OPEN ACCESS
Potravinarstvo Slovak Journal of Food Sciences
Crossref Similarity Check Powered by iThenticate

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Slovak Journal of Food Sciences

Received: 18.4.2022
Revised: 13.5.2022
Accepted: 17.5.2022
Published: 4.7.2022

Potravinarstvo Slovak Journal of Food Sciences
vol. 16, 2022, p. 307-319
https://doi.org/10.5219/1758
ISSN: 1337-0960 online
www.potravinarstvo.com

The yield of adipose tissue and by-products in the course of the slaughter of inbred and outbred bulls of the Ukrainian beef breed

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ABSTRACT

The research focuses on analysing and generalising the distribution of internal adipose tissue and organs that are not part of the carcasses of inbred and outbred bulls of *the Ukrainian beef breed*. Animal stock inbreeding was determined based on five breeding records according to Wright's method modified by Kyslovskyi. Two experimental groups of 5 bulls were formed. The average inbreeding coefficient for inbred bulls was 3.43%. Animals were bred up to 18 months of age. Following slaughter, the mass and the yield of the head, liver, lungs, heart, kidneys, and brain were determined, and 4 types of fat were separated and weighed: perirenal, from the stomach, intestines, and pericardial. Inbred animals are more prone to the accretion of internal adipose tissue. Inbred bulls have 1.8 points more of it. Fat is more intensely accumulated around inbred bulls' multichambered stomachs and kidneys. Intensive fat accumulation was observed around the hearts and intestines of outbred bulls. Adipose tissue around the heart and intestines is more variable in inbred and outbred animals – from the forestomach and kidneys. The weight of inbred bulls' liver is less by 22.4%, kidneys – by 62.5%, heart – by 11.1%, and head – by 23.8% compared to outbred ones. The weight of their lungs is more by 10.5%. At the same time, inbred bulls tend to have brain weight gain of 12.5% and testicles – by 8.3%. Thus, inbreeding application in *Ukrainian beef breed*s with a small population size affects the growth of internal organs and the intensity of accumulation and distribution of interior fat. Due to more intensive accumulation of internal adipose tissue, inbred bulls have increased expenditure of forage energy for its formation. They are characterized by an increased yield of low-value raw fat, making them less efficient than outbred bulls for beef production.

Keywords: inbreeding, outbreeding, internal organs, adipose tissue, bulls.

INTRODUCTION

In the genetic progress of the beef breed, the importance is devoted to substantiating the selection of parent pairs. Spontaneous inbreeding is inevitable with a considerable (approximately 90%) use of natural mating during its breeding **[1]**. A significant number of scientific works currently devoted to a significant number of scientific works is devoted toA significant number are presently dedicated to determining inbreeding problems in pure breeding. Applying inbred mating almost always leads to a negative effect – inbred depression. Inbreeding in beef cattle herds negatively affects the reproductive capacity, weight, and linear growth, milk, and beef productivity of animals – the signs that most often affect the economy of this cattle rearing business. Functional disorders cause inbred depression in animals associated with the influence of genetic factors **[2]**. To understand the mechanisms of its manifestation, it is appropriate to conduct a detailed study of changes in the animal bodies, particularly to analyze the influence of close breeding on individual organs and systems.

Ukrainian beef breed was created by complex reproductive crossbreeding of Kian (K 3/8), Charolais (W 3/8), Simmental (C 1/8), and grey Ukrainian (SU 1/8) cattle **[3]**. In the course of its breeding, to consolidate the desirable traits, inbred mating is used quite often. Inbreeding reduces the productivity of beef cattle **[4]**. Inbreeding depression is manifested mainly by its traditional signs. If the inbreeding coefficient exceeds 7-11%, it negatively affects weaned calves' weight, increasing to 18 months of age and manifesting meat forms **[5]**. The regression coefficients between inbreeding and the weight of calves at the age of 210 days are negative **[6]**. An increase in inbreeding by 1% in Brahman and Tropical Composite cattle breeds is associated with a decrease in live weight

