Evaluation of cereal forage grasses and forages from them according to the content of protein insoluble in acid detergent

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Abstract. The nitrogen content was determined in acid-detergent fiber (ADF) isolated from awnless rump, meadow fescue and meadow timothy, depending on the phase of their the same phases are for silage and haylage. Samples for analyzes were dried at a temperature of 60-65 ° C. As the grasses grew, an increase in the content of CDC in them was observed, which was also accompanied by an increase in ADF from the phase of entering the tube to flowering in timothy grass - from 1.18 to 1.36%, in meadow fescue - from 0.96 to 1.58 5%. When preserving grasses, an increase in the content of CDC is observed in all phases of their growth as compared to the original grass, but the mass fraction of ADF in the dry matter of silage and haylage was no more than in the original grass. If the technology of harvesting silage and haylage is observed, the level of thermal damage to these forages does not increase. With the growth of grasses from the vegetative phase to flowering, the content of SP in grasses and forages from them decreases, while the proportion of ADF in it increases. The inverse relationship between these indicators had correlation coefficients of 0.83, 0.88 and 0.92 for grasses, silage and haylage, respectively. The need to harvest them in earlier phases of growth is noted.

Keywords: perennial cereal forage grasses, growth phases, silage, haylage, acid detergent fiber (ADF), crude protein, acid detergent insoluble protein (ADIP).

1. Introduction

When developing a detergent scheme for the analysis of feed, Van Soest found that samples dried at a high temperature contain more fiber, from which nitrogen was not removed by a detergent solution or pepsin [1]. The formation of such nitrogen compounds has been termed heat damage. In this case, a connection arises between the protein and substances of the cell walls, like tannin and lignin, with the formation of insoluble compounds. They are also the product of the Mayard reaction, which is the condensation of carbohydrates with protein and amino acids. The most accessible way to determine the degree of heat damage is the analysis for the nitrogen content in acid-detergent fiber - ADF (ADIN). By multiplying the acid detergent insoluble nitrogen (ADIN) content by a factor of 6.25, the acid detergent insoluble crude protein (ADICP) is obtained. It is expressed in terms of the dry matter of the feed. Often used is also such an indicator as the proportion of ADICP in the crude protein (CP) of the feed.

Interest in the content of ADICP is due to the fact that it is inaccessible to animals and causes a decrease in the digestibility of the SP. It was found that the concentration of ADICP, expressed as a percentage of CP, closely correlates with the digestibility of the crude protein of herbaceous fodder [2,
With heat damage, not only the quality of the protein decreases, but at the same time its negative effect on the energy value of the feed is observed [2]. Thus, the content of metabolizable energy in the damaged silage by heat decreased by 16% [3].

Heat damage often occurs under conditions such as overheating of feed in the presence of moisture. When hay is stacked or bales of more than 20% moisture, heat is generated by mold growth and the feed temperature rises, which can cause heat damage. It is recommended to lay hay in large bales at a lower moisture content due to slower cooling of the forage than in small bales [2]. Thermal damage to the silage is associated with the presence of oxygen in the silage mass. This is facilitated by insufficient compaction of the grass, extended periods of filling the trench. Heat-damaged silage has a brown or dark brown to black color, the smell of dried tobacco, apples or rye bread. Artificially dried feed is also subject to heat damage when it is overdried. These foods are often brown instead of dark green or yellowish, with a burnt odor and burnt ends of the food particles.

Well-pronounced organoleptic characteristics are characteristic of a high degree of heat damage to feed, but this may be less pronounced. It can be established for a specific batch of feed only on the basis of the analysis of ADICP, since thermal damage does not affect the CP content. Therefore, in some laboratories for determining the quality of feed, along with the total content of CP, data are given and ADICP [4]. It is recommended to make an amendment to the ADICP, if its share in the joint venture is more than 10%

2. Purpose of the study
The aim of the research is to evaluate the most widely cultivated cereal forage grasses and silage and haylage prepared from them by the level of protein insoluble in acid detergent, depending on the growing season in the first cut and the CP content in them.

3. Materials and methods
The object of the study is samples of forage grasses grown on sod-podzolic soil of the Central Experimental Base of the V.R. Williams. To collect samples in the selected area, several areas were identified diagonally. Awnless rump, meadow fescue, and timothy grass were mowed in the phases of tube emergence, inflorescence (earing) and flowering. Growth phases were determined visually. The mowed green mass, after thorough mixing, was divided into two parts. Samples of green grass were taken from one part, and the other part was used to prepare silage and haylage in cisterns.

