and technological aspects of diesel fuel production from it are developed **[27]**.

In the processing industry, fat from cattle has no high nutritional value. Therefore, the consumer's healthy diet aims to replace fatty raw materials with lean ones. The biological value of meat and its health properties for humans are improved by rosemary extract **[28]**, iodine compounds **[29]**, protein-wheat texture **[30]**, organic nitrite based on chard powder with the bacterial culture **[31]**, sea salt and natural dye betanin and beet juice **[32]**, a sourdough starter based on a combination of *Staphylococcus carnosus, L. plantarum, L. rhamnosus,* and *L. paracasei* (SC 2) **[33]**, a complex food supplement based on animal and plant raw materials in an amount of 0.5 to 1.5% in the dry form **[34]**, and fine grinding **[35]**. According to our data, there is a tendency for a correlation between the area of the "muscle eye" and the conformation of carcasses, which is slightly correlated with the development of fat and its thickness, since fatter carcasses are visually assessed as meatier. A study **[36]** also found a strong positive correlation between conformation score, carcass weight, and percentage of collapsed muscle tissue.

An inverse correlation exists between the area of the "muscle eye" and marbling (inclusions of adipose tissue in muscle bundles). The marbling of beef is the main factor determining its good sensory characteristics **[39]**. No factor has a more favourable effect on beef's flavour than marbling **[40]**. Cuts of meat with greater marbling have a better flavour. Since the area of the "muscle eye" directly correlates with the quantitative characteristics of beef, it can be effectively used in assessing the quality of cattle carcasses. The USDA **[5]**, EUROP **[2]**, JMGA **[3]**, and MSA **[6]** methods, it is supplemented by the severity of meat marbling. The composition of beef is influenced by the breed **[41]**, the content of intramuscular fat and its fatty acid composition, the sex and age of the animal at the time of slaughter, and the feeding and housing systems.

There is an inverse correlation between the area of the "muscle eye" and the thickness of the subcutaneous fat. The subcutaneous fat's thickness affects beef's quality by protecting the muscles from drying out in the cold storage room during carcass cooling **[42]**. To preserve carcasses, the quantity and quality of the fat should be optimal. Thus, in 24-month-old bulls of British and British crossbreds, it was found **[43]** that a uniform thickness of adipose tissue at the level of 6.0 mm is the standard of carcass and meat product quality for consumers, providing adequate beef yield with high protein content and the amount of edible muscle tissue with low-fat content.

There is an inverse correlation between the area of the "muscle cell" and the colour of the muscle tissue. With an increase in the area of the "muscle eye", the colour of the muscle tissue was more saturated. This significantly impacts consumer choice **[44]**, as the colour of meat is used **[45]** as an indicator of its freshness and healthiness. The higher colour saturation of beef is caused by feeding cattle on pastures, and its discolouration is caused by fattening on concentrated feed **[46]**.

A tendency to a straightforward, non-significant relationship between the area of the "muscle eye" of *M. longissimus dorsi* and the colour of adipose tissue was found, which was explained **[47]** by the significant content of green fodder, silage, hay, and haylage, which are rich in carotene and relatively low in concentrated fodder in the diet of bulls. The subcutaneous fat of cattle fed on concentrated feed without green feed was yellow **[48]**.

Thus, the sign of carcass quality is the area of the "muscle eye" in crossbred bulls from Ukrainian Black-and-White dairy cows and Holstein bulls aged 20 to 22 months positively correlates with pre-slaughter and slaughter weight, the content of muscle tissue in the carcass, including the highest and first grades, the amount of adipose tissue and tendons and ligaments in the carcass. There was no correlation between the cross-sectional area of *M. longissimus dorsi* and the bone content in the carcasses. Determining the correlation between the area of the "muscle eye" and the quality characteristics of carcasses evaluated by international standards, a negative correlation was found with the development of subcutaneous fat and marbling of muscle tissue. There is a tendency for both a weak inverse correlation in bulls aged 20 to 22 months and a straightforward correlation between the area of the "muscle eye" of *M. longissimus dorsi* and the thickness of the subcutaneous fat, conformation, and colour of muscle tissue. This indicates that in bulls aged 20 to 22 months, the growth rate of the longest muscle does not depend on the carcasses' meatiness, the subcutaneous fat's thickness, and the beef's colour. Comparison of our results with the data from the literature on the correlations between the area of the "muscle eye" of *M. longissimus dorsi* and signs of slaughter and the quality properties of carcasses of animals of different breeds show that in most cases they coincide. This indicates that it is possible to use the area of the "muscle eye" to predict the composition of beef carcasses.