by 0.514 and 0.579 kg at the age of 1 year **[7]**. Inbreeding depression is 0.016 kg for the live weight of newborn calves, 0.418 kg – at the age of 200 days, 0.689 kg – at the age of 400 days, and 0.967 kg – at the age of 600 days. The decrease in the live weight of newborns by 0.103 kg is also observed with the increase in the inbreeding coefficient by 1% **[8]**, at weaning – by 2.03 kg **[9]**, at the age of 365 and 550 days – 0.29 kg **[10]**. The study **[11]** results demonstrated that the decrease in the live weight of beef cattle at different ages is observed in the range of 0.04 to 2.07 kg, with an increase in inbreeding by 1%. The increase in the inbreeding coefficient in animals leads to a decrease in the average daily gain of live weight before weaning and up to one year of age **[12]**. For the characteristics of weight gain, the average inbreeding depression is 0.269% per 1% of inbreeding **[13]**. It is insignificant and about 0.01% **[14]**. Inbreeding increases beef viscosity but does not significantly affect its other qualities or characteristics of carcasses, food consumption, and digestion **[15]**.

Brännäng was the first to study the distinctive features of fat deposition in the depot that are not part of the carcass **[16]**. The amount of adipose tissue in the animal body varies depending on the species **[17]**, breeds and pedigrees **[18]**, **[19]** lines **[20]**, age **[21]**, gender **[22]**, feeding conditions **[23]**, and animal housing **[24]**. Proceeding to the problem of growth of the internal adipose tissue that has low nutritional value in inbred and outbred animals, it should be noted that it is extremely insufficiently studied. Adipose tissue is studied under the skin between the muscles and in the muscles **[25]**. Inbred animals have less fat in carcass **[26]**. Over the past 10 years, almost no one has researched fat distribution in fat depots in inbred and outbred animals of some breeds. Therefore, this factor is quite significant, as the amount and distribution of fat can significantly impact the weight of the carcass after slaughter. The low-fat cost from various fat depots also does not stimulate the study. This kind of information would be beneficial in explaining the differences between various levels of carcass yield.

In the Ukrainian beef cattle breed, inbreeding depression is an escalating problem, as it negatively affects animal health and productivity. In cows, it is manifested by weight gain. However, producing ability **[27]**, although more enhancers in growth rate originate from inbred mating. Many issues of inbreeding influence the growth of internal adipose tissue and organs that are not part of the carcass but affect its yield and beef productivity remain insufficiently studied. Disclosure of the peculiarities of their growth is necessary to produce beef efficiently and purposefully at a higher yield of valuable components.

This paper aims to study inbreeding's influence on the distribution of internal adipose tissue and organ weight in the Ukrainian beef breed bulls.

Scientific Hypothesis

Previous studies have shown that inbreeding negatively affects cattle's live weight and growth rate, and its influence on carcass quality and feed digestion has not been confirmed. It was assumed that inbred animals should have a proportionally lower weight of internal organs while maintaining their relative yield to the pre-slaughter live weight. At the same time, the growth rate is closely related to the metabolic processes in the body, so inbreeding influences the development of individual organs that are actively involved in them, and fat deposition may differ from the general trend of decrease in live weight of animals.

MATERIAL AND METHODOLOGY

Samples

Two groups of experimental bulls were formed for the study using the method of balanced analogue groups. In the first group - inbred animals (5 animal units), the average value of the inbreeding coefficient (F_x) was 3.43%. The second group - is outbred bulls (5 animal units).

Chemicals

Formaldehyde (CH_2O, producer (Inter-Synthesis) Limited Liability Company, Ukraine, chemically pure for analysis).

Formalin (water solution formaldehyde, producer (Inter-Synthesis) Limited Liability Company, Ukraine).

Animals and Biological Material

The study was conducted with the use of the bulls of the Ukrainian beef breed (Figure 1). The experiment was conducted at the Volia breeding plant in the Zolotoninskyi district of the Cherkasy region. The bulls were bred from birth to slaughter at 18 months. Following slaughter, offal (head with horns, liver, lungs, heart, kidneys, brain, and testicles) and internal fat (pericardial, intestinal, multichambered stomach, perirenal) were selected for weighing.

Figure 1 Bull of the Ukrainian meat breed.

Instruments

Static scales 4BDU-1500X-P (Axis, Ukraine). Scale division ≥0.5 kg, weighing rang 10-1500 kg. GOST 29329-92 **[28]**. Weighing of bulls before slaughter.

