BIOSCIENCES BIOTECHNOLOGY RESEARCH ASIA, November 2014. Vol. **11**(Spl. Edn.), p. 51-58

Maral Deer Meat Productivity and Meat Quality When Using the Different Types of Diets

Nurgul Orungalievna Korzhikenova, N.O. Korzhikenova[1], A.A. Sambetbaev[1] and O.D. Iglikov[2]

Kazakh National Agrarian University, Kazakhstan, 050010, Almaty, Abay Street, 8
[1]Department of Production Technology of Animal Husbandry and Fish Farming Products, Kazakh National Agrarian University, Abay Street, 8, Almaty, 050010, Kazakhstan.
[2]Department of Animal Husbandry and Hunting Technology, Semey State University named after Shakarim, 071403, Semey, Kazakhstan.

doi: http://dx.doi.org/10.13005/bbra/1439

(Received: 27 September 2014; accepted: 10 October 2014)

Thirty-three stag maral deer (Cervus elaphus sibiricus) 42 month old were allocated to one of three treatment groups: hay-concentrate typical diet, silage and haylage diets with a mineral block (zeolite clay, boiled antler broth and fodder salt). When mineral block was included in diets higher levels carcass weight, flesh weight, dry matter, pH were measured. Besides this meat and broth sensory qualities were improved.

Key words: Maral stags, Mineral feed supplement, Diet, meat productivity, Venison chemical composition, Sensory evaluation.

The maral - (Cervus elaphus sibiricus, Severzov) - is one of the largest representative of red deer which inhabits in the east and south-east of Kazakhstan. One source of replenishment of meat balance and monetary fund in Kazakhstan is deer breeding. Deer farming is, compared with the husbandry of other species, a low input system, with the animals being grazed extensively and having minimal impact on the environment[1].The use of various deer species as grazing animals in extensive pasture-based systems is important to many countries all over the world. Deer meat (venison) produced in these extensive systems is often valued by consumers as an ecological and ethical alternative to the commercially produced beef, pork and chicken[2]. Meat from one animal comprises considerable value 150-200 kg, which has good taste properties and not much inferior to beef and lamb[3].Meat has a high nutritional value and is related to dietary products. It is a valuable source of vitamins, and the muscle tissue dominated by water-soluble vitamins. Number of fat-soluble vitamins increases with increasing fatness of animals. Meat proteins have a high biological value. The amino acid composition of meat is not inferior to that of traditional animals, and exceeds it by the content of some amino acids (threonine, tryptophan, phenylalanine)[4].

The increasing interest of consumers in the so-called free-range products was reflected, among others, in the development of wild animal farming in different regions of the world[5].In Kazakhstan, the interest to eating venison and the use of nutritional supplements from deer products is growing rapidly. This increase in interest of deer products is due to the desire of population to

* To whom all correspondence should be addressed.

healthy nutrition and consumption of meat with low fat and cholesterol content. Venison (deer meat) has several attributes attractive to consumers — it is tender, has low fat content, a favourable fat composition and high levels of minerals. All these attributes of venison are criteria demanded by today's discerning meat consumer[6].

From the complex of factors affecting the level of maral meat production, at present and the near future outlook one of the most important is to increase marals population and live weight with a shortened duration of feeding. The absence of science-based information, including proven feeding norms and types, low quality of harvested forages, constrain maral productivity. To realize the full genetic potential of deer regarding meat quality, the most important direction belongs to the development of rational feeding systems. The improving way of maral deer meat productivity is presented in this paper.

MATERIALS AND METHODS

The objective of the present study was to determine the comparative efficiency of silage and haylage diet types with inclusion of mineral supplement on maral deer meat productivity, venison chemical composition, physical properties and sensory qualities.

The research was conducted in maral farm "Bagration" at Ulan area of East Kazakhstan region. Thirty-three stag maral deer (analogs on live weight, age and physiological state) were allocated to three groups according to diet types. The experiment lasted 151 days.

