potravinárstvo®
OPEN ACCESS
Received: 2.3.2023
Revised: 24.4.2023
Accepted: 2.5.2023
Published: 9.5.2023

Slovak Journal of Food Sciences

Potravinarstvo Slovak Journal of Food Sciences
vol. 17, 2023, p. 358-370
https://doi.org/10.5219/1869
ISSN: 1337-0960 online
www.potravinarstvo.com

The expressiveness of meat forms of cattle depending on the content of adipose tissue under the skin and between the muscles

Anatolii Ugnivenko, Olha Kruk, Dmytro Nosevych, Tetiana Antoniuk, Yuliya Kryzhova, Mykola Gruntovskyi, Nataliia Prokopenko, Viktor Yemtcev, Iryna Kharsika, Nataliia Nesterenko

ABSTRACT

The paper covers the peculiarities of the degree of meat shapes in the bulls of the Ukrainian meat breed, depending on the adipose tissue content under the skin and between the muscles. They were evaluated according to their productivity from 8 to 18, 21, and 23 months. Bulls with better development of meat shapes are characterized by fat deposition in the carcass and between the muscles earlier and more intensively. They have from 15.1 to 44.7% more fatty tissue in the carcass, including under the skin – from 3.8 to 44.1%. With a different degree of meat shapes, subcutaneous fat is deposited more than between muscles. The content of adipose tissue under the skin relative to its total amount in the body of animals tends to decrease by 6.5 points with age for a better degree of meat shapes, and on the contrary, to increase by 2.6 points for a worse degree. If the fat under the bull skin at 18 months in the best shapes is 72.1% of the fat in the carcass, and in the worst – 72.3%, then at 23 months, its amount decreases by 13.6 and 4.4 points, respectively. The fat between the muscles, on the contrary, increases from 27.9 and 27.7% by the same amounts, respectively. With a greater degree of meat shapes and subcutaneous fat thickness on the carcasses of 18-month-old bulls, intramuscular fat (marbling) content is lower by 75.0%. 18-month-old bulls with better-developed meat shapes have fat cuts off from the carcass by 15.2% more than animals with less developed shapes, 23 – by 11.3%. A large amount of produced waste in the body of animals in the best meat shape leads to excessive (from 0.9 to 14.5%) feed consumption (feed unit) for the increase in live weight. The subcutaneous fat content and the number of cuts off from 16 to 24 months positively correlate with the degree of meat shapes in bulls at 15 months and have correlation coefficients of 0.26 and 0.17, respectively.

Keywords: degree of meat shapes development, subcutaneous fat, adipose tissue, muscle, bulls, Ukrainian meat breed

INTRODUCTION

The degree of meat shape development is affected by the development of adipose tissue under the skin and between the muscles and inbreeding **[1]**. The covering of adipose tissue on the carcass is related to the beef quality by protecting the muscles from drying out during the cooling of the carcass in the refrigerating chamber, which can lead to their stiffness. The carcass must have a sufficient fat thickness to guarantee its preservation and the desired quality for consumption **[2]**. Deposition of a large amount of fat under the skin contributes to an increase in the sexual precocity of animals **[3]**, excessive feed consumption **[4]** and its costs for live weight gain **[5]**. A low tendency to deposit fat is a problem for animals breeds with less adipose tissue under the skin and in the middle of the muscles **[6]**. The amount of adipose tissue in cattle varies depending on the breed and stock **[7]** and

homozygosity **[8]**. Beef fat has a low nutritional value in the processing industry. The healthy nutrition of people is now aimed at the partial replacement of animal fats with triglycerides with polyunsaturated fatty acids, and the introduction of raw materials of plant origin into recipes **[9]**. The biological value of beef proteins is improved **[10]** by the enzymatic method, and its use by people and health-promoting properties are improved by the addition of rosemary extract **[11]** and iodine compounds **[12]**. The issue has not been sufficiently resolved regarding the formation of the degree of meat shapes in animals with different fat content under the skin and between the muscles. This information would help explain its differences. Since the distribution of fat by fat depots is also the subject of accounting for the generation of waste, the disclosure of the features of the formation of the degree of meat shapes in cattle is necessary for the effective and purposeful production of beef for the optimal yield of its valuable quantitative and qualitative components.

This paper aims to establish the relationship between the degree of meat shapes in bulls of the Ukrainian meat breed and the content of various types of adipose tissue in their carcasses and cuts off from them.

Scientific Hypothesis

Previous studies have shown that the better degree of meat shapes in bulls harms their growth rate and breeding value, and the factors of its formation have not been confirmed. It is assumed that animals with less developed meat shapes acquire the shallow-bodied type, closely related to the body's increased metabolic processes. They should have a lower growth rate, a mass of fat in the middle of the muscles and their cuts off because the worse degree of meat shapes affects the development of individual organs that participate in them. Deposition of fat for different degrees of meat shapes may differ from the general trend of increasing the growth of animals.

MATERIAL AND METHODOLOGY

Samples

For research before slaughter, at 18, 21 and 23 months old, two groups of experimental animals were formed using the method of balanced groups by age. The first group included the animals with a degree of meat shape development above the average value for the herd. At 18 months, this value was 56.0 points, at 21 – 56.5, and 23 – 54.2 points. The second group included young animals with a degree of meat shape development less than the average value for the herd. 18 months – 49.2 points, 21 – 50.5, and 23 – 48.0 points. The research was conducted using Ukrainian meat animals (Figures 1, 2) at the Volia stud farm of the Zolotoniskyi district of the Cherkasy region. They were raised from birth to slaughter at 18, 21 and 23 months. After slaughter, fat (subcutaneous, intermuscular, its cuts off) was selected and a piece (300 g) of meat for weighing from *M. Longissimus dorsi*.

Chemicals

Solution of hydrochloric acid, 1.5%, (Khimlaborreaktyv LLC, Ukraine).
Solution of sulfuric acid, 5%, (Khimlaborreaktyv LLC, Ukraine).
Chloroform, (Khimlaborreaktyv LLC, Ukraine).

Figure 1 Bull Pavlyn 7604 CHUM – 62 has slightly better worse expressed meat forms (53.5 points). Live weight is 677 kg at the age of 18 months.

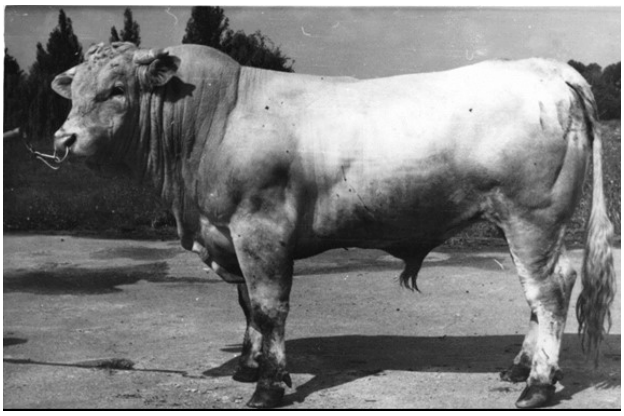

Figure 2 Bull Navodghik 6887 CHRUM – 61 with slightly better expressed meat forms (59.5 points). Live weight is 610 kg at the age of 18 months.