Scales Prok (Ukraine). Weighing range of up to 150 kg. GOST 29329-92 **[28]**. Weighing of offal and internal fat.

Laboratory Methods

Method of forming the balanced analogue groups **[29], [30]**.

Determination of the inbreeding coefficient by Wright's method modified by Kyslovskyi **[31]**.

DSTU 4673: 2006. Cattle for slaughter. Specifications **[32]**.

DSTU 3938-99. Beef industry. Livestock slaughter products. Terms and Definitions **[33]**.

There are rules for pre-slaughter veterinary inspection of animals and veterinary and sanitary examination of beef and beef products (2002) **[34]**.

Description of the Experiment

Sample preparation: The study was conducted for 2 calendar days during the slaughter of bulls. During two calendar days, 140 samples were taken, 70 samples each day.

Number of samples analyzed: 140 samples from two conducted experiments (70 in each) were used in the study of the samples.

Number of repeated analyses: The weight of by-products was determined for each of the slaughtered bulls, including heads with horns 10 times, liver 10 times, lungs 10 times, heart 10 times, kidneys 10 times, brain and testicles 10 times, which amounted to 70 replicates.

Number of experiment replication: The study was repeated 10 times, with the experimental data processed using mathematical statistics methods.

Design of the experiment: The experiment was conducted at the Volia breeding plant in the Zolotoninskyi district of the Cherkasy region. Two groups of newborn well-grown inbred and outbred bulls of 5 animal units were formed in the herd of the Ukrainian beef breed. The animals were tested for the probability of origin by blood group factors. The bulls were grouped by the method of balanced analogue groups. The inbreeding coefficient was determined using a complete five rows of pedigrees according to Wright's method modified by Kyslovskyi. The selected animals at the age of up to 6-7 months were bred near suckler cows. After the weaning, they were accustomed to a typical diet and husbandry until 8 months of age. The animals were housed tethered with individual control of the amount of the feedstuff fed and consumed. Intensive breeding of bulls was carried out from 8 to 18 months. The general level of their feeding was expected to receive the average daily gains from 1000 to 1200 g. During this period, the animals consumed feedstuff of their production with the same rations. The weight of the feed consumed by each bull was counted every decade (two days in a row) by weighing the feed and the orts. During 8 to 18 months, each inbred bull consumed only 2,999, outbred 2,903 feed units (Table 1). The share of the concentrated feed in the diet was 45.6% and 45.8%, roughage feed – 19.0 and 19.2, succulent feed – 15.4 and 13.3, green feed – 20.0, and 21.7%. There was no significant difference in animal feed consumption between the groups.

Table 1 Feed consumption by inbred and outbred bulls at the age of 8 to 18 months, M ± m.

Feeds	Inbred (n = 5)		Outbred (n = 5)	
	Feed Units	%	Feed Units	%
Concentrated	1.369 ±50.9	45.6 ±0.56	1.328 ±55.8	45.8 ±0.10
Roughage	570 ±86.7	19.0 ±1.73	558 ±35.2	19.2 ±1.11
Succulent	461 ±51.4	15.4 ±0.50	387 ±31.5	13.3 ±0.41
Green	599 ±26.8	20.0 ±0.24	630 ±66.9	21.7 ±1.44
Total feed units	2.999 ±88.0	100.00	2.903 ±104.8	100.00

At 18 months, bulls were slaughtered at Cherkasy beef-processing-and-packing plant. Weighing of the animals and the slaughter products was performed individually. The pre-slaughter weight was determined after 24 hours of fasting. Following slaughter, the weight of offal was determined, including the weight of heads with horns, liver, lungs, heart, kidneys, brain, and testicles. Various types of adipose tissue were studied in the animal bodies, including adrenal, intestinal, multichambered stomach, and pericardial adipose tissue. Renal fat was removed from the kidneys and the inner side of the carcass in the lumbar and pelvic areas. The fat that covers the stomach is omentum fat. The intestine fat was isolated in the pericentric mesenterium. Subsequently, the average values by group and the yield of internal fat and offal to pre-slaughter weight were determined.

