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THE INFLUENCE OF VETERINARY AND ZOOTECHNICAL MEASURES ON THE CONTENT OF ESSENTIAL MICROELEMENTS AND THE QUALITY OF MEAT OF WILD DEER-LIKE IN THE WESTERN REGION OF UKRAINE

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ABSTRACT

In the 20th century, representatives of the Cervidae family, in particular the red deer (*Cervus elaphus*) and fallow deer (*Dama dama*) became relatively popular "farm animals", they began to be bred on farms as semi-domestic animals. In Ukraine (especially in its western region) such opportunities are extremely large, which is due to the large areas of agricultural land, the use of which for agriculture and animal husbandry is impractical. In order preserve authenticity wild animals and to maximally improve the quality of the meat obtained from them, it is necessary to carry out veterinary and zootechnical measures in such a farm and they should be of with as little human disturbance as possible to reduce animal stress. The application of veterinary drugs specially developed for aviary complexes to red deer (n=18) and fallow deer (n=18) on the background of a corrected diet twice during three seasons (years) in conditions of semi-free housing did not affect on the organoleptic indicators and moisture content of the meat, but contributed to a more intense increase in its quality due to an increase in the mass fraction of protein by 13.8 and 10.8%, fat – by 7.4 and 15.5%, ash – by 19.1 and 44.2%, as well as enrichment with trace elements: the content of zinc increased by 23.9 and 38.6%, copper – by 6.6 and 13.2%, iron – by 6.4 and 1.9%, manganese – by 20.4 and 19.5%, cobalt – by 30.0 and 50.0%, selenium – by 11.8 and 11.3% respectively.

Keywords: aviary maintenance, meat quality, microelements, wild ungulates

INTRODUCTION

Breeding of wild ungulates in the conditions of semi-free keeping is currently emerging as a new branch of the national economy, which was formed at the intersection of the interests of animal husbandry and hunting science **(Belkin *et al*., 2012; Linnell *et al*., 2020; Moiseeva, 2020)**. In Ukraine, its opportunities are extremely large, which is due to the large areas of agricultural land, the use of which for agriculture and animal husbandry is impractical, as well as the presence of breeding material, in particular, noble and spotted deer, fallow deer, mouflon **(Katysh, 2016; Kratiuk, 2018)**.

The relevance of further development of the enclosure method of keeping and breeding wild ungulates - red deer (*Cervus elaphus L.*, 1758) and European fallow deer (*Cervus dama L.*, 1758) is currently beyond doubt. This is closely related to the economic efficiency of hunting and hunting. The main purpose of breeding deer-like wild ungulates in enclosure complexes is to obtain animals with high trophy characteristics of horns and meat, as well as the sale of animals for resettlement - to other enclosure complexes or for release into the wild **(Khoyetskyy *et al*., 2015; Kuba *et al*., 2015; Balciauskas *et al*., 2017; Viganò *et al*., 2019; Pepko, 2020)**.

At the same time, the quality indicators of the meat of wild animals depend on many factors, in particular, genetics, sex, age at the time of slaughter, season, composition of the diet, environmental conditions in which the animal was or conditions of keeping (farm (enclosure) / wild nature), which is described in sufficient detail in the scientific literature **(Parker *et al*., 2009; Razmaitė *et al*., 2015; Stanisz *et al*., 2015; Daszkiewicz & Mesinger, 2018; Stanisz *et al*., 2019; Żochowska-Kujawska *et al*., 2019)**.

The meat of deer-like wild ungulates has an optimal chemical composition: a low level of fat, a high level of protein, nutritional and energy value, so it is increasingly used in the diets of critical population groups: teenagers, diabetics, patients with cardiovascular diseases, etc. **(Briggs *et al*.,, 2017)**. However, there is a scientific debate regarding the trace element composition of the meat of wild ungulates: the first trend is related to heavy metals and indicates either their significant accumulation **(Nkosi *et al*., 2021)**, or, on the contrary, that the meat of wild ungulates has the lowest level of heavy metals in comparison with the meat of farm animals **(Assenova *et al*., 2016)**, and the second – in relation to the content of essential trace elements in meat (different level of their accumulation and assimilation) **(Kursa *et al*., 2010; Stoebe *et al*., 2015)**.

The data of the literature analysis indicate the dependence of the content of trace elements in the meat of wild ungulates mainly on the territory (geochemical province) in which the animals are located, that is, on the available diet (biochemical composition of local fodder), which indicates the individuality of each conducted study and forms the purpose of our work, namely: to investigate the influence of veterinary and zootechnical measures on the content of essential microelements and the quality of meat of wild deer-like in the western region of UKRAINE

MATERIALS AND METHODS

The work was carried out at the Department of Ecology, Geography and Tourism of the Rivne State Humanities University and the Epizootology Research Station of the Institute of Veterinary Medicine of the National Academy of Agrarian Sciences of Ukraine.

The place of the experiment

Production research was carried out in the Polyske-Sarny Hunting Farm LLC of the Sarnen District of the Rivne Region and in the Hunting Farm enclosures of the LLC BARS Company, LLC "Hunting and Sports Club "Sokil" of the Kostopil District of the Rivne Region on red deer (*Cervus elaphus L.*, 1758) and European fallow deer (*Cervus dama L.*, 1758) (Fig. 1).

Experimental animals

In the experiment, 3 groups (18 animals each) were formed from sexually mature red deer and European fallow deer (Fig. 2). The term of the experiment consisted of three seasons (during 2017-2019), and in 2016, studies were conducted "before the beginning of the experiment" involving 3 animals of each species. The control group of animals received a natural diet with the inclusion of a grain mixture against the background of the absence of treatment with veterinary drugs (close to free-living animals in terms of conditions); And the research group - a natural diet with the inclusion of a grain mixture with a protein-mineral additive against the background of the absence of preventive treatments with veterinary drugs; The II

research group – a natural diet with the inclusion of a grain mixture with a protein-mineral additive against the background of the use of veterinary drugs. Euthanasia of animals (6 per group) was carried out by a gunshot to the head at the end of the season (October-November) and meat samples (quadriceps femoris muscle) were taken to determine individual indicators of its quality and microelement content. This muscle group was chosen as one of the largest in the body of wild ungulates. Animal experiments do not contradict the current legislation of Ukraine (Article 26 of the Law of Ukraine 5456-VI of 16.10.2012 "On protection of animals from cruel treatment") and "General ethical principles of animal experiments", adopted by the First National Congress of Bioethics and international bioethical standards (materials of the IV European Convention for the Protection of Vertebrate Animals Used for Experimental and Other Purposes, Strasbourg, 1985) **(Simmonds, 2017)**. The research program was reviewed and approved by the Bioethics Commission of the National. Rivne State Humanitarian University and Epizootology Research Station of the Institute of Veterinary Medicine of the National Academy of Agrarian Sciences of Ukraine in the current order.