Animals, Plants and Biological Materials

The research was conducted with the use of Ukrainian beef bulls: Bull Pavlyn 7604 CHUM – 62 and bull Navodghik 6887 CHRUM – 61.

Instruments

Static scales 4BDU-1500X-P (Axis, Ukraine). Weight unit ≥0.5 kg, weighing range from 10 to 1500 kg.

Scales Prok (Axis, Ukraine). Weighing ranges up to 150 kg. Weighing of subcutaneous and intermuscular fat and cuts off.

Gaschromatograph (Kupol_55,Shimadzu Corporation, Japan).

Dryingcabinet (SNOL, Khimlaborreaktyv LLC, (Ukraine)

Distiller for steam distillation (Velp Scientifica UDK 129, Khimlaborreaktyv LLC, Italy)

Laboratory Methods

The formation of balanced peer groups was carried out following the requirements of Fundamental concepts of experimentation in breading. Study guide.

To determine the amount of fat in animal carcasses, bulls were slaughtered at the Cherkasy meat processing plant following the requirements of DSTU 4673:2006 **[13]** and DSTU 3938-99 **[14]**. Before that, the pre-slaughter live weight of bulls was determined by weighing them before and after a 24-hour starvation period with free access to water. After the animals were slaughtered and cleaned, their carcasses were weighed in even condition (slaughter weight) and the absolute weight of their cuts off. The left half-carcasses went through skinning and eviscerating. After that, the adipose tissue was weighed and divided into subcutaneous and intermuscular fat according to DSTU 3938-99. The absolute value and percentage of subcutaneous and intermuscular adipose tissue from the slaughter mass (carcass) were determined.

Estimation of total fat content in *M. Longissimus dorsi* was performed following DSTU ISO 1443:2005 **[15]**, protein – GOST 25011-81 **[16]**, mass total ash – DSTU ISO 936:2008 **[17]**, moisture content –DSTU ISO 1442:2005 **[18]**.

Description of the Experiment

Sample preparation: The research was conducted during the second calendar day after skinning and eviscerating slaughtered cattle at 18, 21 and 23 months. For this, 7 subcutaneous and intermuscular fat samples were selected, including 4 samples, each from animals with a better degree of meat shapes and 3 samples each with a worse degree. At the age of 21 and 23 months, samples were taken from 3 animals in groups.

Number of samples analysed: 19 samples from three conducted experiments were used for analysis. For chemical analysis of minced meat from *M. Longissimus dorsi* was taken in 18-month-old animals from both groups by three samples

Number of repeated analyses: Using the carcasses of slaughtered bulls, the weight of subcutaneous fat was determined 3 times, fat between the muscles 3 times and cuts off 3 times, which amounted to 3 repetitions, respectively, at the age of 18, 21 and 23 months.

Number of experiment replication: The study was repeated 3 times, and the experimental data were processed using mathematical statistics methods.

Design of the experiment: Research plan: the research was conducted at the "Volia" stud farm of the Zolotoniskyi district of Cherkasy region. Well-developed bulls of the Ukrainian meat breed from birth to 6-7 months were kept with their mothers as sucker bulls. After weaning, they got typical food and maintenance until 8 months. After weaning, the animals were tested for their performance from 8 to 18 months, 8 to 21, and 8 to 23 months. They were kept on a leash under individual control of the amount of given and consumed feed. Using the herd for slaughter at the age of 18, 21 and 23 months, two groups were formed, including well-developed bulls with different degrees of meat shapes. The first group included animals with a value of this indicator above the herd average, and the second group included animals below the herd average. Bulls were grouped by age using the method of balanced peer groups **[19]**. The degree of meat shape development was evaluated at 15, 18, 21, and 23 months of age on a 60-point scale following methodological instructions **[20]**.

The general level of the feeding of bulls was calculated on receiving average daily gains from 1000 to 1200 g. During this period, the animals were fed with a feed of their products according to the rations prepared according to the norms. The mass of fodder eaten by each bull was calculated every decade (two days in a row) by weighing the given fodder and its residues. Their energy value (in oat fodder units) and costs per 1 kg of live weight gain were calculated based on the consumed fodder. There was no discernible difference in the amount of feed consumed by the bulls of the groups from 8 to 18 months, 8 to 21 months, or 8 to 23 months (Table 1).

Table 1 Fodder consumption by bulls by periods.

Fodder	From 8 to 18 months		From 8 to 21 months		From 8 to 23 months	
	better (56.0 points); n = 4	worse (49.2 points); n = 3	better (56.5 points); n = 3	worse (50.5 points); n = 3	better (54.2 points); n = 3	worse (48.0 points); n = 3
Concentrated, fodder unit	1342 ±48.0	1310 ±34.5	2031 ±109.1	2049 ±72.5	2703 ±1.0	2678 ±26.0
Concentrated, %	46.3 ±26.3	48.0 ±1.95	47.5 ±0.50	47.1 ±0.50	48.7 ±0.20	48.6 ±0.45
Roughage, fodder unit	548 ±109.8	378 ±140.5	900 ±124.3	907 ±91.3	853 ±26.0	942 ±34.0
Roughage, %	18.9 ±2.79	13.8 ±4.78	21.0 ±1.77	20.9 ±1.71	15.4 ±0.40	17.1 ±0.30
Juicy, fodder unit	431 ±54.4	344 ±23.2	655 ±41.8	707 ±12.4	816 ±84.5	831 ±31.5
Juicy, %	14.9 ±1.24	12.6 ±0.82	15.3 ±0.95	16.3 ±0.65	14.7 ±1.40	15.1 ±0.25
Green, fodder unit	578 ±52.9	699 ±81.6	692 ±63.8	685 ±25.6	1174 ±80.0	1059 ±16.0
Green, %	19.9 ±1.54	25.6 ±3.31	16.2 ±1.66	15.7 ±10.10	21.2 ±1.55	19.2 ±0.10
Total, fodder unit	2899 ±208.0	2731 ±60.9	4278 ±263.3	4347 ±130.2	5546 ±29.5	5510 ±107.5
For 1 kg of grain, the fodder unit	9.5 ±1.17	8.3 ±1.44	11.1 ±0.02	11.0 ±0.04	13.2 ±0.70	13.1 ±0.85

Statistical Analysis

Variational statistics processed the obtained data according to the methods adopted in breeding and biology. Statistical processing was performed by Microsoft Excel 2016 in combination with XLSTAT. The average value and standard deviation evaluated indicators. The arithmetic mean (unweighted) value (M) and arithmetic mean were calculated. The accuracy of the obtained experimental data was determined using the Student's test for a confidence probability of ≤0.05 based on the number of parallel determinations at least 5. The results were analyzed using the ANOVA.