HCTD	Hay-concentrate typical diet used in the farm
SDNM	Silage diet with a mineral block
HDMB	Haylage diet with a mineral block

In order to balance the mineral part of dietsthe mineral block was added to the diets of 2nd and 3rd experimental animals groups. For this purpose the sifted zeolite clay from local Mitrofanovskoe field and fodder salt were mixed in boiled antler broth. The blocks were prepared by using of special forms. The weight of one block was 3.0-3.5 kg. The mineral feed supplement consists the zeolite clay, boiled antler broth and salt in the following components ratio, wt.%: 68-70, 26-28, 2-4. Mineral blocks were given to animals in salt feeder. Maral stags consumed them depend on necessity. Water was available at all times.

Feeding diets of marals, diets structures and chemical composition of mineral block has been reported (Korzhikenova *et al*., Efficiency of mineral feed supplement using in maral deer (Cervus elaphus sibiricus) diets. Life Science Journal 2014;11(8s):368-372).

Forage chemical composition and nutritiousness analyzes were carried out in "Forage quality assessment, animals and birds normalized feeding" lab of Semey State University named after Shakarim. For the forage analysis were used common methods of P.T. Lebedev, Usovich A.T.[7]. The weighing of forage samples and their leavings was carried out on electronic scales within accuracy up to 0.1 kg.

Content of macro- and microelements of mineral block was determined on a mass spectrometer with inductively coupled plasma "Varian ICP-MS 820" ("Varian" Co, Australia). As a standard solutions was used the solution Var-TS-MS, IV-ICPMS-71A (Company "Inorganic Ventures", USA). For calibration of the mass spectrometer was used three working standard IV-ICPMS-71A which are consist of 10, 50 and 100 mcg/l of all elements (Ag, Al, Be, Ca, Cd, Co, Cr, Cu, Fe, K, Mg, Mn , Na, Ni, P, Pb, Rb, Se, Sr, V, Zn). The marals were slaughtered at farm "Bagration" slaughterhouse on 152 day of the experiment. Totally 9 maral stags were slaughtered (3 from each group). Blood and viscera were immediately removed. Definition of slaughter yield and taking meat samples for analyzes was carried by Tomme M.F.[8]. After carcasses boning was carried. Morphological composition of carcasses was studied on the basis of the following indicators: carcass weight, flesh weight, tendons and cartilage weight, bones weight.

Carcasses were first kept for cooling chamber at a temperature of 0 - -4^{0}C degrees, relative humidity 95-98% during 24 hours. The venison was frozen in the freezer at a temperature of -18 - -23^{0}C, relative humidity 90-92% during 36-40 hours. Meat was thawed in defrosting chamber by the rapid defrosting wayat a temperature of 15 - 20^{0}C, relative humidity 95-98% during 24-36 hours.

Venison quality was determined on samples of meat average sample (chemical composition) and longissimus dorsi muscle (chemical composition and physical properties). The following State standards were used: protein content –25011-81[9]; fat content – 23042-86[10]; moisture content – 9793-74 [11]; water-holding capacity –by press method of Grau and Gamma in the modification Volovinskaya-Kelman[12]; pH - 2917-2009 [13].

Venison and broth sensory evaluation was carried by degustation commissionaccording to State standard 9959-91[14]. The characteristics were assessed using a nine-point scale. We analyzed samples of meat and broth from the longissimus dorsi by the following indicators: meat – by visual appearance,aroma, taste, consistence, juiciness; broth – by visual appearance, color, aroma, tasteand richness.

The findings were processed by standard statistical method of Plohinsky N.K. in the Windows XP operating system with the help of the program Microsoft Excel[15].

RESULTS AND DISCUSSION

It would be difficult to compare the obtained results with those reported by other authors for venison, including red deer meat. This results from the fact that the number of such experiments is scant, and that they are carried out with the use of different methods[5].

