Acidity and chemical composition of high humidity sealed grains

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Abstract. The article presents data on acidity indicators and chemical composition of high humidity grain in hermetic storage conditions. It is established that by increasing humidity of barley grain fodder its acidity increases with increasing pH value from 5.25 to 4.13, which is explained by increasing content of lactic and acetic acids. During storage the grain did not deteriorate, because the pH value decreases to a certain level (from 5.25 to 4.13). No butyric acid was found in the examined samples and its appearance was not observed during the whole storage period. The content of other acids (lactic acid, acetic acid), as well as their percentage ratio were in optimal quantities, which corresponds to the normative requirements for feeding farm animals. Most of the acids were lactic acid, whose share was 86-93% depending on grain moisture. As the humidity of wheat grain increases, its acidity also increases with the introduction of various additives in the amount of 3% of the mass of raw materials. The number of mineral macro- and microelements in grain slightly increases in comparison with the control variant, which is caused by their higher content in additives. The main part of mineral elements was occupied by potassium, the quantity of which was from 6,53 (variant: mixture of needles and moss, 2%) to 7,93 mg (variant: nettle, 3%). In variants with the use of the studied plant additives, there is a tendency to increase the content of raw protein from 10.72% in the control without additives to 12.72% in variants with meadow grass and 12.84% in variant with pine needles.

1. Introduction

An effective way to store grain with high humidity is chemical canning and storage in hermetic conditions. In the canned grain at optimal conditions there are no essential changes in appearance and visible mold damage, its flow properties are preserved [1,2].

Cereals are the most valuable fodder for agricultural animals, especially in the stabling period [5,6]. Therefore, a number of studies should concern the chemical composition of grain, its preservation at a certain level in the process of its hermetic storage in a wet state and, especially, to change the chemical composition of grain with the introduction of certain bioadditives, intensively consuming oxygen from the intergranular space in hermetic containers.
2. Research methods

A series of experiments consisted in chemical analysis of moist grain forage after 6 months of storage in conditions of hermetic sealing at optimal humidity - 25.4% and optimal dose of bioadditive for its successful preservation - 3% in comparison with the control variant (without additives).

Research into the acidity of grain is of great practical importance. If oilic acid is present in the grain forage, it becomes unsuitable for feeding the animals. The more 2-hydroxypropanic acid is in the feed, the more milk is formed.

Methanic and acetic acids contained in the feed turn into lactic acid (2-hydroxypropanic acid) when they get into the animal body under the influence of enzymes.

The pH value is important for keeping moist grain in airtight conditions. pH is a negative decimal logarithm of hydrogen cations (protons): \( \text{pH} = -\log[H^+] \). In the range from 5 and more pH the feed is poorly preserved and spoils quickly, various microorganisms are observed.

Grain acidity pH [3] was determined with the universal EV-74 ionometer (direct potentiometry).

The average sample was taken for the analysis: in 10 g it was rubbed in a porcelain mortar, the mixture was brought to a distilled water, thoroughly stirred, and measured on the universal EV-74 ionometer. To determine pH we used the method of direct potentiometry, which belongs to the group of electrochemical methods.

During the analysis 2 electrodes were installed: glass and silver chloride. Measurements were made at room temperature +18-20°C. The potentiometer (ionomer) was compared with a control sample without additives.

After opening a sealed container, the grain was rubbed in a pest and a porcelain cup.

Both electrodes of the device (glass and silver chloride) were washed with distilled water and special solutions.

The pH (acidity of grain) was measured at room temperature within ± 0.05. Measurements were repeated three times. The results were recorded in the table and processed mathematically.

Researches were carried out on 2 kinds of grain crops: on barley and wheat grains as a whole and flattened with different humidity from 18 to 35.6%. The period of grain storage was 5.5 months.

At the 1st stage wet grain was evaluated organoleptically.

As a result of the conducted experiments it was found out that the best indicators behold rolled grain.

At the 2nd stage the acidity of barley grain of different humidity was determined in %: 20.6; 28.3; 30.0; 33.6.

At the 3rd stage the content of organic acids (lactic acid, acetic acid, butter acid) in % was determined in 3 directions:
1) for the content of butyric acid in the grain;
2) on the ratio of lactic and acetic acids;
3) by the ratio of these organic acids (in %).

3. Results of the research

The results on the value of grain acidity (pH) are presented in Table 1.1.
Table 1. Change in acidity of barley grain as a function of its moisture content and storage duration

| № | Grain type | Humidity, % | Carotene Grain (pH) | Grain acidity (pH): Acid content, % | Acid balance, | Acid value |
|---|------------|-------------|----------------------|-------------------------------------|---------------|-----------|
| 1 | barley     | 20.6        | 6                    | 5.25                                | 1,37, 0,15, 0 | 1,52      |
| 2 | barley     | 28.3        | 4                    | 4.15                                | 1,57, 0,26, 0 | 1,83      |
| 3 | barley     | 33.6        | 4                    | 4.15                                | 2,28, 0,23, 0 | 2,51      |
| 4 | barley     | 30.0        | 6                    | 4.13                                | 2,81, 0,22, 0 | 3,03      |