RESULTS AND DISCUSSION

Bulls with higher meat shapes are characterized by forming fat earlier and more intensively in the carcass (Table 2). This causes higher (from 0.9 to 14.5%) consumption of fodder (fodder unit) for live weight gain (Table 1). With the different degrees of meat shape development, subcutaneous fat is deposited more than between muscles. Bulls have better-defined meat shapes at 18 months; 44.7% more fatty tissue in the carcass, including 44.1% under the skin. A similar feature is observed in the 21st and 23rd months. For animals with a worse degree of meat shapes at the age of 21 months, compared to peers with a better degree of meat shapes, there is a tendency (by 17.6%) to increase the adipose tissue between the muscles, which in this period has the highest natural growth.

Table 2 The content of adipose tissue under the skin and between the muscles of bulls after slaughtering, depending on the degree of meat shapes.

Degree of meat shapes (points) in age, months		n	Adipose tissue, kg				
			total in the carcasses	under the skin		between muscles	
			M ±m	M ±m	to total, %	M ±m	to total, %
18	**Better (56.0)**	4	6.8 ±0.50	4.9 ±0.70	24.6	1.9 ±0.50	9.5
	Worse (49.2)	3	4.7 ±1.30	3.4 ±0.90	19.3	1.3 ±0.70	7.4
21	**Better (56.5)**	3	6.1 ±0.60	4.4 ±0.40	21.3	1.7 ±0.20	8.2
	Worse (50.5)	3	5.3 ±1.30	3.3 ±0.40	17.0	2.0 ±1.00	10.3
23	**Better (54.2)**	3	9.4 ±0.67	5.5 ±0.39	18.1	3.9 ±0.28	12.9
	Worse (48.0)	3	7.8 ±0.59	5.3 ±0.38	21.3	2.5 ±0.78	10.0

From 18 to 23 months, the content of adipose tissue under the skin relative to its total amount in the body of animals tends to decrease by 6.5 points in the case of a better degree of meat shapes, and vice versa to increase by 2.6 points in the case of the worse degree of meat shape. In animals, with different degrees of meat shape development, adipose tissue between muscles increases curvilinear, unevenly. If the fat under the bull skin at 18 months is 72.1% for the best meat shapes, and 72.3% for the worst, then at 23 months its share decreases by 13.6 and 4.4 points, respectively. The fat content between the muscles, on the contrary, increases by 27.9 and 27.7% by the same values, respectively.

The obtained data on adipose tissue content in animals under the skin and between the muscles indicate that they achieve a better degree of meat shape due to the excess deposition of subcutaneous fat, which to some extent

smooths out the defects of the exterior. With its greater accumulation, cattle is characterized by less angularity and better development of their meat shapes. A higher quantity of fatty tissue in the carcass between the muscles, which causes their displacement on the surface of the carcass, is thought to be why animals with better-defined meat forms have an advantage over peers with worse shapes **[21]**. The yield of edible portions in the carcass diminishes when a lot of fat is under the skin. It is not utilized to enhance meat's tenderness and other aspects of its quality **[22]**, **[23]**. Subcutaneous fat is viewed as **[24]** waste since it has little commercial worth.

Intramuscular or marble fat is necessary to improve beef's juiciness, tenderness and taste **[25]**. During cooking, it melts, soaking the meat. As a result, it is juicy and tender. The content of intramuscular fat in beef is the most important factor that determines its quality in Japan, Korea, Australia and the USA, while in the countries of the European Union, including France and Germany, leaner meat (with less marbling) is preferred **[26]**, **[27]**. With more meat shapes in 18-month-old bulls, the total fat content (marbling) in *M. longissimus dorsi* is lower by 75.0% compared to peers due to their poorer development (Table 3).

Table 3 Chemical composition of beef in 18-month-old animals with different degrees of meat shapes development.

Chemical composition of beef	Better (58.7 points), n = 3		Worse (49.2 points), n = 3	
	M ±m	Cv, %	M ±m	Cv, %
Total fat content	0.37 ±0.17	8.0	0.6 5±0.19	51.6
Protein	20.83 ±0.53	4.4	20.26 ±0.70	6.0
Mass total ash	1.12 ±0.04	5.4	1.04 ±0.02	3.4
Moisture	77.68 ±0.42	0.94	78.05 ±0.13	0.29

Ukrainian meat breed animals are characterized by rapid growth at the expense of muscle tissue and the formation of fat at an older age **[28]**, **[29]**, **[30]**. There was no significant difference in other components of beef's chemical composition between the groups' animals. The obtained data concerning 18-month-old animals of the Ukrainian meat breed do not confirm the connection between subcutaneous fat thickness and the marbling of *M. longissimus dorsi*, discovered **[31]**, **[32]** in bulls from Ukrainian black-spotted dairy cattle at 22 months. Its data shows it is positive and high (r = 0.68). A greater amount of fatty tissue under the skin and between the muscles in animals with better-developed meat shapes is also subject to their excessive waste formation (Table 4).

Table 4 The quantity (kg) of cuts off from the carcasses of bulls depends on the degree of the meat shapes.

Age of slaughter,	Better meat shapes			Worse meat shapes		
months	n	M ±m	Cv, %	n	M ±m	Cv, %
18	4	5.3 ±0.30	12.6	3	4.6 ±0.20	6.5
21	3	4.4 ±0.60	24.2	3	5.5 ±0.60	18.3
23	3	5.9 ±4.20	14.3	3	5.3 ±3.71	12.2

18-month-old bulls with better-developed meat shapes have 15.2% more fat cuts off from the carcass than animals with less developed forms at 23 – by 11.3%. A large amount of waste (internal fat, under the skin and between the muscles) from the body of animals with the best meat shapes, for which the processor does not pay the producer, leads to an increase (from 0.9 to 14.5%) of feed costs (feed units) on the increase in live weight (see Table 1). Thus, these cattle are less efficient for beef production. **[33]**, **[34]**.

Recently, the population of Ukraine has had a demand for marbled beef. An analysis of the latest research and publications on this issue was carried out to understand how to solve the related problems. It is believed **[35]**, **[36]**, that any food, including meat, performs the main functions of nutrition, taste and disease prevention. Concerning beef consumption in Ukraine in 2022, 6.4 kg of the need (36 kg) per average citizen, now the issue is being solved by increasing its quantity, not quality, unlike many foreign countries, where it is consumed as a source of disease prevention. An important aspect of beef quality, identified **[37]** by parts of the production chain (producer, processor, consumer), is fat deposition in the middle of the muscles. The content of intramuscular fat in beef and its nutritional quality is affected by factors that are divided **[38]** into those that occur on the farm and in the period before slaughter (breed, sex, age at the time of slaughter, housing system, feed and handling before slaughter) and after death (handling after slaughter, packaging and cooling temperature), individual genetic predisposition of animals. Therefore, we will consider only a few factors that affect the deposition of intramuscular adipose tissue and cause the most problems during its production.

Genetic factors (breed, gender and heredity).

