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VITAMINS A AND E IN PHYSIOLOGICAL ADAPTATION OF MAMMALS WITH DIFFERENT ECOGENESIS

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The aim of this study was to determine the nonenzymatic antioxidants: vitamins A (retinol) and E (tocopherol) concentrations in tissues (liver, kidney, heart, skeletal muscle) of 24 species of animals with different ecogenesis; some of them in the wild others are farm-bred species. The majority of species had high levels of tocopherol in the liver and kidney. Significant differences were detected in the distribution of vitamin E in the tissues of typical land and semiaquatic mammals. Vitamin E content in the canine kidney was significantly higher in comparison with the other species. Our investigations showed that the vitamin A concentration in the kidneys in most of the animals was much higher than that found in the liver. High variability of vitamins A and E in organs and tissues may be caused by variability in dietary intake, excretion, metabolism, physiology of animals and many other factors. The comparative analysis has shown that the vitamin A and E content in the tissues of carnivorous was significantly higher than that in the herbivorous animals. The unequal degree of metabolism intensity in animals of different species influences their ability to reserve vitamins in the tissues. The differences in the distribution of vitamins A and E and their levels were found with systematically close species mainly due to ecological peculiarities of animals.

Key words: mammals, vitamins A and E, species.

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INTRODUCTION

One of the biochemical index of adaptation to the environment is the vitamins content in the tissues of animals, which largely depends on the species ecological specialization. Endogenous vitamins content is characterizes animal metabolism depending on the physiological processes and biological functions of organs and tissues, species, ecological features of animals and other factors.

The majority of mammals are not capable of synthesizing most vitamins in the organism, therefore the need for them can be satisfied by the exogenous inflow. In nature, animals are often deprived of opportunity to receive food containing with necessary vitamins. For example, endogenic starvation can be observed along the winter hibernation of animals. Obviously, distribution of vitamins in mammals can have significant differences.

Vitamins A and E play an important role in the regulation of physiological and biochemical processes in the organism of animals. Vitamin E functions in tissues as an antioxidant, protecting unsaturated tissue lipids from peroxidation. It is known that tocopherol in animals acts not only as a structural antioxidant, but also as a regulator of energy metabolism. At the same time, the influence of tocopherol on reproductive functions of animals has been investigated in many works. Vitamin A in the organism is responsible for the functions supporting the stability of cell membranes and ensuring their permeability. Vitamin A participates in photoreception processes, provides normal function of epithelial, nervous, osteal tissues, growth and spermatogenesis of animals. The aim of this study was to determine the nonenzymatic antioxidants - vitamins A and E concentrations in tissues of animals with different ecogenesis; some of them from the wild and other species living both in nature and bred on farms also.

MATERIAL AND METHODS

The vitamins A and E (α-tocopherol) concentration were investigated in liver, kidney, heart and skeletal muscle of 24 mammal species: American mink *(Mustela vison* Briss.*)*, sable (*Martes zibellina* L.*)*, polar fox *(Alopex lagopus* L.*)*, silver fox *(Vulpes vulpes* L.*)*, raccoon dog (*Nycterous procionoides* Gray*)*, nutria (*Myocastor coypus* Molina*)*, rabbit (*Leporidae* Fischer), chinchilla (*Chinchilla* Bennett), pine marten (*Martes martes* L.), European otter (*Lutra lutra*), weasel (*Mustela nivalis* L.), wolf (*Canis lupus* L.), brown bear (*Ursus arctos* L.), moose (*Alces alces*), Canadian (*Castor canadensis* Kuhl) and European (*C. fiber* L.) beavers, muskrat (*Ondatra zibethica* L.), mountain hare (*Lepus timidus* L.), water shrew (*Neomys fodiens* Penn.*)*, Laxmann's shrew (*Sorex caecutiens* Laxm.*)*, mole (*Talpa europaea* L.), Brandt's bat (*Myotis brandtii* Eversmann), northern bat (*Vespertillio nilssonii* Kyserling et Blasius), brown long-eared bat (*Plecotus auritus* L.).

The vitamins A and E (α-tocopherol) content in the tissues were determined by high performance liquid chromatography method. The vitamin A was determined in the farm-bred animals only. The obtained data were processed by standard methods of variation statistics.