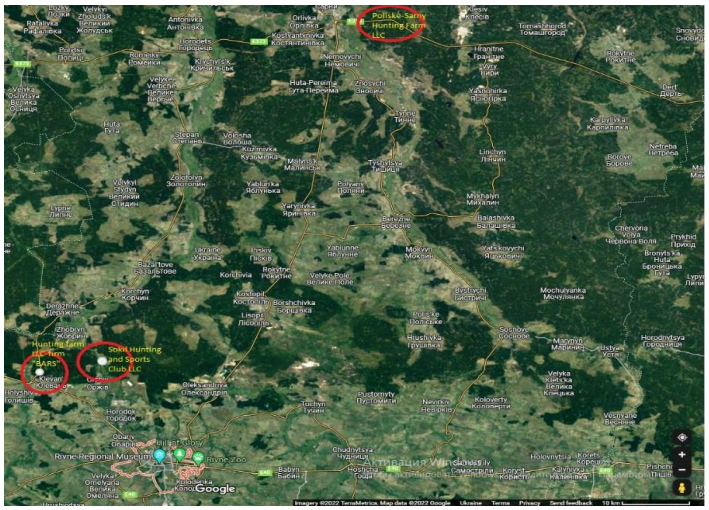

Figure 1 Location of experimental farms for breeding wild ungulates

A **B**

Figure 2 A male red deer (A) and a male European fallow deer (B) in an enclosure for semi-free housing

Rations

The structure of rations of wild ungulates is given in Table. 1.

The feeding ration consists of the following components: natural branch fodder (cutting residues formed during wood harvesting); pasture and agricultural crops (clover, alfalfa, oats); corn grain and grain mixture (corn, oats, etc.). The optimal composition of grain mixtures for feeding doe and deer contained 50-65% oats, 5-10% wheat and 10-15% corn; mineral top dressing (salt-lick); hay, haylage, etc. Forage fields with a total area of 3.5 hectares were created in the middle of the enclosure, of which 2.7 hectares are clover, 0.3 hectares are oats; 0.5 hectares – pasture ryegrass. The content of nutrients in the diet is given in the Table. 2. It was this diet (close to the diet of free-living wild ungulates) that the animals of the control group received during the experiment. However, the analysis of the ration indicates that the animals are not adequately supplied with minerals, and the reduced content of crude protein can negatively affect the assimilation of trace elements, which led to our further work on improving the mineral nutrition of wild ungulates and the formation of the remaining research groups. So, the animals of the first experimental group received a natural diet with the inclusion of a grain mixture with a protein-mineral additive (PMA) (in the amount of 35%), against the background of the absence of preventive treatments with veterinary drugs. The composition of the feed additive is given in Table 3, the adjusted ration is given in Table 4. The animals of the second experimental group received an adjusted diet, and were also treated with the veterinary drugs "Epidez-gel anti-parasitic" and "Akarotak D.V.".

Table 1 Approximate structure of rations of wild ungulates

Feed / Indicators		Summer-autumn ration				Winter-spring ration			
		Deer		Fallow deer		Deer		Fallow deer	
		kg	%	kg	%	kg	%	kg	%
Grain mixture	Oat	1.3	65	0.65	65	1.3	65	0.65	65
	Wheat	0.2	10	0.1	10	0.2	10	0.1	10
	Corn	0.7	25	0.25	25	0,7	25	0.25	25
Total		2.0	10	1.0	10	2.0	10	1.0	10
Herbs of the enclosure	Natural grass	2.16	12	1.08	12	-	-	-	-
	Pasture clover	11.7	65	5.85	65	-	-	-	-
	Oat pasturable	1.44	8	0.72	8	-	-	-	-
	Pasture ryegrass	2.7	15	1.35	15	-	-	-	-
Total		18	90	9	90	-	-	-	-
Juicy	Wood and branch fodder	-	-	-	-	3.08	28	1.54	28
	Hay alfalfa	-	-	-	-	3.3	30	1.65	30
	Corn silage	-	-	-	-	4.62	42	2.31	42
Total		-	-	-	-	11	55	5.5	55
Coarse	Clover hay	-	-	-	-	0.7	10	0.35	10
	Alfalfa hay	-	-	-	-	6.3	90	3.15	90
Total		-	-	-	-	7	35	3.5	35

Table 2 Indicators of the actual content of crude protein, macro- and microelements in the rations of red deer and European fallow deer on dry matter of forage

Ration / Indicators	Summer-autumn ration	Winter-spring ration	Featured Content (Shin *et al.*, 2000)
Crude protein, %	12.1	12.1	No less 13.0
Calcium, g/kg	6.11	6.9	3.0-10.0
Phosphorus, g/kg	1.61	1.27	3.0-8.0
Zinc, mg/kg	10.9	16.8	30.0-95.0
Copper, mg/kg	8.34	7.41	10.0-30.0
Iron, mg/kg	54.1	95.4	50.0-75.0
Manganese, mg/kg	14.6	31.3	20.0-50.0
Cobalt, mg/kg	0.04	0.05	0.1-0.3
Selenium, mg/kg	0.03	0.08	0.1-0.4

Characteristics of veterinary drugs and features of their use

The research used veterinary drugs specially developed for aviary complexes, the composition and formulation of which were tested in previous studies. "Epidez-gel anti-parasitic" (declaration patent of Ukraine for utility model No. 103689) has the following composition (per 100 g), g: fenbendazole – 5.0; sodium chloride – 10.0; cobalt chloride – 0.10; zinc sulfate – 0.25; manganese chloride – 0.20; polyhexaguanidine hydrochloride – 0.7; edible gelatin – 10.0; propylene glycol – 7.0; drinking water up to 100. "Epidez-gel anti-parasitic" was placed in places of periodic stay or accumulation of wild animals (feeders, forest paths, migration routes, watering holes, etc.) 2 times a year.

"Akarotak D.V." (emulsion of tarred water and amitraz 0.025%) – a veterinary drug for the desaccharization of wild ungulates in aviary conditions. Desaccharization was carried out as follows: in places where animals are fed, 3 inclined "combing posts" were installed around them, covered with felt up to 2.0 cm thick, which were treated with an experimental preparation (declaration patent of Ukraine for a utility model No. 140572).

Table 3 PMA composition depending on the season

Indicators \ Season	Summer-autumn	Winter-spring
Crude protein, %	35.0	35.0
Calcium, g/kg	10.5	5.0
Phosphorus, g/kg	50.0	100.0
Zinc, mg/kg	580.0	400.0
Copper, mg/kg	80.0	65.0
Iron, mg/kg	40.0	0
Manganese, mg/kg	460.0	0
Cobalt, mg/kg	2.0	1.5
Selenium, mg/kg	2.5	0.7

Table 4 The actual content of crude protein, macro- and microelements in the rations of red deer and European fallow deer on the dry matter of the feed with corrections (PMA 35% to the grain mixture)

Indicators \ Ration	Summer-autumn ration	Winter-spring ration	Featured Content (Shin *et al.*, 2000)
Crude protein, %	13.02	13.01	No less 13.0
Calcium, g/kg	6.41	7.01	3.0-10.0
Phosphorus, g/kg	3.28	4.66	3.0-8.0
Zinc, mg/kg	30.11	30.33	30.0-95.0
Copper, mg/kg	10.84	10.08	10.0-30.0
Iron, mg/kg	54.10	95.73	50.0-75.0
Manganese, mg/kg	30.11	34.00	20.0-50.0
Cobalt, mg/kg	0.11	0.11	0.1-0.3
Selenium, mg/kg	0.11	0.10	0.1-0.4

Research methods

Meat sampling and organoleptic tests were carried out in accordance with State Standard of Ukraine (SSU) **SSU 7992:2015**. Meat quality indicators (mass fraction of moisture, protein, fat, and ash) were studied by standardized methods: mass fraction of moisture was determined according to **SSU ISO 1442:2005**; protein – by the Kjeldahl method according to **SSU ISO 937:2005**; fat – in accordance with **SSU ISO 1443:2005**; ash – in accordance with **SSU ISO 936:2008**.