The black breed of Wagyu cattle in Japan has the highest intramuscular fat content (marbling) in the world (more than 30%) **[39]**, and the Korean Hanwoo has the second highest content **[40]**. In animals of European breeds, the content of intramuscular fat is only 0.6-4.7% **[41]**. Wagyu is known **[42]** for a significant content of monounsaturated fatty acids and a higher ratio of them to saturated than other breeds. This does not lead to health benefits for people who consume beef with high marbling rates. Increasing the content of useful polyunsaturated fatty acids and conjugated linoleic acid in the middle of beef muscles improves its taste properties and shelf life **[43]**. Aberdeen-Angus cattle meat has the highest intramuscular fat concentration and sensory properties among European breeds. In Ukraine, no beef is not produced from Wagyu animals, and Aberdeen-Angus is not a purebred of Scottish origin but a hybrid (1/2 Aberdeen-Angus x 1/2 black and spotted Holstein), from embryos, imported once from the USA.

Heifers deposit more fatty tissue in the body than steers and bulls. The insignificant ratio of omega n-6 to omega n-3 fatty acids indicates that beef from heifers contributes to human health. Castration of bulls increases adipose tissue deposition in the middle of the muscles **[44]**. The beef of uncastrated bulls is of the worst quality and is valued lower by the consumer **[45]**. During the delivery of young animals at the meat processing enterprises of Ukraine, bulls are rated the best, and heifers the worst. Prepared bulls are not practically sold because, on farms, bulls are not castrated at a young age. The markets sell mainly not beef but veal, which practically has no intramuscular fat.

The marbling of beef increases as the animals mature and their live weight increases **[46]**, but the ratio of omega n-6 to omega n-3 fatty acids is higher in heavyweights (p >0.05) compared to lightweight **[47]**. The deposition of adipose tissue in the muscles of cattle is facilitated by feeding them with concentrated feed with a high energy content **[48]**. However, concerning the beef of animals raised on concentrated feed, there is a lower level of mono- and polyunsaturated fatty acids than in bulls fed with grass on pastures **[49]**. Increasing unsaturated fatty acids in muscles makes them more susceptible to lipid oxidation. As a result, various aldehydes, ketones, alcohols, esters and carboxylic acids are formed, affecting beef's taste. Thanks to the fattening (grazing) of animals on the grass, extraordinary juiciness of the meat were achieved. Feed energy costs for feeding young animals increase during live weight gains due to the increase of internal, subcutaneous, and intermuscular adipose tissue, which has a low commercial value and is considered **[50]** waste from beef production. For its formation, animals spend 2.25 times more feed nutrients than for forming carcass muscles. Excess energy supplied to animals in the late period of fattening significantly reduces feed efficiency due to a decrease in its digestibility, increases the amount of fat waste from them and worsens the efficiency of livestock management.

In contrast to the complexities arising in enterprises during the production of marbled beef, the processor considers the excess fat deposited in the body a problem because it must be removed from the animal or an important ingredient in the processed product. The processor does not pay the producer for a significant amount of removed internal fatty tissue, which cuts off from the carcass. Payment is made only for slaughter weight (carcasses). And with an increase in the grade of marbling of beef, which appears simultaneously with an increase in the body's fat, the percentage of carcass yield decreases **[51]**.

Consumers have different opinions about the content of intramuscular fatty tissue in beef. Some prefer lean meat; others consume beef with more fat. It is important to understand these additional requirements of various industry segments to consider how fat is deposited during the animal's life. In specific depots, inedible internal fat is deposited first, which is located in the abdominal cavity around the internal organs, then under the skin, between the muscles and in their middle (marble) **[52]**. Intramuscular fat, which is desirable for improving the palatability of meat, has a general decrease in lipogenesis and an increase in the activity of the enzyme cholesterol-25 hydroxylase in cattle **[53]**, which is synthesized from the carbon of glucose, not acetate, during intensive fattening already after the accumulation of "excess" fat between the muscles.

Marbling (intramuscular fat) in cattle is considered **[54]** to be a sign of late maturation, which becomes noticeable only after other fat depots, even though the relative rates of its increase are similar to theirs. Marbled beef generally contains more saturated fatty acids than subcutaneous fat **[55]**. Probable differences in increasing the sensory parameters of beef steaks are manifested by lower indicators of the content of intramuscular fat in it **[56]**. Therefore, a minimum level of its marbling is necessary to detect differences in the juiciness of the beef.

Intramuscular fat is deposited between primary and secondary muscle bundles in the perimysium of cattle and muscle bundles **[57]**. However, the quality of beef depends not only on the content of fat inside the muscles but also on the coordinated relationship of three of their components – intramuscular connective tissue (general and insoluble collagen that surrounds each muscle fibre and their bundles and muscle as a whole), types of muscle fibres and intramuscular fat **[58]**.

The quality of marbled beef is affected by the duration of its ripening, which also imposes costs on the cost price of the manufactured products. Beef for steaks goes under dry or wet ageing. During wet ageing, it is vacuum packed and placed in a chamber for 3-5 days in a special microclimate, during which the fibres soften, and the

meat is saturated with juices. During dry maturation, beef cuts are placed in salt chambers at certain temperatures and humidity for up to 120 days.

Consumers are increasingly concerned about the negative effects of extremely marbling beef on the human body (cardiovascular diseases and atherosclerosis). Excess omega-3 polyunsaturated fatty acids (linolenic acid, docosahexaenoic acid, eicosapentaenoic acid) increase the risk of developing prostate cancer. The main polyunsaturated omega-6 fatty acids include linoleic and arachidonic acids. For human nutrition and good health, it is possible to use food containing fat (depending on the composition and number of fatty acids) compared to saturated with simple carbohydrates **[59]**.

Thus, there are many challenges to beef production of bulls with a better degree of meat shapes, including high feed costs, disposal of untreated excreta, and food safety risks that can result from diseases caused by fatty beef. Despite the recent achievements in the world regarding the regulation of fat deposition in the muscles of cattle in the Ukrainian meat breed, this problem remains unsolved and deserves further research. We have started to develop a strategy to optimize the amount of fat deposited in the body of these animals. To predict the content of adipose tissue under the skin and between the muscles after slaughtering bulls aged 16 to 24 months based on the severity of their meat forms at 15 months of age, correlation coefficients were calculated between these indicators. The degree of meat shapes development correlates with the adipose tissue content between muscles slightly and negatively (r = -0.08) (Table 5). The highest (r = 0.26 and 0.17) positive relationship exists between the degree of meat shape development, the content of fatty tissue under the skin, and the number of cuts off the carcass.

Table 5 Correlation coefficients between the degree of the meat shapes of bulls at the age of 15 months and the fat content in their carcasses, between muscles and cuts off from 16 to 24 months.