Red deer (Cervus elaphus) have a highly seasonal and profound pattern of growth, with maximum accretion of body tissue (muscle and fat) in spring and summer, and minimal accretion, or even loss of body mass, during autumn and winter[16]. The concept of a seasonal component to deer growth was first shown by French, McEwan, Magruder, Ingram, and Swift (1956) and it has been explained by the fact that photoperiod (day length) regulates deer growth potential and feed intake. The amplitude of these seasonal changes is greater for intact male deer compared with castrated males and females[17]. Winter live weights are considerably lower than summer live weights. Deer can undergo a 25% weight loss and lose more than 80% of their body energy in 6 week[18].One of the major constraints to increasing the productivity of farmed deer, however, is the seasonality in animal performance. This is characterized by a photoperiod-induced reduction in growth rate during the winter, resulting in an increase in the time required for animals to achieve a desirable slaughter weight[19]. Our research began in winter that is why it is very important to supply animals with balanced high quality feeding. Effect of different types of diets on deer meat productivity and meat quality was studied before. It was found that supplementary feeding affected meat quality in fallow deer, as well as, growth rates[20] and carcass quality[21]. Effects of forage concentrate ratio on growth performance and carcass characteristics of weaned red deer stags was studied by Phillip. There was a linear increase in carcass weight (P < 0.01) as the level of concentrate increased[22]. This is consistent with results of Volpelli *et al*. for fallow deer[21]. In contrast, however, Wiklund *et al*. reported no differences in carcass weight of red deer fed a

Table 1. Maral deer meat productivity

Indicators	HCTD M±m	SDMBM±m	HDMBM±m
LW at the beginning of exp., kg	234,00±3,54	233,09±3,36ns	236,55±3,49ns
LW at the end of exp., kg	273,81±4,23	288,03±4,04 *	291,70±4,15**
Weight before slaughter, kg	268,44±1,90	279,87±2,90 *	284,22±1,51**
Carcass weight, kg	142,19±1,99	151,41±3,54 0	155,10±3,10*
Slaughter yield,%	52,97±0,42	54,09±0,75 ns	54,57±0,81ns
Flesh weight, kg	99,04±1,88	109,09±3,02 *	114,47±2,75 **
Bones weight, kg	35,82±0,22	35,82±0,55 ns	34,35±0,35*
Tendons weight, kg	7,33±0,36	6,51±0,02 0	6,29±0,04*
Flesh yield, %	69,65±0,36	72,04±0,33 **	73,79±0,30 ***
Bones yield, %	25,20±0,36	23,66±0,25 *	22,15±0,25 **
Tendons yield, %	5,16±0,25	4,30±0,09 *	4,05±0,06**
Meatness coefficient	2,77	3,04	3,33

a ns: not significant; 0- zero threshold; P < 0.1: * P < 0.05; ** P < 0.01; *** P < 0.001

pelleted concentrate diet when compared to animals grazed on pasture[23].

The study of meat productivity indicators suggests that feeding silage and haylage detailed diets with mineral blocks promotes a marked increase in carcass weight, slaughter yield and flash weight compared with marals obtained hay-concentrate diet (table 1).

The based data analysis results of experimental slaughter of marals indicate increase in weight before slaughter ($P < 0.05$ for silage diet and $P < 0.01$ for haylage dietssupplemented with minearal block), in carcass weight ($P < 0.1$ and $P < 0.05$), in flash weight ($P < 0.05$ and $P < 0.01$) and in slaughter yield 1,12-1,60%. They also had lower content of bones and tendons compared with animals of group 1.

The average fat content of most game species has been recorded to be less than 3% (Crawford, 1968; Hoffman, 2000b; Kroon, van Rensburg, & Hofmeyr, 1972; Onyango, Izumimoto, & Kutima, 1998; Pauw, 1993; Scho nfeldt, 1993; Von la Chevallerie, 1972). Although Van Zyl and Ferreira (2004) reported fat percentages as high as 4.6% for whole blesbok carcasses, it is still low[6]. The fat content of fallow deer meat is very low as recognized by many authors (Casoli *et al*., 1986; Drew, 1992; Giorgetti *et al*., 1996; Mojto, Kartusek, Palanska, & Zaujec, 1999; Stevenson *et al*., 1992)[1].