The content of trace elements zinc, copper, iron, manganese, cobalt and selenium in the meat of wild ungulates was determined on an atomic absorption spectrophotometer S-115M1 ("SELMI", Ukraine) in accordance with **SSU EN 13804:2014**.

Statistical Analysis

The obtained results were processed by methods of variation statistics using the software package for analysis of variance (ANOVA) StatPlus 5 (6.7.0.3) (AnalystSoft Inc., USA). The probability of the obtained results was evaluated by the Tukey criterion (HSD mean difference) at a probability level of 95.0% (P<0.05).

RESULTS

During the analysis of the meat qualities of red deer and European fallow deer during the experiment, it was established that according to the organoleptic indicators, the fresh meat of both species of wild ungulates at all times of the study was low: the surface of the carcasses was covered with a red crust, the fat was soft from white to a yellowish color, without the smell of rancidity; the muscles on the section were slightly moist, leaving a slight stain on the filter paper; meat color from red to burgundy; the consistency of the meat is dense, springy, when pressed with a spatula, the pit was immediately filled; the smell is specific, without extraneous impurities; tendons are elastic, dense, the surface of the joints is smooth, shiny; the aroma of the broth for meat cooking samples is specific, pleasant, aromatic, the broth is transparent, fat on the surface in the form of large drops.

Studies of meat quality indicators showed that the mass fraction of moisture in the meat of red deer probably did not differ from the control in all experimental groups during all three seasons (Tab. 5).

After the first season, the mass fraction of protein and ash exceeded the control ($P<0.05$) by 7.0 and 17.6%, respectively, in the meat of the red deer of the research group I, which received the adjusted diet, while the rest of the investigated indicators did not have probable deviations from the indicators of the control group. In the meat of the red deer of the II experimental group, which received a corrected diet and were additionally treated with veterinary drugs, the probable excess of the control indicators was determined by the mass fraction of protein and ash by 14.3 and 19.0%, respectively, the mass fraction of fat, although it was higher than in the control groups, but had no statistically significant differences (Tab. 5).

After the second season, in the red deer meat of the I experimental group, an excess of the indicators of the control group in terms of the mass fraction of protein and ash was established by 7.9 and 22.4%, in the II experimental group, the excess of these indicators was more pronounced: the mass fraction of protein increased by 17.9%, and ash – by 26.4% ($P<0.05$), while the fat index probably did not change in both groups (Tab. 5).

After the third season, an increase in quality indicators was also established in the meat of red deer of the I and II research groups. Thus, in the 1st experimental group, the mass fraction of protein increased by 8.5% and ash by 30.9% ($P<0.05$). In the II experimental group, the increase in the mass fraction of protein in meat was 19.1%, fat – 12.9%, ash – 35.8% ($P<0.05$) (Tab. 5).

Table 5 Dynamics of red deer meat quality indicators (M±m, n=18)

Indicator		Moisture, %	Protein, %	Fat, %	Ash, %
Season	Group				
0	Before the start of the experiment (n=3)	72.07±0.23	19.50±0.26	4.55±0.14	1.55±0.10
1	Control	72.05±0.33	19.28±0.38	4.53±0.27	1.53±0.12
	I experimental	72.20±0.14	20.62±0.19*	4.60±0.14	1.80±0.09*
	II experimental	72.53±0.16	22.03±0.45*	4.85±0.10	1.82±0.12*
2	Control	72.02±0.31	19.13±0.52	4.50±0.26	1.50±0.15
	I experimental	72.22±0.15	20.65±0.14*	4.65±0.18	1.83±0.08*
	II experimental	72.23±0.31	22.22±0.33*	4.88±0.12	1.85±0.10*
3	Control	72.00±0.34	19.05±0.45	4.42±0.22	1.42±0.08
	I experimental	72.20±0.17	20.67±0.12*	4.67±0.15	1.85±0.10*
	II experimental	72.15±0.33	22.32±0.26*	4.93±0.08*	1.87±0.08*

Note: Control (natural diet), I – the first experimental group (natural diet + PMA), II – the second experimental group (natural diet + PMA + treatment with veterinary drugs), * – p<0.05 – relative to the control.

Analyzing the data related to the beginning of the experiment, it was established that the correction of the diet of PMA (I experimental group) contributed to the improvement of the investigated indicators of meat quality during 3 seasons. In particular, the mass fraction of protein increased by 5.9% on average, fat by 2.0%, and ash by 17.8%. Additional treatment of animals with veterinary drugs (II research group) led to a more intense increase in the studied meat quality indicators: the mass fraction of protein increased by 13.8%, fat by 7.4%, and ash by 19.1% on average (Tab. 5).

Along with the indicators of the quality of red deer meat, changes in the content of microelements were also determined. Thus, after the first season in the meat of the red deer of the 1st experimental group, no probable changes were detected in the content of all studied microelements, while in the meat of the red deer of the 2nd experimental group, a probable ($P<0.05$) excess of the control indicators was established for the content of zinc, manganese and cobalt – on 24.5; 21.0 and 29.0%, respectively, and the content of cuprum, iron and selenium, although higher than in the control group, had no statistically significant differences (Tab. 6).

After the second season, in the meat of the red deer of the I experimental group, an excess ($P<0.05$) of the indicators of the control group was found for the content of zinc and selenium by 7.8 and 13.5%, while the content of copper, iron, manganese and cobalt did not significantly exceed the control indicators. In the II experimental group, an excess of control ($P<0.05$) was found for the content of zinc – by 30.7%, iron – by 8.2%, manganese – by 28.4%, cobalt – by 38.8% and selenium – by 19.1%, while the content of copper was likely no deviations were found (Tab. 6).

After the third season, in the meat of the red deer of the I and II research groups, an increase in the indicators of the following microelements was also established. In the 1st experimental group, relative to the control, the content of zinc increased by 9.2%, copper by 10.0%, manganese by 13.2% and selenium by 15.7%, respectively ($P<0.05$), while no probable deviations were found in the content of iron and cobalt. In the II experimental group, the increase in the content of zinc was 31.8%, copper – 14.2%, iron – 9.6%, manganese – 35.1%, cobalt - 43.4% and selenium – 22.1% ($P<0.05$) (Tab. 6).

Analyzing the data related to the beginning of the experiment, it was established that the correction of the diet of PMA (I experimental group) contributed to the increase of the investigated indicators of the content of trace elements in meat during 3 seasons, in particular, the content of zinc increased by 5.3% on average, copper – by 4.4%, iron – by 3.8%; manganese – by 4.9%, cobalt – by 7.3% and selenium – by 8.7%. Additional treatment of animals with veterinary drugs (II experimental group) led to a more intense accumulation of the investigated microelements in the meat, namely: the content of zinc increased by 23.9% on average, copper – by 6.6%, iron – by 6.4%; manganese – by 20.4%, cobalt – by 30.0%, and selenium – by 11.8% (Tab. 6).

