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The nutritional value of rabbit meat when using stinging nettle (Urtica dioica) in the ration of rabbits

Keywords: feed ration; stinging nettle; rabbit meat; nutritional value; biochemical indicators.

1. SUMMARY

The article presents the results of studying the influence of the supplementary feeding with stinging nettle hay on the ration balance, biochemical indicators, nutritional value, and keeping quality of rabbit meat. It was established that the replacement of 5% and 25% of coarse fodder with stinging nettle hay resulted in an increase in the content of crude (by 3.5-20.3%), digestible protein (by 4.4-22.8%) and carotene (by 3.3-22.7%) in terms of nutritional value. Growing rabbits with the introduction of a dosage of 5% and 25% of the stinging nettle hay of the nutritional value of coarse fodders was characterized by the least feeds per 10 g of the gain as compared to the content in the traditional ration (1.17 kg of feed units/day). The introduction of 5% of the nettle hay into the rabbit ration as compared to the control group: influenced a decrease in the moisture content (the power of influence of -10,38%, P<0.001), an increase in the content of protein (the power of influence of 34.2%, P<0.01), zinc (the power of influence of 35.6%, P<0.01) and manganese (the power of influence of 34.2%, P<0.01) in the rabbit meat.

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2. Introduction

Recently, the production of new improved food products providing a person with complete proteins, essential nutrients, micronutrients and vitamins has become increasingly important worldwide. At the same time, the production of cheap, dietary meat and meat products enriched with vitamins has become very relevant. One of the ways to obtain them is a perpetual modification through adjusting animal rations **[1, 2, 3]**.

Most countries have recently experienced a sharp increase in the rabbit meat production. Great importance is attached to the development of rabbit breeding in Russia as one of the sources of providing the population with dietary meat **[4]**. Rabbit meat can be compared to chicken meat by its juiciness, softness, taste and digestibility. Rabbit meat is low in fat, connective tissue, cholesterol and sodium salts, it is fine-fibred and highly digestible **[5, 6]**. One of the possible ways of a perpetual modification of rabbit meat is the introduction of stinging nettle (*Urtica dioica*) into the ration of rabbits **[2]**.

Nettle as a weedy plant is widespread throughout the European part of Russia, the Caucasus and Western Siberia, and is found in Eastern Siberia, the Far East and Central Asia. Nettle belongs to high-yielding plants, it is a good source for obtaining highly nutritious grass meal containing many nutrients. The chemical composition of grass, hay, and grass meal from stinging nettle is presented in ***Table 1*** **[7, 8, 9, 10, 11, 12, 13, 14, 15]**. In early spring, nettle contains twice more vitamin C than oranges and lemons, and it contains as much provitamin-A as carrots and has much vitamin K – up to 400 IU/kg. Notably, large quantities of ascorbic acid are contained in fresh leaves and stalks of nettle (up to 269 mg/kg), when nettle is dried, it is destroyed, and its amount decreases markedly **[11, 16, 17]**.

Table 1. The chemical composition and nutritional value of stinging nettle hay fodders

Indicators	Type of fodder		
	Grass	Hay	Grass meal
Feed units (feed units), kg	0,17	0.31	0.65
Dry matter, g/kg	240	891	877-900
Crude protein, g/kg	96	208	215
Digestible protein, g/kg	58-91	108-200	72.1-142
Crude fat, g/kg	7	25	25-42
Crude fiber, g/kg	50	185	241
Nitrogen-free extractive substances, g/kg	83	307	359
including starch, g/kg	0	0	0
sugars, g/kg	12	15	65
Amino acids, g/kg			
Lysine	5.7	11.2	14.7
Methionine + cystine	5.2	7.7	9.8
Macronutrients, g/kg			
Calcium	10.2	24.2	21.1
Phosphorus	1.3	1.4	2.9-4.2
Magnesium	0.8	5.2	8.0
Potassium	4.0	32.0	37
Sodium	0.3	2.2	0.3
Chlorine	0.3	8.0	3.5
Sulfur	0.5	4.0	2.2
Micronutrients, mg/kg			
Iron	21-34	75	210
Copper	1.5-4.0	6.6	11.0
Zinc	3.0-3.5	18	60
Manganese	5.2-10	41	30
Cobalt	0.05	0.03	0.05
Iodine	0.05	0.10	0.20