RESULTS AND DISCUSSION

It was found that species differences in the distribution of vitamins A and E in the mammals tissues from different systematic groups, usually associated with ecological features of species.
The retinol concentration in the liver and kidney farm-bred Mustelids (mink, sable) was higher than Canids (polar and silver fox) species, the heart contains very low vitamin A level (Fig.1) and in the skeletal muscle the retinol content was not detected. The lowest retinol level in the tissues has nutria in comparison with other animals. The retinol concentration in tissues depends on the amount of vitamin A supplied with the diet. Previous research has shown that Canids were classified as low carotenoids accumulators. They had no detectable concentrations of serum carotenoids while consuming diets that were low to moderate in carotenoids content (Slifka et al. 1999). Our investigations showed that the vitamin A concentration in most of the animals' kidney was much higher than that found in the liver. One of the explanations of the observed variations in the vitamin A concentration in the kidney of animals may be that differences in the dietary vitamin intake might exist due to the influence of retinol level in the kidney. On the whole, these results might suggest a significant contribution of the kidney in the vitamin A metabolism in mammals.

The vitamin E level in the tissues of insectivorous was low comparing with other animals. The tocopherol content in the liver of mole was the lowest (Table 1). Insectivorous consume food with low vitamin E content. In addition, they have a very high metabolism level that is associated with an active lifestyle. The insectivorous is most ancient order of mammals (Gureev, 1963). It can be assumed that the inclusion of tocopherol in metabolism of insectivorous is the earliest in chronological relation. Probably, participation of vitamin E in metabolism can be considered as a biochemical adaptations arising at the initial stage of higher vertebrates evolution.

One of the features of the animals is the seasonality of their life cycle. Vitamin E inhibits the metabolism in tissues and tocopherol level is an important regulator of the physiological condition of the animals which sleep in winter. Tocopherol content in the bats was investigated in hibernation in early spring. Northern bat had significantly higher content of α-tocopherol in liver, kidney and skeletal muscle that other bat species. The northern bat that lives in the colder locality with more shortening photoperiod and long hibernation in the winter had in general higher values of natural antioxidant such as vitamins E than bats from a warmer locality. In addition saving adequate levels of tocopherol during hibernation is very important for reproduction in the spring. It can be assumed that tocopherol content in the tissues demonstrates an adequate supply of vitamin E in the bats at the end of winter.

Rodents are the most large and widespread group of mammals. We researched vitamin E content in tissues of five members of this order – european and canadian beavers, muskrat, nutria

