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Nutrient digestibility of fishmeal rations in primates

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SUMMARY

The results of the study on effects of fishmeal on nutrient digestibility and intake in primates are given in the paper. Fishmeal is a feeding stuff, manufactured from fish, marine mammals, invertebrates not suitable for human consumption and by-products of their processing. Fishmeal nutrient composition includes natural substances and minerals, including phosphorus, calcium, iodine, selenium, several essential amino acids, as well as vitamins A, D and B complex. Fishmeal is known to be rich in digestible energy and proteins. One kilogram of fishmeal contains 700 grams of raw protein and up to 15 MJ of digestible energy. It should be noted that fishmeal is easily digested by animals. Nevertheless, there is a lack of data in publications on use of fishmeal as high protein feed in rations of primates. In this regard, the aim of the study was to analyze the effects of fishmeal on digestibility of mixed feed nutrients in male rhesus-macaques and to use the obtained results for understanding of prospects of fishmeal further use for feeding primates. The chemical composition and nutritional value of the total mixed ration was determined. The economic effectiveness of the fishmeal use in the rations of primates was calculated. Based on the experimental data, it was established that the inclusion of fishmeal (18% out of total) into the diet contributes to the improvement of feed intake in experimental primates and reduces the costs of complete granular feed.

Keywords: digestibility, retention, fishmeal, diet, rhesus macaque (*Macaca mulatta*), primates

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Переваримость питательных веществ рациона с рыбной мукой у приматов

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РЕЗЮМЕ

Представлены результаты изучения влияния рыбной муки на переваримость и усвоение питательных веществ корма у приматов. Рыбная мука – кормовой продукт, вырабатываемый из промышленных или сорных видов рыбы, морских млекопитающих, беспозвоночных, отходов их переработки. В состав рыбной муки входит комплекс природных веществ и минералов, в том числе фосфор, кальций, йод, селен, ряд незаменимых аминокислот, а также витамины A, D и группы B. Известно, что рыбная мука богата обменной энергией и протеином. В одном килограмме муки содержится до 700 г сырого протеина и до 15 МДж обменной энергии. Следует отметить, что рыбная мука легко переваривается и хорошо усваивается организмом животных. Однако в литературе имеется недостаточное количество данных по использованию рыбной муки в рационах приматов в качестве высокопротеинового корма. В этой связи целью исследований являлось изучение влияния рыбной муки на переваримость питательных веществ комбикорма у самцов

макаков-резусов и на основании полученных данных определение перспективы дальнейшего использования в кормлении приматов. Был изучен химический состав и определена питательность полученного полнорационного комбикорма. Рассчитана экономическая эффективность использования рыбной муки в рационах приматов. На основании экспериментальных данных установлено, что введение взамен высокобелковых компонентов 18% рыбной муки обеспечивает улучшение процесса усвоения питательных веществ корма у подопытных приматов и обеспечивает снижение себестоимости полнорационного гранулированного комбикорма.

Ключевые слова: переваримость, ретенция, рыбная мука, рацион, макак-резус, приматы

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INTRODUCTION

Quality feeding rations underpin the profitability of keeping primates and other animal species. One of the most important components of high-quality feed is fishmeal, produced by modern fish rendering plants and having valuable nutritional properties. It was found that fishmeal protein is digested by animals much better than vegetable proteins. Experience shows that fishmeal added to the diet increases the efficiency of using other feeds, poor in protein and fat, and its inclusion in the mixed feed facilitates the animal growth and weight gain and improves their general condition [1–3]. As a result of biochemical studies, the so-called albumin factor was found in fishmeal feeds, which is responsible for the absorption of vegetable protein, vitamin B12 and other water-soluble B complex vitamins by animals. For this reason, fishmeal is not only a source of a complete animal protein, but also a catalyst for biochemical processes [4, 5]. For example, studies of the Leningrad Zootechnical Institute showed that animals that absorbed 31.8% nitrogen from vegetable feed, after adding cod meal in an amount of 5% to the feed, began to absorb up to 36.3% of nitrogen, i.e. the digestibility of vegetable proteins increased by 12.5% [1, 6]. Therefore, the inclusion of fishmeal in the feed diet contributes to the growth of healthy animals. Fishmeal has a unique composition. First, it is a surprisingly wide complex of natural substances and minerals: phosphorus, calcium, a set of amino acids, iodine, selenium, as well as A, D and B complex vitamins. Thanks to these elements, the digestive processes are improved and the immune system is strengthened. By the content of digested protein, fishmeal ranks among the highest in feedstuffs. For example, 1 kg of fishmeal contains at least 535 g of digestible protein. Therefore, animals that receive fishmeal as part of their diet are less susceptible to diseases, and due to the optimal ratio of amino acids, young animals develop faster. Fishmeal is considered a valuable preventive tool against thyroid diseases, since it contains iodine in the form of organic compounds. For example, cod fat contains from 4.5 to 15.2 mg of iodine per 1 kg of fat [6, 7].