Indicator	n	r
Subcutaneous fat	20	0.26
Intramuscular fat	20	-0.08
Subcutaneous and intermuscular fat	20	0.11
Cuts off	34	0.17

Thus, according to the degree of meat shapes, it is only possible to a certain extent to predict the amount of deposited non-commercial fat (subcutaneous and between the muscles) and waste (cuts off) obtained during the handling of carcasses. But it is difficult to judge it in terms of the amount of deposited intramuscular adipose tissue (marbling) of beef. A change in the composition of adipose tissue by any factor depends mainly on a person's ability to control its relative amount depending on the development degree of shapes of meat animals. Modern methods of regulating the deposition of adipose tissue in the middle of the muscles should limit the increase in its total content in the body, including inedible. Additional research is needed to develop methods for the production of beef with appropriate levels of marbling to satisfy its quality and taste, following consumer preferences, preserve human health and support the economy of cattle breeding under the condition of justification of the optimal degree of the meat shapes of the bulls without increasing the deposition of total inedible fat in the body, including internal and subcutaneous fat.

A deeper understanding of these complex mechanisms of body composition regulation can improve beef quality and consistency prediction, improve the selection of animals that achieve the desired final meat quality, and identify those better suited to specific diets and consumer treatments. Because of this, meat producers will be able to use a regulatory mechanism to justify the optimal degree of meat shapes of animals, determined by the demand for beef of different qualities, which helps to optimize the accumulation of fat in muscles by improving its ratio to the protein. In addition, understanding the mechanisms of increasing fat deposition and the efficiency of beef production while simultaneously reducing the degree of meat shapes and general conditions of animals will lead to better processing of animals and the overall health of the consumer.

CONCLUSION

Bulls with different degrees of meat shapes, from 18 to 23 months, have more fat deposited under the skin than between the muscles. In animals with the best meat shapes, compared to the worst ones, there is more fat tissue in the carcass from 15.1 to 44.7%, including under the skin from 3.8 to 44.1%. The content of adipose tissue under the skin relative to its total amount in the body in animals with a better degree of meat shapes tends to decrease by 6.5 points, with a worse one – on the contrary, to increase by 2.0 points. 18-month-old bulls with better-developed meat shapes have 15.2% more fat cuts off from the carcass than animals with worse development, 23 – by 11.3%. The formation of a larger amount of internal adipose tissue under the skin and between the muscles in animals causes excessive (from 0.9 to 14.5%) feed consumption (feed unit) for live weight gain. With the content of fatty tissue under the skin and the number of cuts off from the carcass from 16 to 24 months, the degree

of meat shapes at 15 months correlates slightly positively (r = 0.26 and 0.17, respectively). The degree of the meat shape development may be used to predict, to a certain extent, only the deposition of non-commercial fat (subcutaneous, between the muscles) and production waste (cuts off). Further research is needed to develop methods for the production of marbled beef, using bulls with less pronounced meat shapes without increasing the deposition of total inedible fat in the body, including internal and external (subcutaneous) fat and the appropriate level of intramuscular, to satisfy its quality and taste and save people's health.

REFERENCES

1. Ugnivenko, A., Nosevych, D., Antoniuk, T., Chumachenko, I., Ivaniuta, A., Slobodyanyuk, N., Kryzhova, Y., Rozbytska, T., Gruntovskyi, M., & Marchyshyna, Y. (2022). Manifestation of living and post-slaughter traits of productivity in inbred and outbred bull calves of Ukrainian meat cattle breed. In Potravinarstvo Slovak Journal of Food Sciences (Vol. 16, pp. 356 –366). HACCP Consulting. https://doi.org/10.5219/1769
2. Kamani, M. H., Meera, M. S., Bhaskar, N., & Modi, V. K. (2019). Partial and total replacement of meat by plant-based proteins in chicken sausage: evaluation of mechanical, physico-chemical and sensory characteristics. In Journal of Food Science and Technology (Vol. 56, Issue 5, pp. 2660–2669). Springer Science and Business Media LLC. https://doi.org/10.1007/s13197-019-03754-1
3. Naserkheil, M., Lee, D.-H., Kong, H.-S., Seong, J., & Mehrban, H. (2021). Estimation of Genetic Parameters and Correlation between Yearling Ultrasound Measurements and Carcass Traits in Hanwoo Cattle. In Animals (Vol. 11, Issue 5, p. 1425). MDPI AG. https://doi.org/10.3390/ani11051425
4. Santana, M., Rossi, P., Almeida, R., & Cucco, D. (2012). Feed efficiency and its correlations with carcass traits measured by ultrasound in Nellore bulls. In Livestock Science (Vol. 145, Issue 1-3, pp. 252–257). Elsevier BV. https://doi.org/10.1016/j.livsci.2012.02.012
5. Taussat, S., Saintilan, R., Krauss, D., Maupetit, D., Fouilloux, M., & Renand, G. (2019). Relationship between feed efficiency and slaughter traits of French Charolais bulls. In Journal of Animal Science (Vol. 97, Issue 6, pp. 2308–2319). Oxford University Press (OUP). https://doi.org/10.1093/jas/skz108
6. Suchenko, Y., Suchenko, V., Mushtruk, M., Vasyliv, V., & Boyko, Y. (2017). Changing the quality of ground meat for sausage products in the process of grinding. In Eastern-European Journal of Enterprise Technologies (Vol. 4, Issue 11 (88), pp. 56–63). Private Company Technology Center. https://doi.org/10.15587/1729-4061.2017.108876
7. Casas, E., Thallman, R. M., Kuehn, L. A., & Cundiff, L. V. (2010). Postweaning growth and carcass traits in crossbred cattle from Hereford, Angus, Brangus, Beefmaster, Bonsmara, and Romosinuano maternal grandsires1,2. In Journal of Animal Science (Vol. 88, Issue 1, pp. 102–108). Oxford University Press (OUP). https://doi.org/10.2527/jas.2009-2271
8. Zhao, G, Zhang, T., Liu, Y., Wang, Z., Xu, L., Zhu, B., Gao, X., Zang, L.P., Gao, H., & Liu, G. (2020). Genome-Wide Assessment of Runs of Homozygosity in Chinese Wagyu Beef Cattle. In Animals (Vol. 10, Issue 8, p. 1425). MDPI AG https://doi.org/10.3390/ani 10081425
9. Öztürk-Kerimoğlu, B., Kavuşan, H., Benzer Gürel, D., Çağındı, Ö., & Serdaroğlu, M. (2021). Cold-set or hot-set emulsion gels consisted of a healthy oil blend to replace beef fat in heat-treated fermented sausages. In J. Meat Science (Vol. 176, p. 108461). Elsevier BV. https://doi.org/10.1016/7.meatsci.2021.108461
10. Sonko, N., Sukhenko, V., & Shtonda, A. (2021). Determination of the biological value of chopped semi-finished products with a complex food additive enzymatic method. In Animal Science and Food Technology (Vol. 12, Issue 1, pp. 48–55). National University of Life and Environmental Sciences of Ukraine. https://doi.org/10.31548/animal2021.01.048
11. Riabovol, M., & Bal-Prylypko, L. V. (2021). Justification and development of sausage technology with health properties. In Animal Science and Food Technology (Vol. 12, Issue 1, pp. 39 –47). National University of Life and Environmental Sciences of Ukraine. https://doi.org/10.31548/animal2021.01.039
12. Nikolaenko, M. (2021). Optimization of the technology of production of functional semi-finished meat products covered in pastry. In Animal Science and Food Technology (Vol. 12, Issue 1, pp. 19–27). National University of Life and Environmental Sciences of Ukraine. https://doi.org/10.31548/animal2021.01.019
13. DSTU 4673:2006. Cattle for slaughter. General specifications. Quality management systems – Requirements.
14. DSTU 3938-99. Meat industry. Livestock slaughter products. General specifications. Quality management systems – Requirements.
15. DSTU ISO 1443: 2005. Meat and meat products. Quality management systems – Requirements.
16. GOST 2501181: 2010. Meat and meat products. Protein determination methods. (Interstate standard).
17. DSTU ISO 936: 2008. Meat and meat products. Method of determination of mass total ash. (National Standard of Ukraine).