Typically, venison contains less fat, more protein and more water than the more common domestic species[24]. Rincker *et al* studied similarities and differences in composition of reindeer, caribou and beef. Moisture level was the highest in reindeer meat 73.83%, (caribou - 73.80%, beef – 72.82%) and fat level was the lowest 2.76%, (caribou – 1.18%, beef – 4.02%)[25]. Chemical composition of venison can vary not only depending on animal specie but also by feeding type. Dahlan and Norfaizan Hanoon compared venison from farmed fallow, rusa, sambar and red deer (imported venison)The result showed that grazing deer have higher moisture content (75.3%) than concentrate-fed deer (74.4%) and imported venison (70.62%). Grazing animals are usually lower in fat than concentrate-fed or confinement-raised animals (Dahlan *et al*. 1988). This condition is due to higher fat composition in the meat of concentrate-fed animals than grazing animals, which is inversely proportional to the moisture content. Imported venison showed lower moisture content due to the freezing and refreezing processes during air freight, which affects water holding capacity in thawed meat. This study also showed similar moisture content of red deer venison (70–71%), as recorded by Drew *et al*. (1991). Venison samples taken from all muscles and cuts of the four species in this study showed remarkably similar values of protein content in fresh venison, ranging from 20.2% in grazing rusa deer to 22.8% in LD muscle of fallow deer. Similar results were recorded for red deer in New Zealand by Drew *et al*. (1991). Seman and McKenzie-Parnell (1989) stated that similar protein content was also shown by various animal species (19–24% regardless of the species). The fat content in LD muscles was highest in fallow deer followed by concentrate-fed rusa deer ($P < 0.05$), grazing rusa deer ($P < 0.05$) and sambar deer ($P > 0.05$). The result showed that ash content in all deer species and muscles were similar [26].Volpelli studied effects supplementary feeding on meat quality of male fallow deer (Dama dama). Supplemented deer showed a slight but significant increase in the fat content of both muscles (LM: 0.72 vs 0.56%; ST: 0.78 vs 0.55%), and a consequent reduction of water content. Supplemented di*et al*so produced a slight increase of ST protein and ash content[1].

One of the most important attributes of the processing quality of meat is its water-holding capacity (Van Oeckel *et al*. 1999; Huff-Lonergan and Lonergan 2005; Micklander *et al*. 2005) because it decides about meat weight loss during storage as well as about the ability of meat to retain its water during heat treatment (Aaslyng *et al*. 2003; Micklander *et al*. 2005). Water-holding capacity may depend on gender. In the Daskiewicz's study meat from hinds was characterized by better water-holding capacity than from stags[5] This physical property of meat may depend on feeding factor. In some recent comparisons of quality characteristics of meat from pasture raised animals versus animals fed various concentrates or supplements, no effects on the water-holding properties of beef, lamb and fallow deer (Dama dama) meat have been reported. The present results showed a significantly lower drip loss (purge) in meat from the pasture-raised deer compared with the group fed pellets starting after three weeks of storage[27].

Meat quality also can be estimated by such physical property of meat as cooking loss. Rut being one of the most important physiological processes also effects on cooking loss. In research carried by Stevenson *et al*. cooking loss level of red deer stags venison was 22.0% before rut and 21.9% after rut[28]. This feature depends on animal specie. The higher WBC of venison compared to beef is further confirmed by venison's lower (P < 0.07) cook loss (35.7% for venison and 37.6% for beef). Increased storage time post- mortem resulted in increased (P < 0.02) cook loss[29]. In one specie differences by cooking loss was found in representatives of different gender. In Daszkiewicz *et al*. research red deer hinds had lower cooking losses (32.42%) than stags (36.35%)[5]. The higher cooking loss at 70 °C (29.62% for stags and 28.26% for hinds) suggests a lower water-holding capacity, and is supported by the cooking loss being slightly higher at 60 °C (18.13% for stags and 17.57% for hinds) as well, and by the greater drip loss and expressed juice for venison from stags, although these differences were not statistically significant (P >0.10) [30].