Table 6 Dynamics of the content of microelements in red deer meat (M±m, n=18)

Indicator		Zinc, mg/kg	Copper, mg/kg	Iron, mg/kg	Manganese, µg/kg	Cobalt, µg/kg	Selenium, µg/kg
Season	Group						
0	Before the start of the experiment (n=3)	29.99±0.75	1.52±0.12	47.02±1.40	138.33±7.39	12.18±1.20	16.97±0.83
1	Control	29.55±0.87	1.53±0.16	46.88±0.68	136.00±12.00	12.05±1.11	16.87±2.41
	I experimental	31.28±1.20	1.57±0.09	48.64±1.12	144.00±8.29	12.77±1.48	18.07±1.53
	II experimental	36.78±1.13*	1.60±0.07	49.58±0.76	164.50±6.28*	15.55±1.19*	18.42±1.33
2	Control	29.38±0.65	1.47±0.10	46.73±0.83	134.00±11.08	11.95±1.03	16.53±0.87
	I experimental	31.60±1.12*	1.59±0.09	48.82±1.02	145.17±6.59	13.11±0.97	18.59±0.63*
	II experimental	37.30±1.01*	1.62±0.06	50.04±0.42*	166.50±3.83*	15.88±0.93*	19.18±0.52*
3	Control	29.25±0.51	1.46±0.09	46.55±0.72	129.83±7.55	11.75±0.89	16.29±0.74
	I experimental	31.85±0.64*	1.60±0.08*	48.98±0.75	146.00±5.66*	13.31±0.86	18.66±0.57*
	II experimental	37.42±0.91*	1.64±0.04*	50.41±0.40*	168.83±2.48*	16.07±0.85*	19.32±0.34*

Note: Control (natural diet), I – the first experimental group (natural diet + PMA), II – the second experimental group (natural diet + PMA + treatment with veterinary drugs), * – p<0.05 – relative to the control.

In the meat of European fallow deer (Tab. 7), the mass fraction of moisture probably did not differ from the control in both experimental groups during all three seasons, although a tendency to increase was observed.

After the first season, the mass fraction of protein and ash exceeded the indicators of the control group ($P<0.05$) by 6.3 and 31.3%, respectively, in the meat of the European I doe of the research group, which received the adjusted PMA diet, while the mass fraction of fat had no significant differences. In the meat of the European II research group doe, which was additionally treated with veterinary drugs, the mass fraction of protein, fat and ash were higher ($P<0.05$) than the control by 10.2; 24.0 and 45.5%, respectively (Tab. 7).

After the second season, compared to the control group, all studied indicators were higher in the meat of the European I research group. Thus, the mass fraction of protein, fat and ash exceeded the control by 9.9; 25.3 and 39.3%, respectively ($P<0.05$). In the II experimental group, a similar pattern was observed, but the indicators were higher, in particular, the mass fraction of protein, fat and ash probably exceeded the control indicators by 16.3; 37.7 and 58.9% ($P<0.05$), respectively (Tab. 7).

After the third season, in the meat of the European I and II experimental groups, all investigated quality indicators were also found to increase. In the 1st experimental group, the mass fraction of protein increased by 11.9%, fat by 32.2%, and ash by 43.4% (p<0.05) relative to the control group. In the II experimental group, the increase ($P<0.05$) in the mass fraction of protein in meat was 19.7%, fat – 43.8%, and ash – 63.7% (Tab. 7).

The analysis of the obtained data regarding the beginning of the experiment indicates that the correction of the diet of PMA (I experimental group) contributes to the increase of the studied indicators of meat quality during three seasons, in particular, the mass fraction of protein increased by 6.1% on average, fat by 8.0%, ash - by 31.0%. Additional treatment of animals with veterinary drugs (II experimental group) led to a more intense increase in the studied meat quality indicators: the mass fraction of protein increased by 10.8% on average, fat by 15.5%, ash by 44.2% (Tab. 7) .

Table 7 Dynamics of meat quality indicators of European fallow deer (M±m, n=18)

Indicator		Moisture, %	Protein, %	Fat, %	Ash, %
Season	Group				
0	Before the start of the experiment (n=3)	73.76±0.59	19.84±0.44	2.13±0.28	1.01±0.13
1	Control	73.70±0.62	19.69±0.27	1.96±0.11	0.99±0.15
	I experimental	73.78±0.37	20.93±0.55*	2.24±0.21	1.30±0.14*
	II experimental	74.07±0.58	21.69±0.51*	2.43±0.20*	1.44±0.14*
2	Control	73.50±0.69	19.19±0.44	1.84±0.08	0.96±0.11
	I experimental	73.81±0.32	21.09±0.30*	2.30±0.16*	1.33±0.11*
	II experimental	74.13±0.55	22.01±0.30*	2.46±0.17*	1.46±0.13*
3	Control	73.43±0.51	18.91±0.46	1.79±0.09	0.94±0.10
	I experimental	73.84±0.37	21.16±0.19*	2.36±0.13*	1.34±0.10*
	II experimental	74.17±0.55	22.26±0.34*	2.49±0.17*	1.47±0.11*

Note: Control (natural diet), I – the first experimental group (natural diet + PMA), II – the second experimental group (natural diet + PMA + treatment with veterinary drugs), * – p<0.05 – relative to the control.

Along with the meat quality indicators of European fallow deer, changes in the content of microelements were also determined. Thus, after the first season, the content of zinc, cobalt, and selenium in the meat of the European I research group, which received the adjusted PMA ration, probably increased ($P<0.05$) by 8.5; 22.3 and 6.0%, respectively, while the rest of the studied indicators had no probable deviations compared to the control. In the meat of doe deer of the European II research group, which were additionally treated with veterinary drugs, the indicators of the content of almost all the studied trace elements exceeded the

control (*P<0.05*): zinc by 39.2%, copper by 11.1%, manganese by 11.0%, cobalt by 50.5% and selenium by 20.0%. Although the iron content was higher than the control, it was unlikely (Tab. 8).

After the second season, in comparison with the control group, all studied parameters were higher in the meat of the European I research group doe: the content of trace elements zinc, copper, iron, manganese, cobalt and selenium exceeded the control (*P<0.05*) by 15.8; 11.0; 4.41; 16.2; 35.6 and 19.2%, respectively. In the II experimental group, a similar picture was observed, but the indicators were higher, in particular, the content of zinc, copper, iron, manganese, cobalt and selenium exceeded the control (*P<0.05*) by 50.1; 22.4; 6.5; 23.5; 67.0 and 27.4%, respectively (Tab. 8).

After the third season, in the meat of doe deer of the European I and II research groups, an increase in all investigated indicators of microelements was also established: in the I research group, the excess of the reference indicator in terms of zinc content was 21.6%, copper – 15.1%, iron – 5.0%, manganese – 9.4% , cobalt – 38.6% and selenium – 23.0%, respectively (*P<0.05*); in the II experimental group, the content of zinc increased by 57.3%, copper – by 30.3%, iron – by 7.3%, manganese - by 34.7%, cobalt - by 77.1% and selenium - by 34.6% (*P<0.05*) (Tab. 8) .