Table 1 continued. ***.*** *The chemical composition and nutritional value of stinging nettle hay fodders*

Vitamins			
Carotene, mg/kg	80	25	107-150
Vitamin A, IU/kg	0	0	0
Vitamin D, IU/kg	5	62	50
Vitamin E, mg/kg	35	30	60
B_1, mg/kg	3	2.1	2,0
B_2, mg/kg	1.7	6.4	14
B_3, mg/kg	18	5.0	15
B_4, mg/kg	32	520	600
B_5, mg/kg	14.5	12.0	30.0
B_6, mg/kg	0	0	6
B_{12}, mg/kg	0	0	0

Many authors recommend using young nettle in raw, scalded, or boiled form, in the form of infusions, extracts, hay, grass meal or powders as an additive to the ration of pigs, cattle and poultry to increase their resistance, vitality and productivity, as well as to accumulate vitamin A and mineral elements in processed products **[18, 19, 20]**.

The purpose of the research was to study the influence of the supplementary feeding with the stinging nettle hay on the balanced ration, biochemical indicators, nutritional value, and keeping quality of rabbit meat.

3. Materials and methods

The objects of the research were: fodder base, live animals, and carcasses of rabbits of the Soviet chinchilla breed. This breed is the most widespread and promising in Russia among the combined rabbits, it is characterized by a high plasticity and good adaptability to various climatic and feed conditions **[21]**.

The studies covered 30 rabbits aged from 3 to 6.5 months. 3 groups of animals were formed: control and two experimental groups, 10 animals each. The rabbits of the control group received a ration consisting of oats, wheat bran, carrots, cabbage, cereal-and-legume hay and natural land grass (in the summer months) **[22]**. 5% of the coarse fodder in terms of nutritional value were replaced with stinging nettle hay for the rabbits of experimental group I, and 25% were replaced for experimental group II.

The rabbits were selected by the principle of pairs of analogues **[23, 24]**, and were kept in group cages in identical conditions. All the animals were clinically healthy. The feeding rations for all the rabbit groups were balanced by all nutrients according to the current standards **[25]**. To make rations, a comprehensive zootechnical analysis of the used fodder was carried out with the help of the IR-4500 infrared analyzer. The content of basic nutrients in the fodder was determined as follows: nitrogen – by Kjeldahl method, fiber – by Kebenerg and Shtoman method, sugar – by the ebuliostatic method (method for the determination of sugars based on the reduction of copper; Ed.), calcium – by the trilonometric method (complex formation titrimetric method using murexide indicator; Ed.), phosphorus – by the colorimetric method, ash – by the dry ashing method **[26]**.

To prepare nettle hay, young nettle was mowed in May-June and dried in the shade to a moisture content of 12.16%, because rabbits usually do not eat freshly cut nettle **[27, 28]**.

Control weighing of the animals was carried out once a week. The rabbits were slaughtered at the age of 6.5 months after fasting for 24 hours. After stunning, the carcasses were bled white by cutting off the heads. The skins were cased, the extremities were removed along the carpal and tarsal joints, the carcasses were eviscerated and trimmed. The meat was left at a temperature of 15±5 °C for 18 hours for maturation.