Several studies have revealed that the pH of venison ranges from 5.50 to 5.75 (MacDougall *et al*. 1979; Seman *et al*. 1988; Wiklund *et al*. 2000, 2001; Pollard *et al*. 2002). This pH range is similar to pH values obtained from other mammalian species. Average pH values for 1000 head of commercially harvested beef carcasses and almost 4000 commercially harvested pigs both yielded values of 5.50 (Velarde *et al*. 2000; Page *et al*. 2001). The average pH values in the study for beef, reindeer and caribou were 5.48, 5.60 and 5.61, respectively.No significant differences (P <0.05) in pH among species were evident[25].In study of Daszkiewicz was confirmed the average values of pH in meat from hinds and stags were 5,48 and 5.49, respectively. In experiments performed by Kochanowska-Matuszewska (2004) and Trziszka (1975) mean pH values in m. longissimus dorsi of forest-dwelling red deer hinds and stags were 5.45–5.50 and 5.70, respectively. A narrow range of pH in the muscles of farm-raised red deer was also reported by Pollard *et al*. (2002) – 5.54 to 5.60 (stags), Wiklund *et al*. (2001) – 5.71 (hinds) and Wiklund *et al*. (2003) – 5.59 to 5.64 (hinds) [5]. Effects of feeding regimen (pasture and pelletes) and chilled storage on pH level in red deer (Cervus elaphus) meat was investigated. pH value varied from 5.45 to 5.55 (pasture) and from 5.42 to 5.54 (pellets) in deferent period of refrigerated storage[27]. Mean ultimate pH values in Musculus longissimus of the red deer from two treatments (pasture- and pellet-fed) were also searched by Wiklund and amounted respectively 5.59 and 5.64 [23].

Chemical composition and physical properties of venison from marals fed with different types of diets are presented in th table 2.

The results showed that there were diet type differences in dry matter content. The dry matter content in MAS was highest in HDMB-fed 3rd experimental group ($P \leq 0.05$) followed by SDMB-fed 2nd experimental group ($P \leq 0.05$). The percentage of dry matter content in LD muscles was highest in 3rd experimental group ($P \leq 0.05$) followed by 2nd experimental group – zero threshold

Table 2. Chemical composition and physical properties of venison

Indicators	HCTD M±m	SDMBM±m	HDMBM±m
Meat average sample (MAS)			
Dry matter,%	24,80±0,72	27,34±0,39 *	27,59±0,37 *
Fat, %	1,11±0,02	1,34±0,05 **	1,36±0,05 **
Protein,%	20,13±0,36	20,35±0,23 ns	20,34±0,17 ns
Longissimus dorsi muscle (LD)			
Dry matter,%	22,74±0,76	24,91±0,61 0	24,97±0,27 *
Fat, %	0,67±0,04	0,83±0,04 0	0,89±0,04 *
Protein,%	22,34±0,69	22,04±0,51 ns	22,26±0,24 ns
Water-holding capacity, %	70,63±0,55	70,25±1,35 ns	71,26±1,93 ns
Cooking loss, %	28,93±0,20	28,54±0,20 ns	28,60±0,11 ns
pH, without units	5,82±0,06	5,61±0,02 *	5,58±0,07 0

a ns: not significant; 0– zero threshold;P < 0.1, * P < 0.05; ** P < 0.01; *** P < 0.001

(*P* ≤0.1) from 1st control group. Fat content in venison varied depending on meat samples and feeding groups. The control group of stags fed HCTD showed significantly lower (*P* ≤0.01 and *P* ≤0.05) fat content than stags fed HDMB in meat average sample and LD muscle, concerning 2rd stags group fed SDMB 1st group stags showed significantly lower (*P* ≤0.01) fat content only in meat average sample. Venison sample taken from LD muscle and meat average sample of three different fed maral groups in this study showed remarkably similar values of protein content in fresh venison, ranging from 20,13%in MAS of marals fed HCTD to 22,34% in LD muscle of the same group.