The analysis of the data obtained at the beginning of the experiment indicates that the correction of the diet of PMA (I research group) contributes to the increase of the investigated indicators of microelements in meat during three seasons, in particular, the increase in the content of zinc was on average 10.6%, copper - 4.5%, manganese – 3.7%, cobalt – 25.0% and selenium – 6.1%, while the content of Iron almost did not change. Additional treatment of animals with veterinary drugs (II research group) contributes to a more intensive accumulation of microelements in meat, in particular, the content of zinc increased on average by 38.6%, copper - by 13.2%, iron - by 1.9%; manganese – by 19.5%, cobalt – by 50.0%, and selenium – by 11.3% (Tab. 8).

Table 8 Dynamics of the content of trace elements in the meat of European fallow deer (M±m, n=18)

Indicator		Zinc, mg/kg	Copper, mg/kg	Iron, mg/kg	Manganese, µg/kg	Cobalt, µg/kg	Selenium, µg/kg
Season	Group						
0	Before the start of the experiment (n=3)	26.95±0.94	1.19±0.05	50.89±1.10	128.00±3.16	10.10±0.88	14.58±0.79
1	Control	26.69±0.70	1.17±0.03	50.24±0.99	126.57±2.64	9.90±0.66	14.27±0.59
	I experimental	29.24±0.91*	1.22±0.03	50.96±0.63	130.71±3.04	12.35±0.53*	16.51±0.51*
	II experimental	37.14±1.00*	1.30±0.08*	51.40±0.48	140.43±3.10*	14.90±0.42*	17.13±0.70*
2	Control	25.94±0.50	1.13±0.06	49.26±0.56	125.43±1.90	9.63±0.48	14.01±0.40
	I experimental	29.93±0.56*	1.25±0.03*	51.33±0.28*	132.86±2.19*	12.83±0.41*	16.50±0.51*
	II experimental	37.35±0.67*	1.35±0.09*	52.00±1.30*	158.14±4.53*	15.10±0.26*	17.24±0.56*
3	Control	24.97±0.31	1.10±0.07	49.14±0.60	123.71±2.14	9.34±0.43	13.69±0.43
	I experimental	30.21±0.36*	1.26±0.02*	51.47±0.36*	134.71±2.21*	12.71±0.44*	16.60±0.30*
	II experimental	37.53±0.49*	1.39±0.06*	52.22±1.13*	160.43±7.25*	15.44±0.50*	17.67±0.63*

Note: Control (natural diet), I – the first experimental group (natural diet + PMA), II – the second experimental group (natural diet + PMA + treatment with veterinary drugs), * – p<0.05 – relative to the control.

It is appropriate to emphasize the gradual decrease (albeit improbable) of the investigated indicators in the meat of the control group during the 3 seasons. In particular, the mass fraction of protein decreased on average by 2.9%, fat – 12.5%, ash – 4.6%, zinc content –4.0%, copper – 4.8%, iron – 2.6%; manganese – 2.2%, cobalt – 4.7% and selenium – 10.2%.

DISCUSSION

Nowadays, wild ungulates are bred more and more often in the world on small farms or in enclosures (pens) on relatively large areas. In the 20th century, representatives of the Cervidae family, in particular the red deer (*Cervus elaphus*), fallow deer (*Dama dama*) and spotted deer (*Cervus nippon*), became relatively popular "farm animals", they began to be bred on farms as semi-domestic animals **(Janiszewski *et al*., 2016)**. However, in order to preserve their authenticity as wild animals and to maximally improve the quality of the products obtained from them (including meat), it is necessary to carry out veterinary-sanitary and zootechnical (feeding) measures in such a farm or aviary, and they should be of with as little human disturbance as possible to reduce animal stress and have a minimal impact on the environment **(Pepko *et al*., 2019a,b)**.

Reducing stress in animals is important, especially in ruminants, because under stressful conditions animals can lose live weight primarily due to fat deposits **(Asres & Amha, 2014)**. The latter affects meat quality indicators, since, for example, such an indicator as moisture directly depends on the presence of intramuscular fat **(Serrano *et al*., 2019a)** and reflects the juiciness of the meat. In our research, we did not observe probable changes in the moisture content of the meat of both species of wild ungulates in the case of the use of a corrected diet and the use of veterinary drugs, however, the average moisture content of the red deer meat was 2.3% lower than that of the European deer. It should be noted that the results of the moisture content of red deer meat obtained by us (min72.00-max72.53%) were slightly lower compared to the data obtained by scientists in Italy (min75.30-max76.20%) **(Maggiolino *et al*., 2019)**, Slovakia (min75.76-max76.32%) **(Šnirc *et al*., 2017)** and Spain (min73.30-max74.30%) **(Serrano *et al*., 2019a)**, but were within the data range (min70. 91-max72.82%) given in **Novak & Bodrova (2014)**. The results of meat moisture (min73.43-max74.17%) of European fallow deer agreed with the data of **Piaskowska *et al*. (2016)** and **Daszkiewicz *et al*. (2015)** (min74.20-max74.30%), but were lower than the data of **Bykowska *et al*. (2018)** (77.6%).

The indicators of actual fat in the meat of red deer and European fallow deer in our study differed significantly, in particular, the average indicator of fat in the meat of deer was 2.1 times higher than that of doe. In addition, the mass fraction of fat in the meat of wild ungulates was much higher than the indicators available in the literature. Thus, the fat content in red deer meat (min4.42-max4.93%) exceeded the indicators obtained by **Šnirc *et al*. (2017), Maggiolino *et al*. (2019)** and **Serrano *et al*. (2019a)** (min0.05-max1.92%), but agreed with the data of **Novak & Bodrova (2014)** (min4.54-max8.48%). The results of determining the fat content in the meat of European experimental and control group doe deer (min1.79-max2.49%) exceeded the data obtained by **Piaskowska *et al*. (2016), Daszkiewicz *et al*. (2015)** and **Bykowska *et al*. (2018)** (min0.50-max0.87%). We attribute the obtained result to the inclusion in the diet of wild ungulates of both species of such ingredients as clover and alfalfa, which contain a significant amount of crude fat **(Homolka *et al*., 2012)**, as well as corn **(Bathla *et al*., 2019)**.

Venison is considered a complete protein meat, as it contains all 10 essential amino acids **(Strazdina *et al*., 2014)**. It should be noted that in our research we did not observe a significant difference in protein content in the meat of both species of wild ungulates. The mass fraction of protein in the meat of red deer only in the case of the use of veterinary drugs on the background of a balanced diet (II experimental group) (min22.03-max22.32%) was at the level of the indicators obtained by **Šnirc *et al*. (2017), Maggiolino *et al*. (2019)** and **Serrano *et al*. (2019a)** (min21.80-max22.90%), while under the conditions of only a balanced diet (I experimental group), the protein index (min20.62-max20.67%) was lower according to the above data, however, it was consistent with the data of Novak and Bodrova, 2014 (min20.56-max21.97%), and without veterinary and zootechnical measures (control) (min19.05-max19.50%), the indicator of the mass fraction of protein was lower than available literature data. The results of determining the protein content in the meat of European fallow deer (min20.93-max22.26%) both against the background of using only a balanced diet (I experimental group) and in the case of using veterinary drugs (II experimental group) agreed with the data of **Piaskowska *et al*. (2016), Daszkiewicz *et al*. (2015)** and **Bykowska *et al*. (2018)** (min20.70-max22.80%), and the data on the control group were lower than the above data (min18.91-max19.84%).