Samples of green grass, silage and haylage, dried at a temperature of 60-65 °C in a drying oven with forced ventilation, were ground to pass through a sieve with 1 mm holes. The CP content was determined in them by the Kjeldahl method. To determine acid-insoluble nitrogen, the ADF residue was obtained by filtering an acid detergent solution through a paper filter after boiling a sample in it.

4. Results and discussion
As they grew, the ADF content in the herbs increased. Since ADIP is an integral part of ADF, it is logical to expect its accumulation with increasing ADF content. However, no correlation was found between ADIP and ADF levels in herbs. So, if in the original grass of meadow fescue and timothy grass, such a relationship is traced, then in the awnless rump, the opposite picture was observed (Table 1).

| Culture       | Feed type | Exiting the tube | Earing | Bloom |
|---------------|-----------|------------------|--------|-------|
|               | ADF, % DM | ADICP, % DM     | ADF, % DM | ADICP, % DM | ADF, % DM | ADICP, % DM |
| Awnless rump  | grass      | 26,97            | 1,26   | 32,09 | 1,05   | 40,04 | 0,96 |
|               | silage     | 33,08            | 1,27   | 36,64 | 0,92   | 41,39 | 0,88 |
ADF content in the first phases of grass growth, which was also not accompanied by an increase in ADIP. The fact that ADIP is not a permanent part of ADF has been reported in other studies [6]. However, under experimental conditions, a certain dependence of the concentration of ADIP in ADF on the growth phase and type of food was observed: an increase in the accumulation of lignocellulose with the growth of grasses was accompanied by a slight decrease in the concentration of ADIP in it.

Preservation of grasses in all phases of their growth led to an increase in the content of ADF compared to the original grass, but due to a lower concentration of ADIP in ADF than in grass, the mass fraction of ADIP in dry matter of silage and haylage was lower. Although, due to the peculiarities of the silage harvesting technology, the likelihood of thermal damage to the silage is higher than that of other types of forage. But this is true only with insufficient compaction of the silo during its filling and with long-term filling of the trench or tower, when there is an increased infiltration of air into the silage mass. At the same time, it is reported that in silos obtained in the absence of an increase in temperature due to respiration, no significant content of products of the Maillard reaction was found [5]. In our experiments, silage and haylage were prepared for scientific purposes in tanks in compliance with the technology. Perhaps that is why a higher content of ADIP was not observed in the dry matter of silage and haylage compared to the original grass, it was even slightly lower.

It is generally accepted to estimate the level of ADIP by its share in CP, since this indicator is of practical importance for adjusting the protein content in feed and rations, given that some of it is not available to animals. In grasses in the tubing phase with a high CP content, the proportion of ADIP in CP is relatively low (Table 2). As you grow

| Types of herbs | Types of feed | Exiting the tube | Earing | Bloom |
|----------------|---------------|------------------|--------|-------|
|                |               | CP, % DM. | share in CP, % | CP, % DM. | share in CP, % | CP, % DM | share in CP, % |
| Awnless rump   | grass         | 22,25     | 5,7          | 13,25   | 7,9         | 8,12     | 11,8 |
|                | silage        | 20,81     | 6,1          | 13,94   | 6,6         | 9,25     | 9,4  |
|                | haylage       | 17,56     | 6,0          | 14,12   | 9,0         | 8,44     | 10,0 |
| Meadow fescue  | grass         | 16,75     | 5,0          | 11,94   | 11,4        | 9,81     | 16,1 |
|                | silage        | 17,31     | 6,0          | 11,88   | 7,6         | 11,25    | 8,9  |
|                | haylage       | 18,12     | 4,6          | 12,88   | 7,1         | 9,38     | 9,9  |
| Timothy grass  | grass         | 13,94     | 8,5          | 11,81   | 10,7        | 7,69     | 17,6 |
|                | silage        | 14,06     | 6,4          | 10,06   | 9,6         | 9,38     | 9,5  |
|                | haylage       | 14,75     | 6,2          | 11,44   | 9,0         | 8,44     | 10,4 |

plants, the CP level in them decreases and at the same time the proportion of ADIP in CP increases, which reaches 16-17% by the time of flowering. [6] also reported the lowest percentage of ADIP in CP in the earlier phases of herbal growth. The relationship between CP and the share of ADIP in it is quite close (Figure 1)
Figure 1. Dependence of the proportion of ADICP of the CP content in the original herbs.