From research results of venison physical properties it is clear that in spite of different structure of diets fed to maral stags of control and experimental groups water-holding capacity and cooking loss characteristics were much the same. The pH value varied from 5,58 to 5,82.The pH values measured in LD from the SDMB-fed deer were significantly higher (P ≤0.05) than in LD from the HCTD-fed animals. However, between animals fed HDMB and HCTD however small the differencein pH values exists.

The ultimate way of testing eating quality of meat is to place it with a consumer panel for sensory evaluation (Hutchison, Mulley, Wiklund, & Flesch, 2010; Russell, McAlister, Ross, & Pethick, 2005). Quality assurance of meat products can be enhanced by matching live animal and carcase characteristics with consumer acceptance (Hutchison *et al*., 2010; Pethick *et al*., 2002). Sensory evaluation is designed to measure the eating experience of the consumer. Consumer preference is based on evaluation of predictive measures of meat quality by the end user[31].

A range of objective meat quality measurements, including water-holding capacity and color as well as chemical and nutritional composition of meat, have been related to sensory attributes of beef, lamb, goat meat and pork[32]. We suppose this statement to be actual for venison too. The characteristic flavor of venison is related to its chemical composition as well as to the diet of animals and the specific conditions of their harvest[5].

The sensory quality of venison has not been studied extensively but some research has reported various sensory attributes for red deer (Cervus elaphus) (Wiklund, Manley, Littlejohn, & Stevenson-Barry, 2003) and reindeer (Rangifer tarandus tarandus) (Wiklund, Johansson, & Malmfors, 2003). The deer venison included in that study was from wild reindeer (Rangifer tarandus tarandus), moose (Alces alces) and roe deer (Capreolus capreolus)[32].

Different factors can affect to venison sensory quality. Sensory evalution of venison from farmed fallow, rusa, sambar and red deer (imported venison) was carried by Dahlan and Norfarizan Hanoon. Deer species had different feeding types. Results of sensory evaluation by untrained consumer-type panelists showed that there is no significant difference (P > 0.05) in the mean palatability score values, i.e. appearance, tenderness, flavor, juiciness and overall scores of LD and BF steaks. The tenderness, flavour, juiciness and overall score of LD steaks of javan rusa deer were the highest. In fact the steaks of javan rusa deer showed the best appearance but not significantly different (P > 0.05) from other steaks. Red deer steaks showed palatability score more than 4 (neither like nor dislike). The result showed that concentrate-fed venison produced slightly higher (P > 0.05) palatability scores than grass-fed venison[26].

Stevenson *et al*. compared sensory qualities of venison from red deer stags before and after the rut. It was found that the postrut samples were slightly less tender and had lower flavor intensity than the prerut samples. The LM

Table 3. Meat and broth sensory evaluation in marks

Indicators	HCTD	SDMB	HDMB
Meat evalution			
Visual appearance	6,67	7,00	6,67
Aroma	6,33	7,00	7,00
Taste	6,33	6,67	6,67
Consistence	7,00	7,67	8,00
Juciness	6,33	6,33	7,00
Broth evalution			
Visual appearance / color	6,67	6,67	6,67
Aroma	6,00	6,67	6,33
Taste	6,67	6,33	7,00
Richness	6,67	6,67	6,33

Mean values for parameters (1=absolutely not acceptable) (9=excellent) were significantly more tender than SM and also had greater flavor intensity, less cooking loss, and greater desirability. Tenderness, juiciness, and desirability were highly correlated among each other for observations within the LM or SM and highly correlated with flavor within the SM (semimembranosus muscle) but not within the LM (longissimus muscle)[28]. Data obtained in our research presented in table 3.

Sensory evaluation results of boiled meat showed that usage of silage and haylage diets with mineral block did not have considerable affect on venison and broth degustation indexes. It should be pointed that venison of maral stags fed SDMB and HDMB was tastier and more tenderthat venison from maral stags fed HCTD, that is why degustation commission assessed it 0,40-0,54 marks higher. Broth qualityof 1st control group was not inferior byvisual appearance, color and richness to 2ndand 3rd experimental groups. Average mark of maral group fed HCTD was lightly lower.