The indicators of the mass fraction of ash in the meat of red deer and European fallow deer in our study differed significantly, in particular, the average indicator of ash in the meat of deer exceeded the indicator of doe by 1.4 times. In addition, the mass fraction of ash in the meat of wild ungulates exceeded the indicators available in the literature in the case of using a corrected diet (I research group) and veterinary drugs (II research group). Thus, the ash content in red deer meat of these groups (min1.80-max1.87%) was consistent with the indicators of **Novak & Bodrova (2014)** (min1.55-max1.88%), but exceeded the indicators obtained by **Soriano & Sánchez-García (2021)** (min1.10-max1.34%), while in the control group, whose animals received a natural diet, the mass fraction of ash (min1.42-max1.55%) was close to the indicators of the above-mentioned authors. The results of determining the ash content in the meat of European fallow deer regardless of the application of veterinary and zootechnical measures (min0.94-max1.47%) were consistent with the data of **Cawthorn *et al*. (2020)** (min1.10-max1.50%).

Regarding the trace element composition of the meat of wild ungulates, there are also certain discrepancies with the literature data, which confirms the dependence of the content of trace elements in the meat of wild ungulates mainly on the territory (geochemical province) in which the animals are located, that is, on the diet available there (biochemical composition of local fodder).

Thus, the content of zinc in red deer meat (min29.25-max37.42 mg/kg) exceeded the values obtained by **Lorenzo *et al*. (2018)** (min13.60-max18.30 mg/kg), but was consistent with the data of **Serrano *et al*. (2019b)** – (min30.00-max36.00 mg/kg),

but was lower than the data of **Giżejewska *et al*. (2017)** – (min45.15- max94.18 mg/kg).

The iron content (min46.55-max50.41 mg/kg) was higher than the data obtained by both **Lorenzo *et al*. (2018)** (min27.30-max33.70 mg/kg) and **Serrano *et al*. (2019b)** – (min17 .20-max19.10 mg/kg), but agreed with the data of **Giżejewska *et al*. (2017)** - (min22.49-max152.53 mg/kg).

The copper content (min1.46-max1.64 mg/kg) was consistent with the data of **Giżejewska *et al*. (2017)** – (min0.50-max2.09 mg/kg), slightly lower than the data of **Lorenzo *et al*. (2018)** (min1.93-max2.11 mg/kg), but it was slightly higher than the values of **Serrano *et al*. (2019b)** – (min1.12-max1.41 mg/kg).

Manganese content (min0.129-max0.168 mg/kg) partially agreed (under conditions of use of veterinary drugs) both with the data of **Lorenzo *et al*. (2018)** (min0.170-max0.22 mg/kg) and with the data of **Serrano *et al*. (2019b)** – (min0.14-max0.19 mg/kg).

The content of selenium in red deer meat (min0.163-max0.193 mg/kg) agreed with the data of **Kursa *et al*. (2010)** – (min0.076-max0.388 mg/kg), but was significantly higher than the data of **Assenova *et al*. (2016)** – (min0.004-max0.011 mg/kg).

The content of cobalt in the meat of red deer (min0.118-max0.161 mg/kg) agreed with those reported by **Hassan *et al*. (2012)** – (min0.02-max0.550 mg/kg), but was significantly higher than the data of **Assenova *et al*. (2016)** – (min0.042-max0.073 mg/kg).

Regarding the trace element composition of the meat of European fallow deer, there is a little less data in the literature, but in our study, the zinc content in the meat of European fallow deer (min24.97-max37.53 mg/kg) exceeded the data obtained by **Cawthorn *et al*. (2020)** - (min14.52-max21.70 mg/kg), a similar pattern was observed for the content of iron (min49.14-max52.22 mg/kg) versus (min34.79-max47.98 mg/kg) and cobalt (min0.093-max0.154 mg/kg) versus (min0.001- max0.004 mg/kg).

In contrast to the above-mentioned microelements, the content of copper (min1.10-max1.39 mg/kg) in doe meat in our study was lower than the results of **Cawthorn *et al*. (2020)** – (min1.94-max2.02 mg/kg), a similar picture the manganese content was also observed (min0.124-max0.160 mg/kg) versus (min0.200-max0.233 mg/kg).

The content of selenium in the control group (min0.137-max0.146 mg/kg) in the meat of doe in our study was consistent with the results of Cawthorn **Cawthorn *et al*. (2020)** - (min0.122-max0.155 mg/kg), while under correction diet and use of veterinary drugs (min0.165-max0.177 mg/kg) – exceeded the above indicators.

It should be noted that correction of the di*et al*ong with the use of veterinary drugs led to an increase in the content of microelements in the meat of red deer and European fallow deer during 3 seasons.

CONCLUSIONS

During the analysis of the meat qualities of red deer and European fallow deer during the experiment, it was established that according to the organoleptic indicators, the meat of both species of wild ungulates at all times of the research had no deviations from the indicators of "fresh" meat.

The application of veterinary drugs to red deer and European fallow deer on the background of a corrected diet twice during three seasons in semi-free housing conditions contributed to a more intense increase in meat quality due to an increase in the mass fraction of protein by 13.8 and 10.8%, fat by 7.4 and 15.5%; ash - by 19.1 and 44.2%, as well as enrichment with trace elements: the content of zinc increased by 23.9 and 38.6%, copper - by 6.6 and 13.2%, iron - by 6.4 and 1.9%, manganese - by 20.4 and 19.5%, cobalt - by 30.0 and 50.0% and Selena – by 11.8 and 11.3%.

The trace element composition of the meat of wild ungulates mainly depends on the territory (geochemical province) in which the animals are located, that is, on the available diet (biochemical composition of local fodder).

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REFERENCES

Asres, A. & Amha, N. (2014). Effect of Stress on Animal Health: A Review. *Journal of Biology, Agriculture and Healthcare, 4*(27), 116-121.www.iiste.org/Journals/index.php/JBAH/article/view/18643/18919

Assenova, B., Okuskhanova, E., Rebezov, M., Korzhikenova, N., Yessimbeko, V Z. & Dragoev, S. (2016). Trace and Toxic Elements in Meat of Maral (Red Deer) Grazing in Kazakhstan. *Research Journal of Pharmaceutical, Biological and Chemical Sciences, 7*(1), 1425-1433.[201].pdf (rjpbcs.com)

Balciauskas, L., Varanauska, S R. & Bukelskis, E. (2017). Impact of selective hunting on the trophy size of roe deer: Baltic example. *North-Western Journal of Zoology, 13*(1), 118-127.