When assessing biochemical indicators and nutritional value of the rabbit meat, we determined the content of moisture, fat, protein, and ash, including macronutrients, vitamin C and amino acids. The moisture content was determined in the rabbit meat by drying to a constant weight in an oven at a temperature of 150±2 °C. Meat fat was determined using a Soxhlet extraction apparatus. The amount of protein was determined by mineralization of a meat sample with sulfuric acid according to Kjeldahl, distillation into a solution, followed by titration. The total amount of ash was found by burning organic matter with a free air access. The content of iron, copper, zinc, cobalt, magnesium, manganese and lead in the rabbit meat was determined by dry mineralization followed by atomic absorption spectrophotometry. The content of vitamin C in the meat extract was determined by titration with 2,6-dichlorophenolindophenol. Ion exchange chromatography on an amino acid analyzer was used to examine amino acids in the rabbit meat **[29]**.

The nutritional, energy, and biological value of the studied rabbit meat was calculated according to the generally accepted methods **[30, 31]**.

Studying the keeping quality of the meat when stored for 3 months at –18 °C, we investigated a combination of organoleptic, physico-chemical and microbiological indicators. The amount of volatile fatty acids was determined by distillation of the meat in the presence of sulfuric acid, followed by titration of the distillate with potassium hydroxide. The method for determining ammonia and ammonium salts is based on the ability of ammonia and ammonium salts to form a yellow-brown substance with Nessler's reagent. The essence of determining the primary protein breakdown products in the broth lies in the deposition of proteins by heating and the formation of copper sulfate complexes with the products of the primary breakdown of the depositing proteins in the filtrate. The acid index characterizing the degree of fat spoilage was found by alkali titration of molten fat **[32]**.

Statistical processing of the research results was carried out according to a regulated method **[33]** using the Microsoft Excel XP and Statistica 8.0 software suites. The dependencies in the experimental data were searched using the variance analysis **[34]**.

4. Results and discussion

4.1. Studying the rabbit ration balance

All the experimental animals received the same fodder during the experiment (with the exception of nettle hay), taking into account their age and live weight. The rabbits received oats, grass-and legume hay, natural land grass in summer; carrots and cabbage were added to the ration three times a week. The animals of the control group did not receive stinging nettle hay, 5% of the coarse fodder in terms of nutritional value were replaced with the nettle hay for the rabbits of experimental group I, and 25% were replaced for experimental group II. The rations were compiled taking into account the age of the animals – for the animals aged 90-120 days and for the rabbits older than 120 days (***Table 2***).

The rations of all the experimental rabbits aged 90-120 days were balanced by the main nutrients, except for the high fiber content (1.6-1.7 times more than the norm). The rations of the experimental groups (for 1 animal per day), as opposed to the control group, contained slightly less feed units (-1 and -6 g of feed units*) and, accordingly, less energy value (-0.01 and -0.07 MJ), but significantly more raw protein (+1.2 and +5.4 g per 100 g of feed units) and digestible protein +5.8 and +26.7 g per 100 g of feed units), and carotene (+0.5 and +2.0 mg per 100 g of feed units).

Table 2. The consumption of fodders by the animals during the experiment (day/animal)

Components of fodders	**Animal age and group**								
	90-120 days			**120-194 days**			**Total for the experiment 90-194 days**		
	Control	**Experi-mental I**	**Experi-mental II**	**Control**	**Experi-mental I**	**Experi-mental II**	**Control**	**Experi-mental I**	**Experi-mental II**
Carrots, kg	0.6	0.6	0.6	7.4	7.4	7.4	8.0	8.0	8.0
Cabbage leaf, kg	0.6	0.6	0.6	18.5	18.5	18.5	19.1	19.1	19.1
Oats, kg	1.5	1.5	1.5	3.7	3.7	3.7	5.2	5.2	5.2
Grass and legume hay, kg	4.2	3.9	2.9	11.1	10.4	7.4	15.3	14.3	10.3
Nettle hay, kg	0.0	0.3	1.4	0.0	0.7	4.1	0.0	1.0	5.4
Wheat bran, kg	1.2	1.2	1.2	3.7	3.7	3.7	4.9	4.9	4.9
Feed chalk, kg	0.0	0.0	0.0	0.1	0.1	0.1	0.1	0.1	0.1
Natural grass, kg	10.5	10.5	10.5	0.0	0.0	0.0	10.5	10.5	10.5
The fodders contain:									
Dry matter, kg	7.8	7,9	7.9	17.6	17.7	18.1	25.5	25.5	25.9
Crude protein, kg	1.1	1.1	1.2	2.3	2.4	2.9	3.4	3.5	4.1
Digestible protein, kg	0.8	0.8	0.9	1.7	1.8	2.2	2.5	2.6	3.1
Crude fiber, kg	2.0	2.0	1.9	3.9	3.9	3.7	5.9	5.9	5.6
Calcium, g	64.0	64.7	67.4	129.5	131.4	142.1	193.5	196.1	209.4
Phosphorus, g	33.7	34.0	35.0	129.5	130.2	134.3	163.2	164.2	169.3
Carotene, mg	450	464	511	851	884	1042	1301	1348	1552
Feeds per 100 g of the gain in feed units, kg	1.34	0.89	0.99	1.11	1.11	1.18	1.17	1.04	1.12