High sensory quality of meat (m. longissimus dorsi) from red deer was also confirmed by Kochanowska-Matuszewska (2004), Wiklund *et al*. (2003) and Trziszka (1975). Slightly lower quality of deer meat was reported by Stevenson *et al*. (1992), but these authors analyzed older animals[5].

A sensory analysis of meat from wild animals always reveals its characteristic, specific aroma and taste (Smolinska 1975; MacDougall *et al*. 1979; Dzierzyn ska-Cybulko and Fruzinski 1997; Wiklund *et al*. 2000, 2003; Pollard *et al*. 2002; Rincker *et al*. 2006). According to Wiklund *et al*. (2003), consumer acceptance of these properties of game meat depends on individual preferences[5].

CONCLUSION

By the results of research it can be concluded that feeding type and mineral supplementation influenceon maral deer meat productivity and meat quality. The use of silage and haylage diets with mineral block as feed additive in diets increasemeat productivity indexes, improves meat chemical composition and degustation indexes of venison and broth, in comparison with control group of maral stags.

ACKNOWLEDGMENTS

The authors wish to thank the head of the deer-farm “Bagration” Voropai V.G. and all the workers, who have always been ready to co-operate and help in any necessary way on the occasion of field research.

REFERENCES

1. Volpelli, L.A., R. Vlusso, M. Morgante, P. Pittia and E. Piasentier, Meat quality in male fallow deer (Dama dama): effects of age and supplementary feeding. *Meat Science*, 2003; **65**: 555-560.
2. Pearse, A.J. and K.R. Drew, Ecologically sound management: Aspects of modern sustainable deer farming systems. *Acta Veterinaria Hungarica*, 1998; **46**: 315-328.
3. Mirolubov, I.I. and L.P. Ryashenko, Sika deer. Vladivostok: Primizdat, 1948; 114.
4. Ohremenko, V.A., Comparative characteristics of meat productivity and meat quality of domesticated and wild populations of deer family, abstract for the degree of Candidate of Agricultural Sciences, Barnaul, 2006.
5. Daszkiewicz, T., P. Janiszewski and S. Wajda, Quality characteristics of meat from wild red deer (Cervus elaphus L.) hinds and stags. *Journal of Muscle Foods*, 2009; **20**: 429-439.
6. Hoffman, L.C. and E. Wiklund, Game and venison — Meat for the modern consumer. *Meat Science*, 2006; **49**: 197-208.
7. Lebedev P.T. and A.T. Usovich, Research methods of forage, animal organs and tissues, Eds., Hadiarova M.A and V.S. Leontev Rosselhozizdat, 1976; 131-226.
8. Tomme, M.F., Technique of studying of slaughter yield and meat. Moscow: All-Union Research Institute of Animal Husbandry. Department of feeding. All-Union Research Institute of Meat Industry, 1956; 1-31.
9. State Standard of the Republic of Kazakhstan “25011-81 Meat and meat products. Methods of protein determination” of 01.01.1983.
10. State Standard of the Republic of Kazakhstan “23042-86 Meat and meat products. Methods of fat determination” of 01.01.1988.
11. State Standard of the Republic of Kazakhstan “9793-74 Meat products. Methods for determination of moisture content” of 01.01.1975.
12. Zhuravskaya, N.K., L.T. Alehina and L.M. Otryashenkova, Research and control of meat

and meat products quality. Moscow: Agropromizdat, 1985; 7-182.