The results of the ultrasound examination on live animals and the determination of the "muscle eye" area on the carcass were used to verify the accuracy of its assessment. According to the recommendations of ICAR **[37]**, the difference between the scan results and the carcass assessment shall be minimal, and the correlation coefficients between them shall be at least 0.8. Our studies on bulls show that the assessment of the area of the "muscle eye" by ultrasound during life is a reliable criterion with high repeatability after slaughter. According to our data, the average difference between the prediction of the muscle eye area using ultrasound and the post-

slaughter assessment is 0.5 cm^2 at 21 months. The correlation coefficients between the two methods of determining the area of the "muscle eye" are 0.973. This suggests the possibility of using the ultrasound method to predict the composition of carcasses during the life of animals and determine their suitability for slaughter. In studies by other authors **[49]**, it was also found that ultrasound scans performed immediately before slaughter are also more effective in predicting the subcutaneous fat depot, including intramuscular fat.

Thus, with the same carcass weight and adipose tissue content, an increase in the cross-sectional area of the longissimus indicates an increase in the yield of muscle tissue in cuts, including the highest and first grades, and a greater number of steaks for which the consumer pays the highest price when selling. These are the attributes that slaughterhouse producers and processing companies are focused on. Consumers are interested in beef's nutritional value and sensory characteristics. Therefore, it is necessary to determine the relationship between the quality characteristics of beef and the area of the "muscle eye" in cattle of the main breeds of Ukraine.

Prospects for further scientific research are to study the relationship between the area of the "muscle eye" and the characteristics of beef that affect consumer demand, in particular, sensory characteristics of meat, safety indicators and dietary properties for a balanced diet. Studies on the correlation between the area of the "muscle eye" of *M. longissimus dorsi* and quantitative and qualitative features of beef shall be tested in samples from other cattle breeds common in Ukraine and carcasses of other categories, depending on the sex and age of the animals. It is also necessary to study the possibility of integrating the established correlations between the area of the "muscle eye" and quantitative and qualitative features of beef into the management methods of cattle breeding, which will allow us to obtain carcasses with the desired characteristics.

CONCLUSION

The development of the area of the "muscle eye" in the carcasses of crossbred bulls from Ukrainian Black-and-White dairy cows and Holstein bulls at the age of 20 to 22 months can predict the content of only quantitative features - carcass weight, number of cuts of the highest and first grade, content of adipose tissue and tendons and ligaments, but not qualitative features - sensory and physical characteristics and chemical composition of meat. A straightforward correlation exists between the area of the "muscle eye" and pre-slaughter live weight ($r = 0.612$; $p > 0.999$), carcass weight ($r = 0.598$; $p > 0.999$), the amount of muscle tissue ($r = 0.498$; $p > 0.99$), including the highest ($r = 0.745$; $p > 0.999$) and first grade ($r = 0.662$; $p > 0.99$), the content of adipose tissue in the carcass ($r=0.491$; $p > 0.99$). There is a tendency for an inverse correlation between the area of the "muscle eye" and the amount of second-grade muscle tissue ($r = -0.303$), the thickness of the subcutaneous fat ($r = -0.125$), marbling ($r = -0.340$), and the colour of the muscle tissue ($r = -0.309$). The area of the "muscle eye" correlates inversely with the development of subcutaneous fat ($r = -0.389$; $p > 0.95$), and directly with the number of tendons and ligaments ($r = 0.435$; $p > 0.95$). In the future, studies shall be conducted to determine the correlation between the area of the "muscle eye" of *M. longissimus dorsi* and quantitative and qualitative features of beef and management factors for growing and fattening animals of other cattle breeds common in Ukraine to establish a compromise between the quality features of carcasses and beef.

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Conflict of Interest:

The authors have no conflicts of interest.

Ethical Statement:

According to Protocol No. 10 of 18.04.2020 at the meeting of the Ethics Commission of the Faculty of Livestock Raising and Water Bioresources, National University of Life and Environmental Sciences of Ukraine, Act No. 3 and 4 were signed during the experimental research, i.e. in the process of the slaughter of cattle "all the

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