The chemical nature of fishmeal extractive substances has not yet been sufficiently studied. However, a favorable effect of premium quality fishmeal on the appetite of animals has been established. Fishmeal-receiving animals absorb a significant amount of feed nutrients well and have a high growth rate. Thanks to its components, it promotes the development of vital body systems, activation of the immune system, and increases the digestibility of nutrients [8–11]. The digestibility of high-quality fishmeal reaches 90%. In addition, the introduction of fishmeal into the diet has a positive effect on the feed conversion, and the lower the conversion rate, the more efficient the production. Therefore, fishmeal is widely used in the manufacture of mixed feeds, which have become widespread in our country.

The aim of the study was to study the effect of partial or complete replacement of the main feed ingredients with fishmeal and to determine the dietary nutrient digestibility.

For this purpose, the following tasks were set:

– to study the digestibility of nutrients in the fishmeal diet on male rhesus monkeys;

– calculate the economic efficiency of using fishmeal for feeding primates;

– to carry out mathematical analysis of the data obtained.

MATERIALS AND METHODS

The object of the study was male rhesus monkeys (*Macaca mulatta*) aged from 7 to 15 years. For the experimental purposes, two groups of five animals were formed using the method of analogous pairs by gender, origin, age and physiological state at the animal facilities of the FGBRI "Research Institute of Medical Primatology". The experiment was carried out in accordance with the generally accepted research methods developed by L. K. Ernst Federal Research Center for Animal Husbandry and other organizations [7, 12, 13].

Tests of fishmeal and other feed components were carried out at the Research Institute of Medical Primatology.

Based on the obtained laboratory data and reference publications, a feed ration for primates was formulated.

The inorganic compounds of the total mixed ration were determined using a vacuum wave-dispersive X-ray fluorescence spectrometer "SPECTROSCAN MAX-GVM" (NPO "SPEKTRON" LLC, Russia) in accordance with the "Method for measuring the mass fractions of Mg, Al, Si, Zn, P, S, Cl, K, Ca, Ba, Ti, Cr, Mn, Fe, Ni, Br, Rb, Sr in vegetable powder samples by X-ray fluorescence using X-ray spectrometers SPECTROSCAN MAX (M-049-RM/12)", FR.1.31.2014.17343. The rest of the parameters were determined using the NIRS DS2500F feed analyzer (FOSS, Denmark).

During the test period, the control group primates received a total mixed ration feed prepared at the production site of the institution using the Münch-Edelstahl GmbH feed pelletizer (Germany). The feed was composed of primary components: wheat, soy meal, skimmed milk powder, sunflower cake, corn, corn gluten, egg powder, sugar and sunflower oil. Wheat accounted for 21.4% of the ration energy value. In total, soy meal and sunflower cake (the amount of fat 10%) accounted for 17.42 and 13.83% in the mixed feed, respectively. A significant part of the ration energy value (14.39%) was skimmed milk powder. The diet of the control group animals was energetically balanced with the introduction of sunflower oil (0.8%). The remaining 32.16% of energy accounted for corn gluten (11.24%), corn (13.35%), egg powder (3.3%) and sugar (4.27%).

Test group primates received fishmeal with mixed feed, which made up 18% of the ration nutritional value. According to the experimental design, thanks to the inclusion of 60–65% of fishmeal, the content of skimmed milk powder decreased by 100%, sunflower meal – by 10%, egg powder – by 70%, corn gluten – by 2%. The diet was balanced in terms of crude protein according to generally accepted norms; the deficit of crude fiber was insignificant, but within the acceptable limits. For the remaining nutrients, the deviations were within the limits established by the regulatory requirements [14].