18. DSTU ISO 1442: 2005. Meat and meat products. Method for determining moisture content. (National Standard of Ukraine).
19. Casler, M. D. (2015). Fundamentals of Experimental Design: Guidelines for Designing Successful Experiments. In Agronomy Journal (Vol. 107, Issue 2, pp. 692–705). Wiley. https://doi.org/10.2134/agronj2013.0114
20. Svyrydenko, N., & Kostenko, S. (2019). Assessment of fattening performance and slaughter characteristics of young bulls from Aberdeen Angus breed, Volyn Meat breed, and Charolais breed. In Ukrainian Journal of Ecology (Vol. 9, Issue 4, pp. 641–645). Oles Honchar Dnipropetrovsk National University. https://doi.org/10.15421/2019_802
21. Ugnivenko, A., Kos, N., Nosevych, D., Mushtruk, M., Slobodyanyuk, N., Zasukha, Y., Otchenashko, V., Chumachenko, I., Gryshchenko, S., & Snizhko, O. (2022). The yield of adipose tissue and by-products in the course of the slaughter of inbred and outbred bulls of the Ukrainian beef breed. In Potravinarstvo Slovak Journal of Food Sciences (Vol. 16, pp. 307–319). HACCP Consulting. https://doi.org/10.5219/1758
22. Smith, G., Carpenter, Z., Cross, H., Murphey, C., Abraham, H., Savell, J., Parrish, F.C.Jr., Davis, W., & Berry, B.W. (1985). Relationship of USDA marbling groups to the palatability of cooked beef. In Journal of Food Quality (Vol. 7, Issue 4, pp. 289–308). Wiley. https://doi.org/10.1111/j.1745-4557.1985.tb01061.x
23. Ugnivenko, A. (2018). On the problem of using inbreeding in beef cattle breeding. In Ukrainian Journal of Ecology (Vol. 8, Issue 1, pp. 596–600). Oles Honchar Dnipropetrovsk National University. https://doi.org/10.15421/2018_254
24. Li, X., Fu, X., Yang, G., & Du, M. (2020). Enhancing intramuscular fat development via targeting fibro-adipogenic progenitor cells in meat animals. In Animal (Vol. 14, Issue 2, pp. 312–321). Elsevier BV. https://doi.org/10.1017/S175173111900209X
25. Park, S., Beak, S.-H., Jung, D. J., Yeob, K. S., Jeong, I. H., Piao, M. Y., Kang, H. J., Fassah, D. M., Na, S. W., Baik, M. (2018). Genetic, management, and nutritional factors affecting intramuscular fat deposition in beef cattle – A review. Asian-Aust. In J Anim Sci (Vol. 31, Issue 7, pp. 1043–1061). Asian Australasian Association of Animal Production Societies. https://doi.org/10.5713/ajas.18.0310
26. Ugnivenko, A., Getya, A., Nosevych, D., Antoniuk, T., Kruk, O., Slobodyanyuk, N., Ivaniuta, A., Omelian, A., Gryshchenko, S., & Israelian, V. (2022). The study of "muscle eye" in bulls of Ukrainian black-spotted dairy-meat breed as a factor in improving the properties of meat products. In Potravinarstvo Slovak Journal of Food Sciences (Vol. 16, pp. 519–529). HACCP Consulting. https://doi.org/10.5219/1762
27. Bal-Prylypko, L., Nikolaenko, M., Stepasyuk, L., Cherednichenko, O., & Lialyk, A. (2022). Forecasting the sale price of por I agricultural enterprises. In Agricultural and Resource Economics (Vol 8. Issue 4, pp. 170–187). AgEcon Seach. https://doi.org/10.51599/are.2022.08.04.08
28. Brzáková, M., Boskova, I., Vostry, L., Rychtarova, J., & Bucek, P. (2021). Impact of COVID-19 on animal production in the Czech Republic. In Animal Frontiers (Vol. 11, Issue 1, pp. 47–50). Oxford University Press (OUP). https://doi.org/10.1093/af/vfaa053
29. Kondratiuk, V., Slobodyanyuk, N., & Ivaniuta, A. (2021). Effect of feeding conditions on the quality traits of rainbow trout. In Acta fytotechn zootechn (Vol. 24, Issue 3, pp. 256–264). Elsevier BV. https://10.15414/afz.2021.24.03.256-264
30. Cafferky, J., Hamill, R., Allen, P., O'Doherty, J., Cromie, A., & Sweeney, T. (2019). Effect of Breed and Gender on Meat Quality of M. Longissimus thoracis et lumborum Muscle from Crossbreed Beef Bulls and Steers. In Foods (Vol. 8, Issue 5, pp. 2–11). MDPI AG. https://173.10.3390/foods8050173
31. Ugnivenko, A., Demchuk, S., Nosevych, D., & Bondarenko, G. (2021). Duration of calving stages in beef cows under different housing systems. In The Indian Journal of Animal Sciences (Vol. 90, Issue 11, pp. 1531–1534). Indian Council of Agricultural Research, Directorate of Knowledge Management in Agriculture. https://doi.org/10.56093/ijans.v90i11.111566
32. Israelian, V., Palamarchuk, I., Sevin, S., Holembovska, N., Prokopenko, N., Ivaniuta, A., Shynkaruk, O., Rudyk, Y., Nosevych, D., & Tverezovska, N. (2022). The effect of vibration massage on the salting process of ostrich meat. In Potravinarstvo Slovak Journal of Food Sciences (Vol. 16, Issue 1, pp. 530–544). HACCP Consulting. https://doi.org/10.5219/1775
33. Moran, L., O'Sullivan, M., Kerry, J., Picard, B., McGee, M., O'Riordan, E., & Moloney, A.P. (2017). Effect of a grazing period before finishing on a high concentrate diet on meat quality from bulls and steers. In Meat Sci (Vol. 125, pp. 76–83). Elsevier BV. https://doi.org/10.1016/j.meatsci.2016.11.021
34. Cherednichenko, O., Bal-Prylypko, L., Paska, M., & Nikolaenko, M. (2021). Expediency of creation of technology of production of meat products of long term of storage of the combined structure. In IOP Conference Series: Earth and Environmental Science (Vol. 723, Issue 3, p. 032086). IOP Publishing. https://doi.org/10.1088/1755-1315/723/3/032086