Statistical Analysis

The obtained data were processed by variation statistics according to the methods adopted in breeding and biology **[35]**. Statistical processing was performed in Microsoft Excel 2016 in combination with XLSTAT. Values were estimated using mean and standard deviation. We calculated the arithmetic mean (unweighted) value (M) and the arithmetic mean error (± m), which allowed us to estimate with some probability the deviation of the arithmetic mean deviation of the Fulton fattening factor. The statistical reliability of research results was ensured by analyzing samples with the number of fat samples from 5 to 10 samples per bull.

RESULTS AND DISCUSSION

Accumulation of a bull's internal fat is important due to its connection with feed costs. It has been proven that visceral fat accumulation is connected with the increased feed costs for live weight gain **[36]**. At the same time, the value of beef fat in the food and processing industries is decreased. Current trends in healthy feeding aim to reduce the caloric content of foods and partially replace solid animal fats with triglycerides containing polyunsaturated fatty acids due to the introduction of primary products of plant origin. In particular, the beef fat in cutlets for burgers is replaced by tiger nut oil emulsions. In sausages, the fat is recommended to be replaced by jelly-containing emulsified systems with the inclusion of peanut and linseed oil **[37]**. The cutlets are recommended to be prepared with olive oil **[38]**, so it is important to understand all the factors contributing to an increase in the yield of internal adipose tissue of slaughter animals.

In the case of such feeding, the bulls at the age of eighteen-month demonstrate different levels of internal adipose tissue deposition (Table 2). Samples of internal adipose tissue are shown in Figure 2ab. Inbred animals are more prone to increased deposition than outbred ones. Their bodies contain 69.8% of the total amount of internal adipose tissue. This is 1.8 points more in comparison with outbred animals. The increased amount of internal fat in the bodies of inbred animals is explained by its biological susceptibility to better reserving nutrients in intensive feeding and using them in periods of adversity.

Internal fat is deposited unevenly on various organs of the animal's body. The largest amount is in the intestines and forestomach of the animals of both groups. The smallest amount is formed around the heart.

Inbreeding in beef bulls causes significant differences in the distribution of internal adipose tissue. Inbred bulls have a relatively larger amount of fat in kidneys and stomachs in comparison with a relatively larger amount of fat than outbred bulls. In outbred bulls - around heart and intestines. Increased accumulation of adrenal adipose tissue in the bodies of inbred bulls may be one of the reasons for increased feed costs, as it contains the largest amount of refined fat compared to other depots **[39]**. According to certain data **[40]**, adrenal fat contains about 90% of extracted fat and the smallest amount of water and protein slaughter products.

Adipose tissue around the heart and intestines is more variable in inbred animals. In outbred animals - from forestomach and kidneys. In the bodies of inbred animals, adipose tissue is deposited twice more evenly on the forestomach and kidneys. In outbred animals - around the heart and intestines. The susceptibility of individual animal units may explain significant variability in inbred bulls related to the amount of pericardial fat to obesity and the manifestation of heart failure that is often observed during intensive beef cattle breeding **[41]**.

Table 2 Distribution of internal adipose tissue in inbred and outbred bulls at 18 months.

Adipose tissue	Inbred (n = 5)		Outbred (n = 5)	
	M ± m	Cv, %	M ± m	Cv, %
Total adipose tissue, kg	21.2 ±1.09	10.4	17.5 ±1.54	17.5
Internal fat, kg	14.8 ±1.10	14.9	11.9 ±1.24	20,9
Internal fat before pre-slaughter live weight, %	2.7 ±1.19	14.1	2.1 ± 018	17.2
Including pericardial, kg	1.2 ±0.52	90.8	1.5 ±0.42	55.0
% related to the internal fat	7.4 ±2.87	78.0	12.9 ±4.9	38.6
% related to the total fat	5.2 ± 2.13	81.7	8.7 ±1.84	42.3
From intestines, kg	5.6 ±0.41	14,7	6.3 ±0.40	12.6
% related to the internal fat	38.5 ±4.11	21.4	54.5 ±3.53	12.9
% related to the total fat	26.6 ±2.45	18.5	36.8 ±3.54	19.2
Fat from forestomach, kg	4.1 ±0.40	19.2	2.0 ±0.27	27.2
% related to the internal fat	27.9 ±0.48	11.9	16.9 ±0.70	22.4
% related to the total fat	19.4 ±1.46	15.0	13.2 ±3.72	56.5
Pararenal, kg	3.9 ±0.59	30.2	2.0 ±0.60	60.6
% related to the internal fat	26.3 ±2.36	18.0	15.9 ±3.14	39.5
% related to the total fat	18.3 ±1.92	21.0	10.8 ±2.37	44.1