* 1 feed unit: energy content of 1kg of medium dried oats

The rations for the older rabbits (1 animal per day), similar to the rations for the young rabbits, were characterized by a high fiber content – by 1.4-1.5 times. The rations of the experimental groups contained more raw protein (+1.2 and +7,0 g per 100 g) and digestible protein (+5.9 and +33.8 g), carotene (+0.5 and +2.6 mg) and slightly less energy value (-0.01 and -0.06 MJ) than in the control group. The increased content of crude and digestible protein, carotene, and vitamin E in the rations of the experimental groups throughout the entire experiment was preconditioned by the addition of the stinging nettle hay rich in these substances.

Note: The two values in parentheses always refer to the two nettle portions: 5% and 25%, respectively.

However, due to the lower energy value of the stinging nettle hay than the grass-and-legume hay, we observed a decrease in the nutrition value in the rations of the experimental groups as compared to the control group.

The ration structure for the rabbits aged 90-120 days contained coarse fodder – 29-31%, succulent fodder – 2-3%, green fodder – 27-28%, concentrates – 39-41%. The ration for the rabbits older than 120 days contained coarse fodder – 32-34%, succulent fodder – 21-22%, concentrates – 45-46%, there was no green fodder.

As it can be seen from the consumption of fodders over the entire experiment, breeding of the rabbits with the introduction of 5% (per 0.13 kg of fed units) and 25% (per 0.05 kg of fed units) of the stinging nettle hay in terms of nutritional value of coarse fodders as compared to the content in the traditional ration was characterized by the lest feeds per 100 g of the gain by feeding 25% nettle.

4.2. Studying the biochemical indicators and nutritional value of rabbit meat

Rabbit meat is close to chicken by its dietary indicators and surpasses it by the content of protein. There is no significant difference in the chemical composition of rabbit meat of different breeds. The chemical composition of meat depends more on the animal age and the feeding level **[5, 6]**.

The content of basic nutrients was determined in the muscle tissue of matured rabbit meat (**Table 3**).

Table 3. The chemical composition of the muscle tissue of the rabbit meat ($\bar{X}\pm S\bar{x}$, n=10)

Indicators	**Animal groups**		
	Control	***Experimental I***	***Experimental II***
Water, %	70.39±0.16	63.08±0.82**	69.74±0.87
Protein, %	19.42±0.19	20.23±0.25*	18.93±0.29
Fat, %	7.05±0.12	6.81±0.06	6.70±0.10*
Vitamin C , mg %	39.58±1.47	38.39±5.91	41.11±5.10
Ash, %	0.87±0.04	0.89±0.05	0.88±0.04

**P<0.05; **P<0.001*

It was established that there was less water in the meat of the animals from experimental group I than in the control group (-10,38%, *P<0.001*) and experimental group II (by 6.66%, *P<0.001*). The mass fraction of protein in the rabbit meat of experimental group I is larger than in the rabbit meat of the control group by 0.81% (*P<0.05*), and experimental group II – by 1.30% (*P<0.01*). The fat content of the muscle tissue in the rabbits of the control group and experimental group I did not differ significantly, while in experimental group II this indicator was lower than in the control group by 0.4% (*P<0.05*). The content of vitamin C and ash in all the samples was out of statistical control.