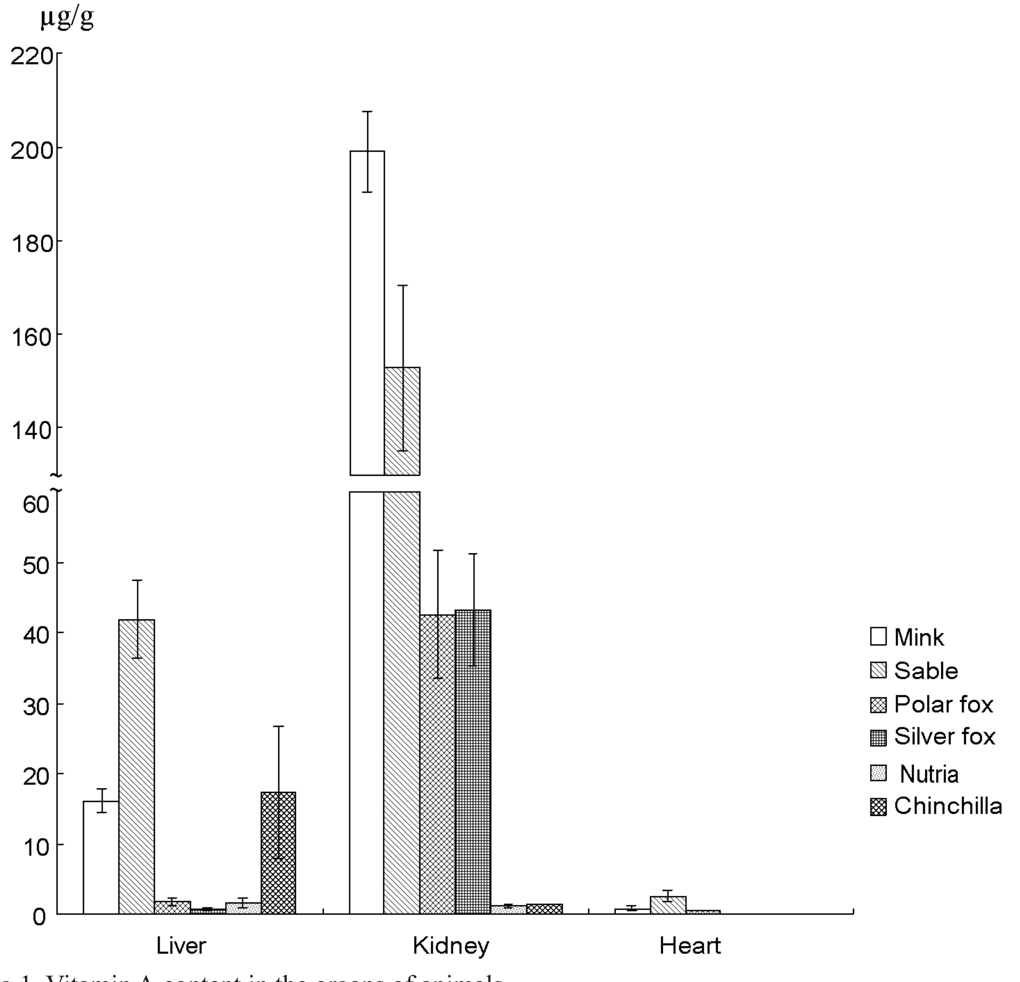

Fig.1. Vitamin A content in the organs of animals.

Table. 1. Vitamin E content in the organs and tissues of mammals, µg/g

№	Species	n	Organs and tissues			
			Liver	Kidney	Heart	Muscle
1	Laxmann's shrew	1	5,5	–	–	–
2	Water shrew	11	11,23 ± 1,44	8,67 ± 1,6	2,22 ± 0,55	3,26 ± 0,49
3	Mole	4	2,83 ± 0,59	0	0	4,25 ± 2,15
4	Brandt's bat	3	9,71 ± 4,12	4,35**	–	4,7**
5	Northern bat	5	12,30 ± 8,02	15,58 ± 8,84	13,68 ±1,63	5,99 ± 0,03
6	Brown long-eared bat	2	7,59 ± 3,54	4,91 ± 2,69	11,74**	3,20 ± 0,70
7	Mountain hare	2	12,1 ± 5,1	9,5 ± 3	4,7 ± 1,1	4,55 ± 0,95
8	Rabbit (farm-bred)	3	22,83 ± 15,05	12,33 ± 8,03	10,85 ± 2,55	7,8 ± 2
9	European beaver	4	12,475 ± 3,60	15,425 ± 6,05	12,3 ± 3,76	0
10	Canadian beaver	4	8,425 ± 2,68	8,8 ± 0,64	7,85 ± 1,63	2,2 ± 1,74
11	Nutria	4	23,65 ± 2,03	24,65 ± 2,24	28,38 ± 1,85	26,65 ± 1,93
12	Chinchilla	4	32,6 ± 2,64	31,7 ± 4,11	33 ± 2,44	31,3 ± 2,48
13	Muskrat	2	8,39 ± 0,37	19,12 ± 7,21 11, 91–6,33*	9,95 ± 3,96	20,74 ± 12,72 8,02 – 33,45*
14	Moose	8	6,35 ± 5,56	11,21 ±12,54 3,3 – 43,5 *	5,64 ± 2,98	8,48 ± 11,41 0 – 37,7*
15	Marten	2	30,8 ± 3,82	15,2 ± 2,55	7,25 ± 1,03	5,85± 2,51
16	American mink (farm-bred)	5	41,18 ± 5,59	55,4 ± 15,49	31,68 ± 4,60	24,76 ± 4,30
17	American mink (wild)	3	56 ± 11,90	94,9 ± 7,58	53,13 ± 8,69	33,83 ± 9,69
18	Sable (farm-bred)	10	29,45 ± 3,24	51,76 ± 4,09	28,61 ± 1,43	5,91 ± 0,59
19	Weasel	1	7,25	34,83	17,04	7,17
20	European otter	1	8,5	12,78	12,68	10,55
21	Wolf	3	54,78 ± 42,43 9,93 – 139,6*	9,39 ± 5,69 0 – 19,66*	6,06 ± 1,6	2,9**
22	Silver fox (farm-bred)	5	38,1 ± 2,71	77,78 ± 10,59	27,31 ± 2,27	27,6 ± 2,67
23	Polar fox (farm-bred)	5	38,58 ± 3,84	138,76 ± 15,08	34,6 ± 6,77	35,4 ± 6,84
24	Raccoon dog (wild)	1	93,2	40,5	27,5	29,4
25	Raccoon dog (farm-bred)	6	16,02 ± 2,4	66,23 ± 23,07	11,73 ± 0,78	17,09 ± 2,25
26	Brown bear	4	49,27 ± 19,22 17,4 – 97,2*	11,28 ± 4,54 2,9 – 23,8*	18,29 ± 10,94 4,7 – 50,6*	13,9 ± 10,94 4,3 – 27,0*

* min and max.