Following animal slaughter, some by-products that have nutritional value are produced. The liver, heart, tongue, kidneys, etc., are important protein sources. The liver, heart, tongue, kidneys, etc., are important protein sources, including key amino acids, vitamins, and mineral elements **[42]**. Cattle liver is the primary product for pasta and paste production **[43]**. The by-products such as kidneys, lungs, and heart contribute to increased absorption of non-heme iron in vegetables, food supplements, and other products of plant origin **[45]**, and their efficiency far exceeds the influence of beef **[44]**.

The weight of offal depends on many factors. In particular, it is known that the weight of testicles depends on age and puberty, and it is gained due to intensive feeding **[46]**. There is evidence that the weight of offal in the bodies of similar bulls at 18 months is affected by pre-slaughter weight, but their percentage yield changes insignificantly **[47]**. The total number of edible and inedible offal is significantly affected by the breed and the age of the animals **[48]**.

Figure 2a Samples of internal adipose tissue.

Figure 2b Samples of internal adipose tissue.

The internal organs of cattle are not only available primary products for the processing industry. They are indissolubly related to many valuable traits such as growth, health, and productivity. It was established **[49]** that 38 significant single nucleotide polymorphisms affect the weight of internal organs, which indicates the genetic condition of offal yield related to slaughter animals. The genetic condition of offal weight may be manifested in the course of inbreeding application due to the concentration of similar genes and the reduction of their diversity.

The average weight of by-products of inbred and outbred bulls is shown in Table 3.

Table 3 The weight of bull organs that are not part of the carcass.

Organ	Inbred (n = 5)		Outbred (n = 5)	
	M ± m	Cv, %	M ± m	Cv, %
Head with horns, kg	16.8 ±0.59	6.1	20.8 ±0.69	5.7
% of pre-slaughter live weight	3.3 ±0.10	5.3	3.6 ± 0.06	2.6
Liver, kg	5.8 ±0.12	3.6	7.1 ±0.50	12.2
% of pre-slaughter live weight	1.1 ±0.03	4.4	1.2 ±0.06	7.8
Lungs, kg	4.2 ±0.24	9.9	3.8 ±0.32	14.6
% of pre-slaughter live weight	0.8 ±0.05	10.2	0.7 ±0.06	15.4
Heart, kg	1.8 ±0.09	8.8	2.0 ±0.04	3.2
% of pre-slaughter live weight	0.4 ±0.01	7.4	0.4 ±0.01	4.2
Kidneys, kg	0.8 ±0.09	20,4	1.3 ±0.06	8.0
% of pre-slaughter live weight	0.2 ±0.03	38.5	0.2 ±0.03	22.2
Brain, g	431 ±57.1	22.9	383 ±14.8	6.7
Testicles, g	615 ±30.0	8.5	568 ±38.9	6.9

The weight of inbred bulls' liver is less by 22.4%, kidneys – by 62.5%, heart – by 11.1%, and head – by 23.8% compared to outbred ones. The weight of their lungs is more by 10.5%. At the same time, inbred bulls tend to have brain weight gain of 12.5% and testicles – by 8.3%. Similar data were published by Eisner **[50]**. According to him, the size of the heart, liver, brain, kidneys, pituitary gland, and pancreas in the bodies of inbred animals decreases, and the size of lungs, thyroid, and adrenal glands – increases. In studies on Holstein calves **[51]**, it was established that the relative weight of heads is larger in the animals that are significantly inferior to the animals of the same age-related to growth rate, or those that are characterized by higher gains and larger live weight at the time of slaughter. A similar result was obtained in our studies. Outbred bulls with larger live weights took precedence over the actual and relative head weights of inbred ones.

In contrast to inbreeding, in the course of crossbreeding, particularly Simmentals and Holsteins, no effect on the weight of by-products was found when breeding bulls in the same conditions and slaughtering at the same age **[52]**. Thus, in Ukrainian beef breed of small population size and with inbreeding application in combination with

the reduction in weight gain, reproductivity, and milk-producing ability of cows **[53]**, one of the most significant problems is the reduction of weight of liver, heart, kidneys, head, and increased content of internal fat.