Bathla, S., Jaidka, M. & Kaur, R. (2019). *Nutritive Value*. In (Ed.), Maize – Production and Use. IntechOpen.https://doi.org/10.5772/intechopen.88963

Belkin, V., Panchenko, D. V., Tirronen, K. & Danilov, P. (2012). Semi-free ranging ungulates in European taiga. *Zoology and Ecology, 22*(1), 1-8.https://doi.org/10.1080/21658005.2012.674660

Briggs, M. A., Petersen, K. S. & Kris-Etherton, P. M. (2017). Saturated fatty acids and cardio-vascular disease: replacements for saturated fat to reduce cardiovascular risk. *Healthcare, 5*(2), 1-29.https://doi.org/10.3390/healthcare5020029

Bykowska, M., Stanisz, M., Ludwiczak, A., Składanowska, J. & Ślósarz, P. (2018). The effect of muscle, time post-mortem and sex on the quality of meat from fallow deer (Dama dama) farmed in Poland. *Small Ruminant Research, 160*, 12-18.https://doi.org/10.1016/j.smallrumres.2018.01.007

Cawthorn, D.-M., Fitzhenry, L. B., Kotrba, R., Bureš, D. & Hoffman, L. C. (2020). Chemical Composition of Wild Fallow Deer (Dama Dama) Meat from South Africa: A Preliminary Evaluation. *Foods, 9*, 598.https://doi.org/10.3390/foods9050598

Daszkiewicz, T. & Mesinger, D. (2018). Fatty acid profile of meat (Longissimus lumborum) from female roe deer (Capreolus capreolus L.) and red deer (Cervus elaphus L.). *International Journal of Food Properties, 21*(1), 2276–2282.https://doi.org/10.1080/10942912.2018.1508160

Daszkiewicz, T., Hnatyk, N., Dąbrowski, D., Janiszewski, P., Gugołek, A., Kubiak, D., Śmiecińska, K., Winarski, R., & Koba-Kowalczyk, M. (2015). A comparison of the quality of the Longissimus lumborum muscle from wild and farm-raised fallow deer (Dama dama L.). *Small Ruminant Research, 129*, 77-83.https://doi.org/10.1016/j.smallrumres.2015.05.003

Giżejewska, A., Szkoda, J., Nawrocka, A. Żmudzki, J. & Giżejewski, Z. (2017). Can red deer antlers be used as an indicator of environmental and edible tissues' trace element contamination? *Environmental Science and Pollution Research, 24*, 11630-11638.https://doi.org/10.1007/s11356-017-8798-7

Hassan, A. A., Rylander, C., Brustad, M., & Sandanger, T. M. (2012). Level of selected toxic elements in meat, liver, tallow and bone marrow of young semi-domesticated reindeer (Rangifer tarandus tarandus L.) from Northern Norway. *International Journal of Circumpolar Health, 71*, 1-7.https://doi.org/10.3402/ijch.v71i0.18187

Homolka, P., Koukolová, V., Podsedníček, M. & Hlaváčková, A. (2012). Nutritive value of red clover and lucerne forages for ruminants estimated by in vitro and in vivo digestibility methods. *Czech Journal of Animal Science, 57*(10), 454-568.https://doi.org/10.17221/6346-CJAS

Janiszewski, P., Bogdaszewski, M., Murawska, D. & Tajchman, K. (2016). Welfare of farmed deer – practical aspects. *Polish journal of natural sciences, 31*(3), 345-361.

Katysh, S. V. (2016). Game breeding in the territory of forest-steppe and steppe zones of Ukraine (by the example of Poltava and Zaporizhzhia regions). *Biological sytems, 8*(2), 219-227. [in Ukrainian]

Khoyetskyy, P., Novak, A. & Pokhalyuk, O. (2015). World Experience of Captive Hunting Game Management. *Scientific Bulletin of UNFU, 25*(3), 32-37. [in Ukrainian] https://nv.nltu.edu.ua/index.php/journal/article/view/1119

Kratiuk, O. L. (2018). Species composition and number dynamics of Artiodactyla ungulates in enclosures in the territory of Zhytomyr region. *Scientific Bulletin of UNFU, 28*(3), 34-37.https://doi.org/10.15421/40280307

Kuba, J., Landete-Castillejos, T. & Udała, J. (2015). Red deer farming: breeding practice, trends and potential in Poland – a review. Annals *of Animal Science, 15*(3), 591-599.https://doi.org/10.1515/aoas-2015-0033

Kursa, J., Herzig, I., Trávníček, J., Illek, J., Kroupová, V. & Fuksová, Š. (2010). Iodine and Selenium Contents in Skeletal Muscles of Red Deer (Cervus elaphus), Roe Deer (Capreolus capreolus) and Wild Boar (Sus scrofa) in the Czech Republic. *Acta Veterinaria Brno*, 79, 403-407. https://doi.org/10.2754/avb201079030403

Linnell, J. D. C., Cretois, B., Nilsen, E. B., Rolandsen, C. M., Solberg, E. J., Veiberg, V., Kaczensky, P., Van Moorter, B., Panzacchi, M., Rauset, G. R. & Kaltenborn, B. (2020). The challenges and opportunities of coexisting with wild ungulates in the human-dominated landscapes of Europe's Anthropocene. *Biological Conservation, 244*, 108500.https://doi.org/10.1016/j.biocon.2020.108500

Lorenzo, J. M., Maggiolino, A., Gallego, L., Pateiro, M., Serrano, M. P., Domínguez, R., Diaz, A., Landete-Castillejos, T. & De Palo, P. (2018). Effect of slaughter age on nutritional properties of Iberian wild red deer meat. *Journal of the Science of Food and Agriculture, 99*, 1561-1567.https://doi.org/10.1002/jsfa.9334

Maggiolino, A., Pateiro, M., Serrano, M. P., LandetE-Castillejos, T., Domínguez, R., García, A., Gallego, L., De Palo, P. & Lorenzo, J. M. (2019). Carcass and meat quality characteristics from Iberian wild red deer (Cervus elaphus) hunted at different ages. *Journal of the Science of Food and Agriculture, 99*(4), 1938-1945.https://doi.org/10.1002/jsfa.9391

Moiseeva, T. A. (2020). Legal and organizational basis of aviary keeping of animals. IOP Conf. Ser.: *Earth Environmental Science, 421*, 032056.https://doi.org/10.1088/1755-1315/421/3/032056

Nkosi, D.V., Bekker, J.L. & Hoffman, L.C. (2021). Toxic Metals in Wild Ungulates and Domestic Meat Animals Slaughtered for Food Purposes: A Systemic Review. *Foods, 10*, 2853.https://doi.org/10.3390/foods10112853

Novak, G. V. & Bodrova, L. F. (2014). The chemical composition of reindeer meat when using various types of feeding. *Izvestiya OGAU, 6*(50). 120-122.

