Digestibility of dry matter and bioavailability of starch of various types of grain in the rumen

Sh G Rakhmatullin \textsuperscript{1,4}, G K Duskaev\textsuperscript{1}, I I Kochish\textsuperscript{2}, Yu A Yuldashaev\textsuperscript{3}, B S Nurzhanov\textsuperscript{1}, K S Inchagova\textsuperscript{1}, V A Ryazanov\textsuperscript{1}

\textsuperscript{1}Federal Scientific Center of Biological Systems and Agrotechnologies of the Russian Academy of Sciences, 29, January 9 str., Orenburg, 460000, Russia
\textsuperscript{2}Moscow State Academy of Veterinary Medicine and Biotechnology named after K.I. Skryabin, Moscow, Russia
\textsuperscript{3}Russian State Agrarian University-Moscow Agricultural Academy named after K.A. Timiryazev, 49, Timiryazev street, Moscow, 127550, Russia

E-mail: shahm2005@rambler.ru

Abstract. The constant introduction of a huge amount of concentrates at the stage of growing and fattening animals can lead to diseases associated with non-compliance with the feeding technique (acidosis). In this regard, the study of metabolism, destruction of dry matter, as well as starch in various feeds of grain origin, including those growing in the Orenburg region and contributing to the acidification of the rumen, is essential and necessary to increase feed efficiency. The highest rate of starch digestion six hours after incubation was in rye, exceeding the similar values of other crops by 0.4-1.3\%. Further, two groups of crops should be distinguished with almost the same rate of starch digestion: these are wheat, imported barley, oats and chickpeas, domestic barley. It should be noted that the lowest rate of starch digestion was characteristic of the latter group (6.0\%). The need to study the decay of the components of cereals with their active feeding to cattle is important. Including it is necessary to consider regional peculiarities of cultivation of these crops, since the content of substances in the grain, and for the same species, varies greatly, which ultimately affects the feed efficiency.

1. Introduction

Increasing the efficiency of the use of feed is one of the important tasks of animal husbandry [1-3]. In particular, the active inclusion of many concentrated feeds at the stage of rearing and fattening may provoke the occurrence of diseases associated with irrational feeding. So, feeding animals with grain (especially crushed), which quickly ferments, causes a sharp decrease in the pH of the rumen fluid and the occurrence of subacute and acute acidosis, which ultimately reduces feed efficiency. In world practice, to solve this problem, substances that contribute to the depreciation of the acidic environment in the rumen (ionophores, monensin, bicarbonates, etc.) are used. However, the final effect of monensin on microbial populations has not yet been studied and requires additional research [4-6]. Thus, the use of monensin led to an increase in the microbial synthesis of protein and nitrogen in the feeding of sheep on high-concentration diets, and this occurs against the background of a decrease in the number of protozoa in the rumen [7-10]. Ionophores (as well as fodder antibiotics used as growth promoters) have been banned in Europe since 2006 due to concerns about the development of antibiotic resistance [11-
Plant extracts, essential oils from plants attract considerable attention as an alternative to promoting the growth of cicatricial modifiers since the ban on the use of antibiotics as feed additives [13-14], but the results must be confirmed in vivo in accordance with commercial production conditions [15].

The aim of the study was to study the digestibility and decay of dry matter and starch of various grains, including those growing in the Orenburg region.

2. Materials and research methods.

The experimental part of the research consisted of a physiological experiment, which was carried out on fistulirovannyh steers of the red steppe breed, in the conditions of the physical department of the Pokrovsky Agricultural College of the Orenburg District of the Orenburg Region. At the beginning of the preparatory period experimental animals according to the method A.A. Aliyev (1998); fistulas of the scar were established [16]. During the preparatory period of the experiment, the bull-calves were transferred to tethered content, individual feeding, to rations based on detailed feeding standards developed by A.P. Kalashnikov et al., (2003) [17].

Animal care and experimental studies were performed in accordance with the instructions and recommendations of the Russian Regulations, 1987 (Order No.755 on 08/12/1977 by the USSR Ministry of Health) and "The National Academy Press Washington, DC 1996). In doing research, efforts were made to minimize animal suffering and reduce the number of samples used.

The following feed samples were prepared for the study: wheat, domestic barley, rye, bare oats, imported barley, chickpeas.

During the experiment, the diet for the experimental animals was balanced in essential nutrients in accordance with the norms designed to obtain 800-900 g of average daily weight gain. To determine the starch digestibility, dry matter in the rumen, the in-situ method or the so-called “nylon bag” method was used [18, 19].