Regardless of carcass composition, offal and internal fat taken together negatively affect the carcass yield. Approximately 1/4-1/3 of the basic components (water, protein, and fat) are in body parts that are not part of the carcass. The lowest price is for such parts **[54]**. Therefore, it is necessary to find the opportunity to change this ratio in the desired direction, as the cost of by-products is significantly lower than a carcass.

Internal fat is the most changeable and pliable tissue. After slaughter, it is removed from fat depots, as adipose tissue is not of great nutritional value. However, internal fat is associated with additional feed costs in animal breeding, which is unprofitable. In the course of inbreeding, the carcass yield is reduced due to internal fat accumulation. Excessive omental fat deposition in cattle under the same conditions is caused by several genetic loci **[55]**. The genes involved in proteolysis, transcription, translation, transport, immune function, and oxidative processes are different **[56]**. Inbreeding probably leads to the concentration of the relevant genes, which provokes an increase in internal fat deposition. Therefore, it is desirable to avoid close breeding in commercial beef cattle breeding and prefer outbred beef cattle production. Another disadvantage of excessive internal fat deposition is the negative correlation of its amount with intramuscular fat content **[57]**. Thus, the animals' marbling degree that isprone animals' accumulation will decrease. This negatively affects the cost of the most valuable cuts of the carcass. The maximum growth rate of adipose tissue of large and small glands and adrenal glands in bulls occurs in 7 to 12 months **[58]**. The most intensive adipose tissue growth around the heart is noted in 12 to 18 months of animal life. According to the data obtained in the study, inbreeding reduces heart size. Probably the less amount of fat deposited around the heart is due to this. This is compensated by an active adipose tissue accumulation in the forestomach and around the kidneys.

Peculiarities of fat distribution by fat depots may be considered in case of excessive generation of cattle waste. The formation of the larger amount of internal fat in the forestomach and kidneys of inbred bulls also leads to the assumption that the difference in internal fat content is mainly conditional on different periods of its accumulation commencement in this period on these organs, not rate. It was established **[59]**, **[60]** that adrenal fat is formed early, and subcutaneous and other fats are formed later. Analyzing the level of lipids in the body of *Aberdeen-Angus* and *white-headed Ukrainian cattle* and the crossbreeds of *Aberdeen-Angus* × *white-headed Ukrainian* **[61]**, it is noted that the crossbreeds showed true heterosis in internal adipose tissue accumulation per 1 kg of net weight, it is 113.2%. Topography of fat deposition in the cattle body is the trait primarily associated with animal precocity. Animals of precocious breeds are prone to early obesity. They also deposit much more fat on the outer parts of the carcass **[62]**. The patterns established in the study indicate the change in animal precocity under the influence of inbreeding. Thus, more fat is deposited on outbred animals' internal organs (heart, intestines), as they are relatively late-maturing cattle. Inbred animals, relatively more precocious bulls, accumulate more internal adipose tissue around the stomach and kidneys but have a less developed head, liver, heart, and kidneys.

CONCLUSION

Incombined with a decrease in pre-slaughter live weight of bulls, a decrease in pre-slaughter live weight of bulls, and a reduction in pre-slaughter live weight of bulls, inbreeding leads to the accumulation of internal adipose tissue. Inbred animals' total weight of internal fat is 24% higher, leading to inefficient feed consumption and an increased yield of low-value raw fat. Internal fat accumulation in outbred bulls is more often observed around the heart and intestines and in inbred animals – around the stomach and kidneys. Excessive accumulation of adrenal fat due to low moisture and protein content may negatively affect the redistribution of the feed energy consumed to grow more valuable parts of the carcass. Inbred bulls are also characterized by severe inhibition of the growth of internal organs such as the liver, heart, and kidneys, which reduces the weight of such offal following slaughter—still, the weight of their lungs, brain, and testicles increases. Regarding the results obtained, it is appropriate to breed outbred bulls of Ukrainian beef and apply inbreeding to a limited extent for breeding purposes.

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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).

Acknowledgments:

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

Conflict of Interest:

The authors declare no conflict 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.

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