The correlation coefficients between these indicators were 0.83; 0.88 and 0.92 for grasses, silage and haylage, respectively. The share of ADIP in the CP of silage and haylage remains lower as the grasses grow during all phases of grass growth than in grasses. Therefore, it can be assumed that canned herbs, subject to the technology of their harvesting, are less susceptible to heat damage than fresh grass dried at 60 °C, although samples of silage and haylage were dried at the same temperature. Perhaps this is due to differences in the carbohydrate and protein composition of fresh and canned herbs. Thus, it is noted that at an appropriate rate of fermentation of the grass mass, the content of water-soluble carbohydrates in it, participating in the Maylard reaction, decreases [5]. A higher susceptibility to heat damage in silage with a higher dry matter content is associated with a lower fermentation rate and also with a lower compaction capacity. Alfalfa silage with a dry matter content> 35% is more susceptible to heat damage than grasses with a higher moisture content [7].

Our results are comparable with the literature data on the level of ADIP in cereals and the inverse dependence of its share in CP on the CP content [6]. With regard to silage, it is reported that the level of its thermal damage depends on various factors such as the type of silage crop, the type of silo, the moisture content of the silage mass, the length of the cut and others [8]. According to them, of the 146 silage samples taken from farms in Ontario, 25 samples contained more than 1.8% ADIP in dry matter, indicating thermal damage. The rest of the silage was of good quality. At the same time, at some agricultural enterprises in Belarus, ADIP exceeded 30% CP in cereal silage samples [9]. Therefore, in laboratories for assessing the quality of feed, along with CP, it is recommended to determine the ADIP in its composition.

5. Conclusion
The content of ADIP in dry matter and in perennial grasses was studied depending on the growth phase, as well as in silage and haylage prepared from grasses of the same growth phases. It was found that the proportion of ADIP in CP correlated with the content of CP. Silage and haylage under experimental conditions did not differ from the original grass by a higher level of heat damage. It is recommended that if there are signs of heat damage to the feed, the CP value should be corrected based on the ADIP analysis.

References
[1] Van Soest P.J.,. Use of detergents in analysis of fibrous feeds. III. Study of effects of heating and drying on yield of fiber and lignin of forages. J. A.O.A.C. –1965. –V.48.– 4.– P. 785-790. Access mode: https://catalogo.latu.org.uy/opac_css/doc_num.php?explnum_id=1418.
[2] Coblentz W.K. and P.C. Hoffman, 2010. Effects of spontaneously heating on estimates of TDN for alfalfa-orchardgrass hays packaged in large-round bales. J. Dairy Sci., 93 p. 3377-3389. Access mode: https://www.sciencedirect.com/science/article/pii/S0022030210003474.

[3] Fedorenko N.N., Fedorenko V.F. The qualitative composition of feed in Agricultural Biology, 1987. - T. 7. - P. 76-82.

[4] Nutrient Requirements of Dairy Cattle. 2001, 7th rev. ed. National Academy Press, Washington, DC.

[5] John A. Rooke, Ronald D. Hatfield Biochemistry of Ensiling. Rooke, John A. and Hatfield, Ronald D., "Biochemistry of Ensiling" (2003). Publications from USDA-ARS / UNL Faculty. Paper 1399. p.95-139. – Electronic resource. Access mode: http://digitalcommons.unl.edu/usdaarsfacpub/1399.

[6] Sanderson, Matt A., Nitrogen composition of herbage in relation to the ruminant animal (1987). Retrospective Theses and Dissertations. 9302. –Electronic resource. Access mode: http://lib.dr.iastate.edu/rtd/9302.

[7] Garsia, Alvaro. Heat Damage in Alfalfa Silage (2005)/ Extension Exstra. Paper 130. – Electronic resource. Access mode: http://openprairie.sdstate.edu/cgi/viewcontent.cgi?article=1129&context=extension_extra.

[8] D.W. Gallagher, K.R. Stevenson. Heat damage in hay-crop silage// Ministry of Agriculture and Food. Factsheet order No. 76-007, january 1976. – Electronic resource. Access mode: http://https://www.plant.uoguelph.ca/sites/plant.uoguelph.ca/files/forages/documents/S4-Heat%20damage%20in%20hay%20crop%20silage-76-007.pdf.

[9] A. Lapotko. Available protein for dairy cows. Belarusian agriculture, 2015, No. 11 – Electronic resource. - Access mode: http://agriculture.by/articles/zhivotnovodstvo/dostupnyj-belok-dlja-dojnyh-korov (open access).