35. Gotoh, T., Nishimura, T., Kuchida, K., & Mannen, H. (2018). The Japanese Wagyu beef industry: current situation and prospects — A review. In Asian-Australasian Journal of Animal Sciences (Vol. 31, Issue 7, pp. 933–950). Asian Australasian Association of Animal Production Societies. https://doi.org/10.5713/ajas.18.033
36. Randhawa, I. A. S., McGowan, M. R., Porto-Neto, L. R., Hayes, B. J., & Lyons, R. E. (2021). Comparison of Genetic Merit for Weight and Meat Traits between the Polled and Horned Cattle in Multiple Beef Breeds. In Animals (Vol. 11, Issue 3, p. 870). MDPI AG. https://doi.org/10.3390/ani11030870
37. Hidalgo, J., Cesarani, A., Garcia, A., Sumreddee, P., Larios, N., Mancin, E., García, J. G., Núñez, R., & Ramírez, R. (2021). Genetic Background and Inbreeding Depression in Romosinuano Cattle Breed in Mexico. In Animals (Vol. 11, Issue 2, p. 321). MDPI AG. https://doi.org/10.3390/ani11020321
38. Schumacher, M., DelCurto-Wyffels, H., Thomson, J., & Boles, J. (2022). Fat Deposition and Fat Effects on Meat Quality – A Review. In Animals. (Vol. 12, Issue 12, pp. 1550). MDPI AG. https://doi.org/10.3390/ani12121550
39. Raza, S. H. A., Khan, R., Abdelnour, S. A., Abd El-Hack, M. E., Khafaga, A. F., Taha, A., & Zan, L. (2019). Advances of molecular markers and their application for body variables and carcass traits in Qinchuan cattle. In Genes (Vol. 10, Issue 9, p. 717). MDPI AG. https://doi.org/10.3390/genes10090717
40. Naserkheil, M., Lee, D.-H., Kong, H.-S., Seong, J., & Mehrban, H. (2021). Estimation of Genetic Parameters and Correlation between Yearling Ultrasound Measurements and Carcass Traits in Hanwoo Cattle. In Animals (Vol. 11, Issue 5, p. 1425). MDPI AG. https://doi.org/10.3390/ani11051425
41. Mushtruk, M., Deviatko, O., Ulianko, S., Kanivets, N., & Mushtruk, N. (2021). An Agro-Industrial Complex Fat-Containing Wastes Synthesis Technology in Ecological Biofuel. In Lecture Notes in Mechanical Engineering (pp. 361–370). Springer International Publishing. https://doi.org/10.1007/978-3-030-77823-1_36
42. Ngapo, T. M., Rubio Lozano, M. S., & Braña Varela, D. (2018). Mexican consumers at the point of meat purchase. Pork choice. In Meat Science (Vol. 135, pp. 27–35). Elsevier BV. https://doi.org/10.1016/j.meatsci.2017.08.005
43. Mueller, L. F., Balieiro, J. C. C., Ferrinho, A. M., Martins, T. da S., Silva Corte, R. R. P., Amorim, T. R., Jesus Mangini Furlan, J., Baldi, F., & Pereira, A. S. C. (2019). Gender status effect on carcass and meat quality traits of feedlot Angus × Nellore cattle. In Animal Science Journal (Vol. 90, Issue 8, pp. 1078–1089). Wiley. https://doi.org/10.1111/asj.13250
44. Kul, E., Şahin, A., Aksoy, Y., & Uğurlutepe, E. (2019). The effects of slaughter weight on chemical composition, physical properties, and fatty acid profile of musculus longissimus dorsi in Holstein bulls. In Tropical Animal Health and Production (Vol. 52, Issue 1, pp. 159–165). Springer Science and Business Media LLC. https://doi.org/10.1007/s11250-019-01996-x
45. Terevinto, A., Saadoun, A., & Cabrera, M. C. (2020). From the fatty acid content perspective, is it healthier to eat a hindquarter or a forequarter cut? Angus steers in pasture or concentrate systems. In CyTA - Journal of Food (Vol. 18, Issue 1, pp. 698–703). Informa UK Limited. https://doi.org/10.1080/19476337.2020.1843543
46. Hudson, N. J., Reverter, A., Griffiths, W. J., Yutuc, E., Wang, Y., Jeanes, A., McWilliam, S., Pethick, D. W., & Greenwood, P. L. (2020). Gene expression identifies metabolic and functional differences between intramuscular and subcutaneous adipocytes in cattle. In BMC Genomics (Vol. 21, Issue 1). Springer Science and Business Media LLC. https://doi.org/10.1186/s12864-020-6505-4
47. Listrat, A., Gagaoua, M., Normand, J., Andueza, D. J., Gruffat, D., Mairesse, G., Chesneau, G., Mourot, B.-P., Gobert, C., & Picard, B. (2020). Are there consistent relationships between major connective tissue components, intramuscular fat content and muscle fibre types in cattle muscle? In Animal (Vol. 14, Issue 6, pp. 1204–1212). Elsevier BV. https://doi.org/10.1017/s1751731119003422
48. Randhawa, I. A. S., McGowan, M. R., Porto-Neto, L. R., Hayes, B. J., & Lyons, R. E. (2021). Comparison of Genetic Merit for Weight and Meat Traits between the Polled and Horned Cattle in Multiple Beef Breeds. In Animals (Vol. 11, Issue 3, p. 870). MDPI AG. https://doi.org/10.3390/ani11030870 28
49. Fernandes Júnior, G. A., Silva, D. A., Mota, L. F. M., de Melo, T. P., Fonseca, L. F. S., Silva, D. B. dos S., Carvalheiro, R., & Albuquerque, L. G. (2022). Sustainable Intensification of Beef Production in the Tropics: The Role of Genetically Improving Sexual Precocity of Heifers. In Animals (Vol. 12, Issue 2, p. 174). MDPI AG. https://doi.org/10.3390/ani12020174
50. Yamada, T., Kamiya, M., & Higuchi, M. (2020). Fat depot-specific effects of body fat distribution and adipocyte size on intramuscular fat accumulation in Wagyu cattle. In Animal Science Journal (Vol. 91, Issue 1). Wiley. https://doi.org/10.1111/asj.13449

51. Greenwood, P. L. (2021). Review: An overview of beef production from pasture and feedlot globally, as demand for beef and the need for sustainable practices, increase. In Animal (Vol. 15, p. 100295). Elsevier BV. https://doi.org/10.1016/j.animal.2021.100295

52. Zheplinska, M., Mushtruk, M., Vasyliv, V., Slobodyanyuk, N., & Boyko, Y. (2021). The Main Parameters of the Physalis Convection Drying Process. In Lecture Notes in Mechanical Engineering (pp. 306–315). Springer International Publishing. https://doi.org/10.1007/978-3-030-77823-1_31