The data of the variance analysis covering the chemical composition of the boneless rabbit meat are presented in ***Table 4***.

Table 4. The influence of the supplementary feeding with the stinging nettle hay on the chemical composition of the muscle tissue of the rabbit meat (n=10)

Indicators	**Power of effect indicator, %**
Water	71.4***
Protein	34.2**
Fat	19.7*
Vitamin C	0.6
Ash	0.2

**P<0.05; **P<0.01; ***P<0.001*

It was determined that the introduction of nettle had the maximum influence on the water content; the amount of protein and fat in the muscle tissue of the rabbit meat 2.1 and 3.6 times less depended on the supplementary feeding with nettle feeding than the water content of the meat.

Based on the chemical composition, we calculated the energy value of the rabbit meat ignoring perinephric fat (***Table 5***).

Table 5. Nutrition value of the rabbit meat ignoring perinephric fat, kJ/100 g

Samples investigated	Animal groups		
	Control	***Experimental I***	***Experimental II***
Muscle tissue	607	611	586
Boneless meat	787	862	808
Bone meat	590	653	602

It was revealed that the caloric density of the muscle tissue in the rabbits of the control group and experimental group I differed insignificantly (by +4.187 kJ/g i.e., +0.7%), while the muscles of the rabbits in the control group contained more amount of fat, and experimental group I – more protein. The reduced nutrient value of the muscle tissue of the rabbits of experimental group II (by -20.93 and -25.12 kJ/g i.e., -3.4 and -4.1%) is preconditioned by the low content of protein and fat in the muscles. The increased caloric density of the boneless meat and bone meat in experimental group I (+75.36 kJ/g i.e., +9.6%; +62,80 kJ/g i.e., +10.6%) and experimental group II (+20.93 kJ/g i.e., +2.9%; +12.56 kJ/g i.e., +2.1%) was determined by large deposits of fat on the shoulders and groin.

Note: The two values in parentheses always refer to the two nettle portions: 5% and 25%, respectively.

Based on the aforesaid, it follows that the introduction of 5% of the nettle hay into the rabbit ration resulted in a decrease in the moisture content and an increase in the protein content in the rabbit meat, and the introduction of 25% – ensured a lower fat content of the rabbits' muscle tissue. The energy value of the rabbit meat increased in proportion to the nettle dosage in the ration due to a larger deposition of fat on the shoulders and groin.

The mineral composition of the rabbit meat samples is shown in ***Table 6***.

Table 6. The mineral composition of the rabbit meat ($\bar{X}\pm S\bar{x}$, n=10)

Investigated mineral components	Animal groups		
	Control	***Experimental I***	***Experimental II***
Iron, mg/kg	6.16±0.55	7.43±0.44	6.60±0.71
Copper, mg/kg	0.14±0.02	0.17±0.03	0.21±0.04
Zinc, mg/kg	8.17±0.36	12.37±1.14**	11.10±0.66**
Cobalt, mg/kg	0.44±0.08	0.41±0.11	0.30±0.07
Magnesium, mg/kg	19.86±0.11	19.61±0.18	19.71±0.07
Manganese, mg/kg	0.11±0.03	0.20±0.03*	0.24±0.02**
Lead, mg/kg	0.49±0.04	0.43±0.06	0.40±0.06

**P<0.05; **P<0.01*

It was established that the meat samples of the rabbits in experimental group I was distinguished by a high content of iron and zinc. There is 1.27 mg/kg more (20.66%) iron in it as compared to the meat of the control rabbits, and 0.83 mg/kg (12.61%) more than in the meat of experimental group II, and it has more zinc by 4.20 mg kg (51.33%; *P<0.01*) and 1.27 mg/kg (11.41%), respectively. The samples of the rabbit meat from experimental group II contain 2.93 mg/kg (35.83%; *P<0.01*) more zinc than the control group. The highest copper content was observed in the rabbit meat of experimental group II – by 0.07 mg/kg (48.61%) as compared to the control group, and by 0.04 mg/kg (19.16%) as compared to experimental group I.