The method of these studies was assumed to be 3- and 6-hours exposure of nylon bags with food in the rumen of experimental animals after feeding. Sacks 110 x 50 mm in size were sewn with double stitching. A sample of feed weighing 3 g of air-dry matter was placed in a previously weighed and numbered bag. The upper edge of the bag was tied up and sewn up with a double seam, but so that it was possible to stitch the bag onto the nylon fishing line (D = 0.8 mm). At the same time, no more than 6 sacks were placed in the rumen of each bull, that is, 3 types of food. The bags removed from the rumen were washed in running water at room temperature for 3-4 layers of filtered paper. Then the bags were placed in a thermostat, where the samples were brought to constant weight at a temperature of 80 °C.

Laboratory studies were conducted using the material and technical base of the Testing Center of the Collective Scientific Center of the BST RAS (accreditation certificate No. RA.RU.21ПФ59 of 10/12/2015), including the GP-20 dry heat ovens (drying the samples for 45 minutes at a temperature 60 °C to constant weight), subsequent weighing (laboratory scales VM 510D).

Statistical processing was performed using the program "Statistica 10 RU", calculating the average value (M), standard deviation (σ), standard deviation error (m). The significance level was considered significant at p <0.05.

3. Research results and discussion.

According to the results of the research, it was established that the digestibility of the components of the grain varied depending on the plant type and the incubation time of the sample in the rumen of the animal (Table 1).
Table 1. Digestibility in the studied samples (in situ), %

| Crushed grain         | After 3 hours |                       | After 6 hours |                       |
|-----------------------|---------------|-----------------------|---------------|-----------------------|
|                       |               | dry matter            |               | dry matter            |
| Wheat                 | 25.8±1.33     | 35.8±1.34             | 57.8±1.98     | 94.3±1.23             |
| Barley domestic       | 28.3±2.01     | 39.6±1.55             | 63.3±1.42     | 93.3±1.19             |
| breeding              |               |                       |               |                       |
| Barley import selection| 58.2±1.68    | 74.6±1.03             | 71.4±1.20     | 96.9±1.71             |
| Oats bare             | 34.0±1.51     | 49.1±1.25             | 82.4±1.53     | 98.2±1.07             |
| Rye                   | 30.1±0.93     | 35.7±1.63             | 87.6±1.05     | 98.5±1.08             |
| Chickpea              | 62.1±1.14     | 68.8±1.42             | 82.6±1.32     | 97.5±1.67             |

So, 3 hours after incubation, the digestibility of dry matter of chickpea grain was higher than in other cultures by 3.9-36.3%. The digestibility of dry matter of barley grain of import selection was also higher than that of other cereals by 24.2-32.4% (P <0.05). The smallest value of digestibility of dry matter of grain was found in wheat (25.8%). After 6 hours after incubation, the digestibility of the dry matter of the grain in rye significantly increased, the difference in comparison with other cultures was 5-29.8%. Almost the same values in this period had oats and bare chickpeas (82.4-82.6%), the least digestibility, as in the previous period, was in wheat (57.8%). Accordingly, rye and oats digestibility over the three-hour period increased by 57.5 and 48.4%, while in barley import selection and chickpea was lower (13.2 and 6.7%) due to the initially high fermentation of the substance.

After three hours of incubation, the starch digestibility changed almost similarly to dry matter, except for imported barley, where this value was 5.8-38.8% higher than other cultures. Chickpea grain has a similar value of 19.7-33% higher. The lowest digestibility of starch was observed in wheat and rye grain (35.7-35.8%). A characteristic feature of the chemical composition of rye is a rather high content of mucus - 1.5-2.5%, in the composition of which high-molecular-weight carbohydrates are predominant. In addition, starch rye grains are the largest. Six hours after incubation, the starch digestibility was highest for rye grain and bare oats. At the same time, the greatest difference was in comparison with the barley of domestic breeding (5.2%).

Knowing the initial starch content in the grains of the assessed crops, the rate of in situ digestion was calculated for a three- and six-hour study period (Fig. 1, 2).

Figure 1. In situ starch digestion rate for 3-hour period, %
Three hours after incubation in the rumen of cattle, barley starch of imported breeding and oats underwent active fermentation.

The highest rate of starch digestion six hours after incubation was in rye, exceeding the similar values of other crops by 0.4-1.3%. Further, two groups of crops should be distinguished with almost the same rate of starch digestion: these are wheat, imported barley, oats and chickpeas, domestic barley. It should be noted that the lowest rate of starch digestion was characteristic of the latter group (6.0%).