13. State Standard of the Republic of Kazakhstan "2917-2009 Meat and meat products. pH determination. Control method." of 01.07.2010.
14. State Standard of the Republic of Kazakhstan "9959-91 Meat products. General conditions of organoleptical assessment" of 01.01.1993.
15. Plohinsky, N.A., Guide to biometry for zootechnicians, Eds., Balakin V.M. Kolos, 1969; 7- 53.
16. Suttie, J.M. and J.R. Webster, Are arctic ungulates physiologically unique?. *Rangifer*, 1998; **18**: 99-118.
17. Wiklund, E., P. Dobbie, A. Stuart and R.P. Littlejohn, Seasonal variation in red deer (Cervus elaphus) venison (M. longissimus dorsi) drip loss, calpain activity, colour and tenderness. *Meat Science*, 2010; **86**: 720.
18. Drew, K.R., Meat Production from Farmed Deer. Biology of Deer Production, *Royal Soc.* 1985; **22**: 285.
19. Drew, K.R., The farming of red deer in New Zealand. *World Rev. Anim. Prod*., 1976; **12**: 49-60.
20. Sacaa, E., L.A. Volpelli, S. Bovolenta, E. Piasentier and M. Pinosa, Effect of supplementary feeding on pasture utilization by growing fallow deer. Zootecnica e Nutrizione Animale, 2011; **27**: 33-39.
21. Volpelli, L.A., R. Valusso and E. Piasentier, Carcass quality in male fallow deer (Dama dama): effects of age and supplementary feeding. *Meat Science*, 2002; **60**: 427-432.
22. Phillip, L.E., T.F. Oresanya and J.St. Jasques, Fatty acid profile, carcass traits and growth rate of red deer fed diets varying in the ratio of concentrate:dried and pelleted roughage, and raised for venison production. *Small Ruminant Research*, 2007; **71**: 218.
23. Wiklund, E., T.R. Manley, R.P. Littlejohn and J.M. Stevenson-Barry, Fatty acid composition and sensory quality of musculus longissimus and carcass parameters in red deer (Cervus elaphus) grazed on natural pasture or fed a commercial feed mixture. *Journal of the Science of Food and Agriculture*, 2003; **83**: 419-424.
24. Marchello, M.J., P.T. Berg, W.D. Slanger and R.L. Harrold, Cutability and nutrient content of whitetail deer. *J. Food Quality*, 1985; **7**: 267-275.
25. Rincker, P.J., P.J. Bechtel, G. Finstadt, R.G. C. Van Buuren, J. Killeffer and F.K. McKeith, Similarities and differences in composition and selected sensory attributes of reindeer, caribou and beef. *Journal of Muscle Foods*, 2006; **17**: 71-72.
26. Dahlan, I. and N.A. Norfarizan Hanoon, Chemical composition, palatability and physical characteristics of venison from farmed deer. *Animal Science Journal*, 2008; **79**: 500-501.
27. Wiklund, E., S. Sampels, T.R. Manley, J. Pickova and R.P. Littlejohn, Effects of feeding regimen and chilled storage on water-holding capacity, colour stability, pigment content and oxidation in red deer (Cervus elaphus) meat. *Journal of the Science of Food and Agriculture*, 2006; **86**: 101-103.
28. Stevenson, J.M., D.L. Seman and R.P. Littlejohn, Seasonal variation in venison quality of mature, farmed red deer stags in New Zealand. *Journal of Animal Science*, 1992; **70**: 1392-1393.
29. Farouk, M.M., M. Beggan, S. Hurst, A. Stuart, P.M. Dobbie and A.E.D. Bekhit, Meat quality attributes of chilled venison and beef. *Journal of Food Quality*, 2007; **30**: 1031-1032.
30. Purchas, R.W., C.T. Ellen and B. Egelandsdal, Quality characteristics and composition of the longissimus muscle in the short-loin from male and female farmed red deer in New Zealand. *Meat Science*, 2010; **86**: 506.
31. Hutchison, C.L., R.C. Mulley, E. Wiklund and J.S. Flesch, Effect of concentrate feeding on instrumental meat quality and sensory characteristics of fallow deer venison. *Meat Science*, 2012; **90**: 801-804.
32. Hutchison, C.L., R.C. Mulley, E. Wiklund and J.S. Flesch, Consumer evaluation of venison sensory quality: Effects of sex, body condition score and carcase suspension method. *Meat Science*, 2010; **86**: 311.