The least cobalt content was found in the meat of the rabbits of the experimental groups: in the samples of group II this indicator is less than in the control group by 0.14 mg/kg (32.73%), and in the meat of group I – by 0.03 mg/kg (5.91%).

The proportion of magnesium was the same in all the rabbit meat samples, and the proportion of manganese was 2.2 times higher in the meat of experimental group II (*P<0.01*), and 0.09 mg/kg more (85.85%; *P<0.05*) in the meat of experimental group I than in the control group. As compared to the meat of the control animals, the lead content in the rabbit meat of experimental group II decreased by 0.10 mg/kg (19.31%), of experimental group I – by 0.07 mg/kg (13.41%).

The results of the variance analysis covering the mineral composition of the rabbit meat are shown in ***Table 7.***

Table 7. The influence of the supplementary feeding with the stinging nettle hay on the mineral composition of the rabbit meat (n=10)

Indicators	Power of effect indicator, %
Iron	8.5
Copper	8.9
Zinc	35.6*
Cobalt	5.5
Magnesium	6.8
Manganese	34.2*
Lead	5.5

**P<0.05*

We can see from the obtained data that the addition of nettle to a larger extent influenced the content of zinc and manganese. In contrast, the effect of nettle is approximately 4 times less on the content of iron and copper and 5-6 times less – on the amount of cobalt, lead and magnesium.

Thus, the introduction of nettle into the rabbit ration increased the content of zinc, manganese, iron and copper in the meat. Moreover, the content of zinc and iron was higher at a dosage of 5% of the nutritional value of coarse fodder than at a 25% dosage, and the amount of manganese and copper grew with an increase in the concentration of nettle in the ration. There was less cobalt and lead in the rabbit meat proportional to the share of nettle in the fodder.

The biological value of rabbit meat is judged by the content of complete and incomplete proteins and their amino acid composition. With the animals ageing, the content of complete proteins in rabbit meat increases, while the content of incomplete proteins decreases. The meat of animals aged 4-5 months may considered to be most complete **[6]**.

To assess the protein quality, we carried out an amino acid analysis of the rabbit meat, the results of which are shown in ***Table 8.***

Table 8. Amino acid composition of the rabbit meat, g/kg ($\bar{X} \pm S\bar{x}$, n=5)

Name of amino acid	Animal groups		
	Control	***Experimental I***	***Experimental II***
Essential amino acids:			
Theorine	12.10±1.95	9.46±3.30	10.12±2.61
Valine	12.75±3.47	9.34±3.28	14.09±2.10
Methionine	23.96±4.04	33.73±7.21	26.06±4.52
Isoleucine	1.33±0.59	9.60±3.21	4.14±1.24
Leucine	3.95±3.16	7.39±3.02	2.59±1.25
Phenylalanine	2.52±1.34	16.06±3.70	9.28±3.51
Lysine	9.86±6.05	7.69±5.55	8.10±3.45
Non-essential amino acids:			
Aspartic acid	5.26±2.07	2.67±2.56	3.07±2.24
Serine	8.64±2.26	7.69±1.32	6.71±1.16
Glutamic acid	10.96±3.57	17.80±4.52	16.99±1.12
Proline	7.35±3.73	6.13±2.00	8.33±1.35
Glycine	1.78±0.21	2.06±0.42	1.91±0.22
Alanine	7.44±0.63	7.66±1.26	7.52±0.78
Tyrosine	12.14±5.12	17.51±7.43	4.03±1.30
Histidine	12.63±5.40	15.70±8.32	20.44±2.21
Arginine	2.42±2.42	5.51±5.51	9.30±3.07