Parker, K. L., Barboza, P. S. and Gillingham, M. P. (2009). Nutritional ecology of

ungulates Nutrition integrates environmental responses of ungulates. *Functional Ecology*, *23*, 57-69.https://doi.org/10.1111/j.1365-2435.2008.01528.x
Pepko, V. O., Velesik, T. A., Sachuk, R. M., Mandigra, Yu. M. & Zhigalyuk, S. V. (2019a). Zoohygienic and economic aspects of construction and operation of the average complex for the conservation of wild haves. *Ukrainian Journal of Veterinary and Agricultural Sciences*, *2*(2), 37-40.https://doi.org/10.32718/ujvas2-2.08
Pepko, V. O., Zhigalyuk, S. V. & Sachuk, R. M. (2019b). Environmental and sanitary ang hygienic aspects of the prevention of wild helminthosis in the contemporary climate change. *Ukrainian Journal of Veterinary and Agricultural Sciences*, *2*(3), 43-47.https://doi.org/10.32718/ujvas2-3.10
Pepko, V.O. (2020). The influence of mineral supply of wild ungulates bred in enclosures on the quality of their trophies. *Taurida Scientific Herald. Series: Rural Sciences*, *114*, 195-202. [in Ukrainian]
Piaskowska, N., Daszkiewicz, T., Kubiak, D., & Zapotoczny, P. (2016). Quality of meat (Longissimus dorsi) from male fallow deer (Dama dama) packaged and stored under vacuum and modified atmosphere conditions. *Asian-Australas Journal Animal Sciences*, *29*(12), 1782-1789.https://doi.org/10.5713/ajas.15.1016
Razmaitė, V., Šiukščius A., Pileckas, V. & Švirmickas, G. J. (2015). Effect of different roe deer muscles on fatty acid composition in intramuscular fat. *Annals of Animal Science*, *15*, 775-784.https://doi.org/10.1515/aoas-2015-0012
Serrano, M. P., Maggiolino, A., Lorenzo, J. M., De Palo, P., García, A., Landete-Castillejos, T., Gambín, P., Cappelli, J., Domínguez, R., Pérez-Barbería, F. J. & Gallego, L. (2019b). Meat quality of farmed red deer fed a balanced diet: effects of supplementation with copper bolus on different muscles. *Animal*, *13*(4), 888-896.https://doi.org/10.1017/S1751731118002173
Serrano, M. P., Maggiolino, A., Pateiro, M., LandetE-Castillejo, S T., Domínguez, R., García, A., Franco, D., Gallego, L., De Palo, P. & Lorenzo, J. M. (2019a). *Carcass Characteristics and Meat Quality of Deer. More Than Beef, Pork and Chicken – The Production, Processing, and Quality Traits of Other Sources of Meat for Human Diet*. Springer Nature Switzerland AG 2019. 227-268.https://doi.org/10.1007/978-3-030-05484-7_9
Shin, H. T., Hudson, R. J., Gao, X. H., & Suttie, J. M. (2000). Nutritional requirements and managements strategises for farmed deer – review. Asian *Asian-Australas Journal Animal Sciences*, *13*(4), 561-573.
Simmonds, R. C. (2017). Chapter 4. *Bioethics and animal use in programs of research, teaching, and testing*. In: Weichbrod, R. H., Thompson, G. A. H., Norton, J. N. (Eds.). *Management of animal care and use programs in research, education, and testing*. 2nd edition. CRC Press, Taylor & Francis, Boca Raton. 1-28.https://doi.org/10.1201/9781315152189-4
Šnirc, M., Kral, M., Ošťádalová, M., Golian, J. & Tremlová, B. (2017). Application of principal compo nent analysis method for characterization chemical, technological, and textural parameters of farmed and pastured red deer. *International Journal of Food Properties*, *20*(4), 754-761.https://doi.org/10.1080/10942912.2016.1180532
Soriano, A., & Sánchez-García, C. (2021). *Nutritional Composition of Game Meat from Wild Species Harvested in Europe*. In (Ed.), Meat and Nutrition. IntechOpen.https://doi.org/10.5772/intechopen.97763
SSU 7992:2015. (2017). Meat *and meat raw materials. Methods of sampling and organoleptic assessment of freshness.* Effective from 01.01.2017. K.: Derzhspozhivstandard of Ukraine, 9. (National standards of Ukraine). [in Ukrainian]
SSU EN 13804:2014. (2015). *Food products. determination of trace elements. performance criteria, general analysis and sample preparation*. Effective from 01.07.2015. K.: Derzhspozhivstandard of Ukraine, 14. (National standards of Ukraine). [in Ukrainian]
SSU ISO 936:2008. (2008). *Meat and meat products. Method for determining the mass fraction of total ash.* Effective from 01.09.2008. K.: Derzhspozhivstandard of Ukraine, 10. (National standards of Ukraine). [in Ukrainian]
SSU ISO 937:2005. (2007). *Meat and meat products. Determination of nitrogen content (control method).* Effective from 01.07.2007. K.: Derzhspozhivstandard of Ukraine, 11. (National standards of Ukraine). [in Ukrainian]
SSU ISO 1442:2005. (2008). *Meat and meat products. Method for determining moisture content (control method)*. Effective from 01.03.2008. K.: Derzhspozhivstandard of Ukraine, 9. (National standards of Ukraine). [in Ukrainian]
SSU ISO 1443:2005. (2008). *Meat and meat products. Method for determining the total fat content*. Effective from 01.03.2008. K.: Derzhspozhivstandard of Ukraine, 9. (National standards of Ukraine). [in Ukrainian]
Stanisz, M., Ludwiczak, A., Buda, P., Pietrzak, M., Bykowska, M., Kryza, A. & Ślósarz, P. (2015). The effect of sex on the dressing percentage, carcass, and organ quality in the fallow deer (Dama dama). *Annals of Animal Science*, 15, 1055-1067.https://doi.org/10.1515/aoas-2015-0045
Stanisz, M., Skorupski, M., Ślósarz, P., Bykowska-Maciejewska, M., Składanowska-Baryza, J., Stańczak, Ł., Krokowska-Paluszak, M. & Ludwiczak, A. (2019). The seasonal variation in the quality of venison from wild fallow deer (Dama dama) – a pilot study. *Meat Science*, *150*, 56-64.https://doi.org/10.1016/j.meatsci.2018.12.003
Stoebe, S., Müller, A. S., Most, E., Coenen, M. & Vervuert, I. (2015). Effects of selenium supplementation on selenium status of farmed fallow deer in outdoor pens. *Journal of Trace Elements in Medicine and Biology*, *29*, 216-221.https://doi.org/10.1016/j.jtemb.2014.10.006
Strazdina, V., Jemeljanovs, A. & Sterna, V. (2014). Protein Quality of Game Meat Hunted in Latvia. World Academy of Science, Engineering and Technology. *International Journal of Nutrition and Food Engineering*, *8*(7), 807-810.https://doi.org/10.5281/zenodo.1327252
Viganò, R., Demartini, E., Riccardi, F., Corradini, A., Besozzi, M., Lanfranchi, P., Chiappini, P. L., Cottini, A. & Gaviglio, A. (2019). Quality parameters of hunted game meat: Sensory analysis and pH monitoring. *Italian Journal of Food Safety*, *8*(1), 7724.https://doi.org/10.4081/ijfs.2019.7724
Żochowska-Kujawska, J., Kotowicz, M., Sobczak, M., Lachowicz, K. & J. Wójcik (2019). Age-related changes in the carcass composition and meat quality of fallow deer (Dama Dama L.). *Meat Science*, *147*, 37-43.https://doi.org/10.1016/j.meatsci.2018.08.014