** one sample has been investigated.

and chinchilla. The high tocopherol content was in the beaver and muskrat kidneys, which is typical for semiaquatic animals (Galantsev 1977). Comparative analysis of tocopherol in the European and Canadian beaver marked difference between these sister species. Studies have shown that vitamin E content in all tissues was higher in the european beaver. High level of tocopherol found in the tissues of chinchilla and nutria, apparently the fact is connected both with the exogenous supply and ecogenesis. The natural habitat of chinchilla is the highlands, but nutria is an amphibian in the wild. It is obvious that the vitamin E level in the tissues and organs of animals with different lifestyles, is a reflection of environmental sensitivities and depends on metabolic processes in organism (Ikeda et al., 2004).

Significant interspecific differences were observed in the distribution of tocopherol in representatives of the family Mustelidae. Mink and otter are attributed to semiaquatic species; marten, weasel and sable are typical land mammals. The tocopherol content in the otters' tissues was significantly lower than in the mink. Perhaps this is due to the differences in the diet type and the way of life of animals. The tocopherol was higher in the tissues of wild minks than in the tissues of minks bred in captivity, but the distribution of α-tocopherol in all mink tissues was almost the same. The α-tocopherol content in the tissues of the marten was significantly lower than in the mink. Marten has maximum tocopherol concentration in liver, and mink has a higher level of vitamin E in the kidney. It is interesting that the higher tocopherol concentration is installed in the wild mink tissues comparing with the farm-bred mink.

Significant differences of the vitamin E distribution in the tissues were in the Canidae. The maximum tocopherol concentration was detected in the liver of wolf. Fox and polar fox have the highest α-tocopherol concentration in kidney, which is essential in the regulation of tocopherol (Nikifirova et al., 1993). The vitamin content in the kidney of polar fox was the highest compare to other animals.

The polar fox energy expended in the kidney is more significant than the same of boreal climate animals. Obviously, this is due to the peculiarities of Arctic aboriginals' kidney functioning. The high tocopherol concentration was found in the raccoon dog. Raccoon dog is the only Canidae spending several winter months in a burrow in hibernation (winter dormancy), therefore, its autumnal fattening and natural weight loss in winter and spring is greater compare to other Canidae (Mustonen et al., 2007). The fattening accompanied by insulin resistance can evoke increased reactive oxygen species generation, which stimulates the activity of the antioxidant system in this species. Vitamin E is the most important natural antioxidant and its sufficient intake is important especially in the northern regions before the winter period. It is connected with significant metabolic changes. It has been reported that the vitamin E accumulation in animal tissues in autumn may induce winter sleep (Kalabuhov, 1985). Another hibernates in winter predator – bear - had the highest vitamin E concentration in the liver and heart. The character of bear's motor activity is considerably different from the Canidae and Mustelidae, which have higher level of metabolic processes.

The moose was the only researched of Artiodactyla order – the largest representative of the family Cervidae. 6 adult animals were studied (3 males, 3 females) and 2 males-yearlings. The adult mosses have a higher concentration of vitamin E in the kidney compared to the liver. In the young animals the tocopherol content in liver was higher than in other tissues. Tocopherol concentration in skeletal muscle in females and young males was almost the same as in the heart and in the adult males significantly exceeded this level. The moose's tocopherol distribution reflects the intense aerobic metabolism in muscle tissues which animals with a high level of metabolism have.

Studies show that vitamin E content in the organs and tissues of mammals varies widely. Significant differences were detected in the distribution of α-tocopherol in the tissues and organs of typical land mammals and semiaquatic, which reflects ecological characteristics and it is associated with the process of staying semiaquatic animals under water (Galantsev, 1977).

The comparative analysis has shown that the vitamin A and E content in the tissues of carnivorous was significantly higher than in the herbivorous animals. High variability in organs and tissues of vitamins A and E may be the result of variability in dietary intake, excretion, metabolism and physiology of animals and many other factors. The unequal degree of metabolism intensity in animals of different species influences their ability to reserve vitamins in the tissues. There is a positive correlation between the lifetime of the animals and the antioxidants concentration in the tissues (Cutler, 1991). Differences in the distribution of vitamins A and E and their level were found with systematically close species mainly due to ecological peculiarities of animals.

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