It was determined that the content of such amino acids as threonine, serine, proline, alanine, valine, and lysine in the meat was practically the same. As compared to the control rabbit meat, the meat of the rabbits of experimental group I contained slightly more methionine (+9.77 g/kg i.e., +40.79%), isoleucine (+8.27 g/kg i.e., 7.22 times more), phenylalanine (+13.54 g/kg i.e., 6.37 times more), glutamic acid (+6.84 g/kg i.e., 62.40%), glycine (+0.29 g/kg i.e., +16.23 %) and histidine (+3.08 g/kg i.e., 24.38%). The rabbit meat of experimental group II had a higher amount of the same amino acids as compared to the control group: methionine (+2.1 g/kg i.e., 8.77%), isoleucine (+2.81 g/kg i.e., 3.1 times more), phenylalanine (+6.76 g/kg i.e., 3.68 times more), glutamic acid (+6.03 g/kg i.e., 55.01%), glycine (+0.13 g/kg i.e., 7.39%) and histidine (+7.82 g/kg i.e., 61.91%). The amount of some amino acids varied randomly; both high and low indices were present in the groups. This concerned aspartic acid, tyrosine and leucine, while arginine was found only in one sample from the control group and experimental group I.

Note: The two values in parentheses always refer to the two nettle portions: 5% and 25%, respectively.

The amino acid content in the rabbit meat samples was subjected to the variance analysis (***Table 9***).

Table 9. The influence of the supplementary feeding with the stinging nettle hay on the amino acid composition of the rabbit meat (n=10)

Amino acids	Power of effect indicator, %
Theorine	4.2
Valine	9.9
Methionine	12.9
Isoleucine	42.1*
Leucine	12.9
Phenylalanine	45.2*
Lysine	0.8
Aspartic acid	5.8
Serine	5.4
Glutamic acid	16.9
Proline	3.0
Glycine	3.7
Alanine	0.2
Tyrosine	21.7
Histidine	7.0
Arginine	11.6

**P<0.05*

Judging by the indicator of the nettle's power of influence on the amino acid content of meat, the amount of phenylalanine, isoleucine, glutamic acid, tyrosine, leucine, methionine and arginine changed most of all due to feeding with nettle.

As a result of the amino acid analysis, we revealed a tendency of prevailing such essential amino acids as methionine, isoleucine and phenylalanine, as well as non-essential amino acids – glutamic acid and glycine in the meat of the rabbits grown on the ration with the introduction of 5% of nettle of the nutritional value of coarse fodder as compared to the 25% dosage and the control group. The histidine content increased in proportion to the concentration of nettle in the rabbit ration.

4.3. Studying the keeping quality of meat

All the frozen rabbit meat samples corresponded to fresh meat by the organoleptic indicators. The surface of the carcasses had a pink drying crust, the fat tissue was yellowish white, the muscles in the section were slightly moist, leaving slight moisty spots on the filter paper (which is typical of frozen meat), pale pink with a reddish tint. The muscles are dense, elastic, the body hole is typical of fresh rabbit meat, the broth is transparent, and its smell was acceptable.

During the chemical analysis of rabbit freshness, we assessed such indicators as the content of ammonia and ammonium salts, the content of primary protein breakdown products in the broth, the amount of volatile fatty acids (VFA), and the fat acidity value in the adipose tissue.

When determining ammonia and ammonium salts, after adding Nessler's reagent, the meat extract from all the samples remained transparent and acquired a greenish-yellow color, which corresponded to the requirement of fresh meat. The rabbit meat broth from all the samples remained transparent after the addition of copper sulfate, which indicated the absence of primary protein breakdown products in the meat and, therefore, the meat freshness. The amount of volatile fatty acids (VFA) in the muscle tissue and the fat acidity value of the rabbit meat samples are shown in ***Table 10***.