Experiments on animals were carried out in accordance with the intergovernmental standards for accommodation and care of laboratory animals GOST 33215-2014 and GOST 33216-2014, adopted by the Intergovernmental Council for Standardization, Metrology and Certification, as well as in accordance with the Declaration of Helsinki (2000) and Directive 2010/63/EU of the European Parliament and of the Council of 22.09.2010 on the protection of animals used for scientific purposes. The study was approved by the bioethical commission of the Research Institute of Medical Primatology.

The obtained results were processed statistically and expressed as arithmetic averages and their standard errors. The statistical significance of the differences was determined using a one-factor analysis of variance with subsequent posteriori corrections for multiple comparisons using the Tukey and Sidak method. The accepted level of statistical significance is $p< 0.05$.

RESULTS AND DISCUSSION

To determine the absorption and digestibility of dietary nutrients, a physiological study was performed on ten *M. mulatta* primates. The amount of feed consumed by the animals and the amount of feces excreted by them were recorded daily. Then, the chemical composition of the feed and feces was analyzed, which allowed to determine the amount of nutrients consumed and excreted per day. Based on the obtained data, the amount of absorbed nutrients and the digestibility coefficients were determined (Table).

The analysis of the data presented in the table showed that the best results in digestibility for most of the standardized organic matter were observed in the primates of the experimental group. In this group, the digestibility of crude protein and fat was higher than in the control group by 1.66 and 21.92%, respectively ($p< 0.01$). It should be noted that nitrogen-free extracts in the structure of which starch plays an important role, were absorbed by 11.74% better in the control group than in the test group.

The research results indicate that the inclusion of fishmeal in the structure of rations for primates (18% by nutritional value) had a positive effect on the digestibility and use of basic nutrients.

Since the economic indicators of primate feeding efficiency are among the main indicators of the system regulating the profitability of their keeping, the production costs of the tested total mixed ration feed with fishmeal added were calculated in comparison with the control one.

In the structure of the control group ration, the most expensive component is skimmed milk powder, its share in the composition accounts for 14.39% (24 rubles 20 kopecks from the cost of 1 kg of mixed feed). The next most expensive component is soy meal, which accounts for 17.42% of the nutritional value, the cost of it amounted to 9 rubles 66 kopecks. The highest purchase price was set for egg powder, but due to its insignificant content in the structure of the diet (3.3%), it cost 6 rubles 98 kopecks. The costs of the remaining components of the diet are at an acceptable level, which is due to their initially low cost or low percentage content in the feed composition. Thus, the price of 1 kg of total mixed ration feed for the control group was 70 rubles 96 kopecks.

When creating a new formula of the mixed feed for primates of the experimental group, the diet was significantly

Table
Nutrient digestibility of primates' rations, % (X ± Sx)

Indicators	Crude protein	Crude fat	Crude fiber	Crude ash	NFE	Calcium	Phosphorus
Control	27.34 ± 1.04	20.09 ± 0.98	16.88 ± 1.01	49.58 ± 0.88	54.05 ± 1.12	18.37 ± 1.94	21.79 ± 2.01
Test	29.00 ± 1.14	42.01 ± 1.85**	52.13 ± 1.26	53.63 ± 1.03	42.31 ± 1.27	94.14 ± 1.18*	90.00 ± 1.84

NFE – nitrogen-free extracts.
* $p < 0.05$; ** $p < 0.01$.

changed. In particular, fishmeal replaced soy meal by 7%, sunflower cake – by 10%, egg powder – by 50% and skimmed milk powder – by 100%. In the structure of the feed ration, fishmeal (60–65%) in terms of nutritional energy value was 18%, the price was 6 rubles 84 kopecks. The cost of 1 kg of total mixed ration feed as a result amounted to 48 rubles 38 kopecks. Thus, due to the inclusion of fishmeal in the composition of the mixed feed, it became possible to reduce the cost of 1 kg of the feed by 22 rubles 58 kopecks.

The cost of feed conversion depends on the cost of feed and their nutritional value. In the control group, the cost of 1 MJ was 5 rubles 32 kopecks. The cost of digestible energy in the experimental group was lower and amounted to 3 rubles 63 kopecks per 1 MJ. A similar pattern was observed for crude protein. The low cost of 1 g of protein was observed in the experimental group, it was 14 kopecks, and in the control group – 26 kopecks.

CONCLUSION

From the analysis of the data obtained by the experiment, it can be concluded that the inclusion of fishmeal in the composition of a total mixed ration feed for primates allows to enrich the diet with nutrients, improve the digestibility of nutrients and reduce the cost of feed without losing its quality.

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