53. Sugii, S., Wong, C. Y. Q., Lwin, A. K. O., & Chew, L. J. M. (2022). Reassessment of adipocyte technology for cellular agriculture of alternative fat. In Comprehensive Reviews in Food Science and Food Safety (Vol. 21, Issue 5, pp. 4146–4163). Wiley. https://doi.org/10.1111/1541-4337.13021

54. Li, Y., Cheng, G., Yamada, T., Liu, J., Zan, L., & Tong, B. (2020). Effect of Expressions and SNPs of Candidate Genes on Intramuscular Fat Content in Qinchuan Cattle. In Animals (Vol. 10, Issue 8, p. 1370). MDPI AG. https://doi.org/10.3390/ani10081370

55. Shanina, O., Minchenko, S., Gavrysh, T., Sukhenko, Y., Sukhenko, V., Vasyliv, V., Miedviedieva, N., Mushtruk, M., Stechyshyn, M., & Rozbytska, T. (2020). Substantiation of basic stages of gluten-free steamed bread production and its influence on quality of finished product. In Potravinarstvo Slovak Journal of Food Sciences (Vol. 14, pp. 189–201). HACCP Consulting. https://doi.org/10.5219/1200

56. Peña-Gonzalez, E., Alarcon-Rojo, A. D., Garcia-Galicia, I., Carrillo-Lopez, L., & Huerta-Jimenez, M. (2019). Ultrasound as a potential process to tenderize beef: Sensory and technological parameters. In Ultrasonics Sonochemistry (Vol. 53, pp. 134–141). Elsevier BV. https://doi.org/10.1016/j.ultsonch.2018.12.045

57. Sleboda, D. A., Stover, K. K., & Roberts, T. J. (2019). Diversity of extracellular matrix morphology in vertebrate skeletal muscle. In Journal of Morphology (Vol. 281, Issue 2, pp. 160–169). Wiley. https://doi.org/10.1002/jmor.21088

58. Kim, M., Franke, V., Brandt, B., Lowenstein, E. D., Schöwel, V., Spuler, S., Akalin, A., & Birchmeier, C. (2020). Single-nucleus transcriptomics reveals functional compartmentalization in syncytial skeletal muscle cells. In Nature Communications (Vol. 11, Issue 1). Springer Science and Business Media LLC. https://doi.org/10.1038/s41467-020-20064-9

59. Mushtruk, M., Vasyliv, V., Slobodaniuk, N., Mukoid, R., & Deviatko, O. (2020). Improvement of the Production Technology of Liquid Biofuel from Technical Fats and Oils. In Advances in Design, Simulation and Manufacturing III (pp. 377–386). Springer International Publishing. https://doi.org/10.1007/978-3-030-50491-5_36

Funds:

The study was conducted within the framework of the academic research work “To substantiate systems of production and monitoring of safe animal husbandry products” funded by the state budget of Ukraine (state registration number: 0121U110192).

Acknowledgements:

We would like to thank you to Dr. for Anatolii Ugnivenko.

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 rules of the current legislation of Ukraine were observed, following DSTU 4673: 2006.

Contact Address:

Anatolii Ugnivenko, National University of Life and Environmental Sciences of Ukraine, Faculty of Livestock Raising and Water Bioresources, Department of Milk and Meat Production Technologies, Heroiv Oborony str., 12b, Kyiv, 03041, Ukraine,
E-mail: ugnivenko@nubip.edu.ua
ORCID: https://orcid.org/0000-0001-6278-8399

Olha Kruk, Gushchynets StateVocational School, Shevchenka str., 114, Gushchyntsi, Vinnytsia region, 22434, Ukraine,
E-mail: olgakruk2016@ukr.net
ORCID: https://orcid.org/0000-0001-9975-8994

Dmytro Nosevych, National University of Life and Environmental Sciences of Ukraine, Faculty of Livestock Raising and Water Bioresources, Department of Milk and Meat Production Technologies, Polkovnika Potekhina, str.16, Kyiv, 03040, Ukraine,
E-mail: dknocevich@i.ua
ORCID: https://orcid.org/0000-0003-2495-2084

Tetiana Antoniuk, National University of Life and Environmental Sciences of Ukraine, Faculty of Livestock Raising and Water Bioresources, Department of Milk and Meat Production Technologies, Heroiv Oborony str., 12b, Kyiv, 03041, Ukraine,
E-mail: antoniuk_t@nubip.edu.ua
ORCID: https://orcid.org/0000-0001-5045-5546

Yuliya Kryzhova, National University of Life and Environmental Sciences of Ukraine, Faculty of FoodTechnology and Quality Control of Agricultural Products, Department of Technology of meat, fish and marine products, Polkovnika Potekhina, Str. 16, Kyiv, 03041, Ukraine,
E-mail: yuliya.kryzhova@ukr.net
ORCID: https://orcid.org/0000-0003-1165-8898

Mykola Gruntovskyi, National University of Life and Environmental Sciences of Ukraine, Faculty of Livestock Raising and Water Bioresources, Department of Technologies in Poultry, Pig and Sheep Breeding, Heroiv Oborony str., 12b, Kyiv, 03041, Ukraine,
E-mail: kolya_gr26@ukr.net
ORCID: https://orcid.org/0000-0002-6969-2987

Nataliia Prokopenko, National University of Life and Environmental Sciences of Ukraine, Faculty of Livestock Raising and Water Bioresources, Department of Technologies in Poultry, Pig and Sheep Breeding, Heroyiv Oborony Str., 12b, Kyiv, 03041, Ukraine,
E-mail: nataliia.prokopenko@ukr.net
ORCID: https://orcid.org/0000-0001-7967-884X

Viktor Yemtcev, The National University of Life and Environmental Sciences of Ukraine, Faculty of Food Technology and Quality Control of Agricultural Products, Department of technology of meat, fish and marine products, Polkovnika Potekhina Str., 16, Kyiv, 03040, Ukraine,
Tel.: +38(050)334 70 47
E-mail: viem17@gmail.com
ORCID: https://orcid.org/0000-0001-5684-1863

Iryna Kharsika, National University of Life and Environmental Sciences of Ukraine, Faculty of Food Technology and Quality Control of Agricultural Products, Department of Technologies of Meat, Fish and Seafoods, Heroiv Oborony Str., 15, 03040, Kyiv, Ukraine,
E-mail: veretynska23@ukr.net
ORCID: https://orcid.org/0000-0002-2789-7757

Nataliia Nesterenko, State University of Trade and Economics/ Kyiv National University of Trade and Economics, Faculty of Trade and Marketing, Department of Commodity Science, Safety and Quality Management, Kyoto Str.,19, 02156, Kyiv, Ukraine,
E-mail: nesterenko.natalia.1988.31@gmail.com
ORCID: https://orcid.org/0000-0003-3003-0406

Corresponding author: *