Table 10. The amount of VFA and the fat acidity value of the rabbits ($\bar{X}\pm S\bar{x}$, n=10)

Indicators	Animal groups			Norm*
	Control	Experimental I	Experimental II	
VFA, mg KOH/25g	3.59±0.37	3.37±0.37	3.81±0.34	up to 4.51
Fat acidity value, mg KOH/25g	0.87±0.01	0.82±0.03	0.62±0.09**	premium grade: 1.10 first grade: 1.10-2.22

* *According to Pronin and Fisenko (2018), **P<0.05*

As it can be seen from the above data, the content of VFA in all the rabbit meat samples corresponded to fresh meat, but the differences between the groups were unreliable in terms of this indicator. However, the following tendency was observed: VFA in the meat of experimental group I is 0.22 mg KOH (-6.16%) less, and in experimental II it is 0.23 mg KOH (+3.36%) more than in the meat of the control group. As for the acidity value, the fat of the rabbits from all the groups corresponded to the premium-grade fresh fat. The fat acidity value in the rabbit meat of experimental group I and control group did not differ significantly, while in the rabbit meat of experimental group II this indicator was 0.24 mg KOH (-28.16%, *P<0.05*) lower than in the control group. The influence of the addition of the stinging nettle hay into the rabbit ration on the amount of VFA and the fat acidity value of the meat is shown in ***Table 11***.

Table 11. The influence of the supplementary feeding with the stinging nettle hay on the rabbit meat freshness indicators (n=10)

Indicators	Power of influence indicator, %
VFA	2.7
Fat acidity value	28.9*

**P<0.05*

It was established that feeding with nettle did not influence the amount of VFA in the rabbit meat after 3 months storage, and the change in the fat acidity value reliably depended on the supplementary feeding with nettle.

Thus, the introduction of nettle into the rabbit ration had a positive effect on the keeping quality of the rabbit meat when stored for 3 months at a temperature of -18 °C. With an increase in the proportion of nettle in the ration, the rabbits' fat acidity value decreased, i.e., its food safety is increased. A 5% dosage of the nettle hay in the rabbit ration of the nutritional value of coarse fodder resulted in a slight decrease in VFA in the meat as compared to a 25% dosage of nettle. This allowed us to suggest that the lower dosage of nettle in the ration had a better effect on the safety of the muscle tissue in the rabbit meat than the higher dose.

5. Conclusions

The introduction of the studied dosages of the stinging nettle hay into the ration led to an increase in the content of crude (+3.5 and +20.3%), digestible protein (+4.4 and +22.8%) and carotene (+3.3 and +22.7%). In this case, growing rabbits with a dosage of 5% (per 0.13 kg of feed units) and 25% (per 0.05 kg of feed units) of the stinging nettle hay of the nutritional value of coarse fodders was characterized by the least feeds per 10 g of the gain as compared to the content in the traditional ration (1.17 kg of feed units). The introduction of 5% of the nettle hay into the rabbit ration as compared to the control group: influenced a decrease in the moisture content (the power of effect is -10,38%), an increase in the content of protein (the power of influence of +34.2%), zinc (the power of influence of +35.6%) and manganese (the power of influence of +34.2%) in the rabbit meat; we revealed a tendency of prevailing essential amino acids: methionine, isoleucine, phenylalanine, as well as non-essential amino acids – glutamic acid and glycine in the meat.

The introduction of 25% of the nettle hay into the ration resulted in a lower fat content (the power of effect is -19.7%) and a higher manganese content (the power of effect is +34.2%) in the muscle tissue of rabbits.

We revealed a positive influence of the supplementary feedings with nettle on the keeping quality of meat when stored for 3 months at -18 °C due to slightly smaller amounts of volatile fatty acids (-6.2%) and the fat acidity value (-28.2%) than the control samples.

Note: The two values in parentheses always refer to the two nettle portions: 5% and 25%, respectively.

6. Conflicts of interest

We declare that we have no financial and personal relationships with other people or organizations that can inappropriately influence our work, there is no professional or other personal interest of any nature or kind in any product, service and/or company that could be construed as influencing the content of this paper.

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