4. Conclusions

Thus, the need to study the decay of the components of cereals with their active feeding to cattle is important. Including it is necessary to take into account the regional peculiarities of cultivation of these crops, since the content of substances in the grain, and for the same species, varies greatly depending on the nature of the soil, the climate and the fertilizers applied, which ultimately affects the feed efficiency. According to the results of research, it has been established that the starch of barley of import selection, oats and chickpeas - three hours after incubation, rye, wheat, oats - after six hours, undergo the greatest fermentation in the rumen.

Acknowledgments

The studies were performed in accordance with the plan of research works Federal Research Centre of Biological Systems and Agrotechnologies of the Russian Academy of Sciences 0526-2019-0005.

References

[1] Shatskikh E V, Gafarov Sh S, Boyarintseva G G and Safronov S L 2006 Use of feed additives in animal husbandry (Yekaterinburg: Ural Agrarian Publishing House)
[2] Panneer S and Yamuna R 2018 7 (2) 188–90
[3] Levakhin G., Duskaev G. and Dusaeva H., 2015. Assessment of Chemical Composition of Grain Crops Depending on Vegetative Stage for Feeding. Asian Journal o fCrop Science, 7: 207-213.
[4] Weimer P J, Stevenson D M, Mertens D R and Thomas E E 2008 Microbiol. Biotechnol. 80 135–45
[5] Krieg J, Seifried N, Steingass H and Rodehutscord M 2017 In situ and in vitro ruminal starch degradation of grains from different rye, triticale and barley genotypes Animal. 11(10) 1745–53
[6] Duskaev G, Karimov I, Levakhin G, Nurzhanov B, Rysaev A and Dusaeva H 2019 Ecology of ruminal microorganisms under the influence of Quercus cortex extract *Int. J. of Geomate* March 16(55) 59–66

[7] Rogers M, Jouany J P, Thivend P and Fontenot J P 1997 Anim *Feed Sci. Tech.* 65 113–27

[8] Garcia C C G, Mendoza M G D, Gonzales M S, Cobos P M, Ortega C M E and Ramirez L 2000 Effect of Saccharomyces cerevisiae and monensin on ruminal fermentation *Feed Sci. Tech.* 83 165–70

[9] Lee C, Morris D L, Copelin J M and Kwon I H 2019 *Effects of lysophospholipids on short-term production, nitrogen utilization, and rumen fermentation* (102) 3110–20

[10] Oh J, Harper M, Lang C H, Wall E H and Hristov A N 2018 Effects of phytonutrients alone or in combination *J. of Dairy Sci.* 101(8) 7190–8

[11] Callaway T R, Edrington T S, Rychlik J L, Genovese K J, Poole T L, Jung Y S, Bischoff K M, Anderson R C and Nisbet D J 2003 *Iss. Intest. Microbiol.* 4 43–51

[12] Lahane S B, Deokate US and Ahire S 2014 Available analytical method for macrolide antibiotic *International J. of Pharmac. Sci. Rev. and Res.* 26(2) 256–61

[13] Calsamiglia S, Busquet M, Cardozo P W, Castillejos L and Ferret A 2007 Invited Review: Essential Oils as Modifiers of Rumen Microbial Fermentation *J. Dairy Sci.* 90 2580–95

[14] Sizova E.A., Yausheva E.V., Miroshnikov S.A., Lebedev S.V. and Duskaev G.K. 2015 Element status in rats at intramuscular injection of iron nanoparticles. *Biosciences Biotech. Res. Asia* 12 119–27

[15] Karimov I., Duskaev G., Inchagova K., Kartabaeva M. Inhibition of bacterial Quorum sensing by the ruminal fluid of cattle. International Journal of GEOMATE, Dec., 2017, Vol. 13, Issue 40, pp.88-92

[16] Logachev K., KarimovI., Duskaev G., Frolov A., Tulebaev S. and Zav`yalov O. 2015. Study of Intercellular Interaction of Ruminal Microorganisms of Beef Cattle. Asian Journal of Animal Sciences, 9: 248-253

[17] Ivanov D V, Krapivina E V, Fedorov Yu N and Albulov AV 2009 Immunoreactivity in heaths succinate *Agricultural Biology* 2 104–10

[18] Meshcheryakov A G 2008 Scientific and practical approaches to the rational use of feed protein in rations of beef cattle, taking into account the peculiarities of its metabolism *Thesis doctor of biological sci.* 339

[19] Swarich D A, Trukhachev V I and Zlyidnev N Z 2007 Effects of protein degradability *Prod. Anim. Biol.* 2 103–13