Table 2. Change in acidity of barley grain as a function of additive dose from 0.5% to 10% of the grain mass in a container

| № | Additive | Grain humidity, % | Additive mass in % | Average value (pH) |
|---|----------|-------------------|--------------------|--------------------|
| 1 | Pine and spruce needles + moss. | 25,3 | 0,5 | 4,75 |
| 2 | Pine and spruce + moss. | 25,3 | 1 | 4,60 |
| 3 | Pine and spruce + moss. | 25,3 | 2 | 4,58 |
| 4 | Pine and spruce + moss. | 25,3 | 3 | 4,54 |
| 5 | Pine and spruce + moss. | 25,3 | 10 | 4,53 |
| 6 | Pine and spruce needles | 25,3 | 0,5 | 4,82 |
| 7 | Pine and spruce needles | 25,3 | 1 | 4,66 |
| 8 | Pine and spruce needles | 25,3 | 2 | 4,65 |
| 9 | Pine and spruce needles | 25,3 | 3 | 4,62 |
| 10 | Control without additives | 25,3 | 10 | 4,60 |
| 11 | Pine and spruce needles + moss. | 25,3 | - | 6,72 |

The influence of wheat grain moisture on its acidity is presented in Table 1.3.

Table 3. Results of the study of acidity of wheat grain (pH) of different humidity with the shelf life of 3 months

| № | Additive | Grain humidity, % | Average value (pH) |
|---|----------|-------------------|--------------------|
| 1 | The needles of pine trees, 3% of the weight of the container. | 18,4 | 5,94 |
| 2 | Pine and spruce, 3%. | 18,4 | 5,84 |
| 3 | Pine needles, 3%. | 20,2 | 5,75 |
| 4 | Pine and spruce needles, 3%. | 20,2 | 5,69 |
| 5 | Pine needles, 3%. | 25,3 | 4,65 |
| 6 | Pine and spruce needles, 3%. | 25,3 | 4,61 |
| 7 | Pine needles, 3%. | 30,4 | 4,40 |
| 8 | Pine and spruce needles, 3%. | 30,4 | 4,39 |
| 9 | Pine needles, 3%. | 35,6 | 4,32 |
| 10 | Pine and spruce needles, 3%. | 35,6 | 4,28 |
Table 4. Influence of additives on mineral elements content in barley grain with 25.4% humidity after 6 months of storage

| №   | Additives options            | Content (mg per 100 grams of grain) | Contents (µg per 100 grams of grain) |
|-----|-----------------------------|-------------------------------------|--------------------------------------|
|     |                             | Ca       | P       | Na       | Mg       | K        | Zn       | Co       |
| 1   | Control (no additives)      | 0.61     | 2.62    | 0.39     | 1.05     | 6.93     | 15.73    | 0.14     |
| 2   | Moss, 3%                    | 0.86     | 3.07    | 0.33     | 1.06     | 7.67     | 19.95    | 0.11     |
| 3   | Pine, 3%                    | 0.80     | 3.57    | 0.40     | 1.16     | 7.86     | 20.54    | 0.15     |
| 4   | Spruce, 3%                  | 0.89     | 3.36    | 0.87     | 1.06     | 6.71     | 17.59    | 0.13     |
| 5   | Meadow grass, 2%            | 0.72     | 3.29    | 0.39     | 1.17     | 6.95     | 17.11    | 0.14     |
| 6   | Meadow grass, 3%            | 0.91     | 3.46    | 0.44     | 1.19     | 7.17     | 17.63    | 0.23     |
| 7   | Fireweed, 3%                | 0.76     | 3.49    | 0.38     | 1.33     | 7.08     | 18.63    | 0.14     |
| 8   | Pine, 2%                    | 0.85     | 3.54    | 0.39     | 1.12     | 7.70     | 18.42    | 0.14     |
| 9   | A mixture of pine and moss, 2% | 0.82   | 3.26    | 0.38     | 1.10     | 6.53     | 18.06    | 0.13     |
| 10  | Nettle, 3%                  | 0.89     | 3.07    | 0.42     | 1.64     | 7.93     | 18.4     | 0.20     |

Table 5. Influence of additives on organic matter content in barley grain with 25.4% humidity after 6 months of storage

| №   | Additives options            | Content (%) |
|-----|-----------------------------|-------------|
|     |                             | raw protein | raw fibre | raw fat | starch | sugar |
| 1   | Control (no additives)      | 10.72       | 9.81      | 2.17    | 44.14  | 9.25  |
| 2   |                             | 10.81       | 11.26     | 2.97    | 34.22  | 8.90  |
| 3   | Moss, 3%                    | 12.45       | 11.81     | 2.95    | 41.42  | 8.97  |
| 4   | Pine, 3%                    | 12.84       | 11.58     | 2.84    | 40.29  | 8.93  |
| 5   | Pine, 2%                    | 12.72       | 11.88     | 3.27    | 34.07  | 8.94  |
| 6   | Spruce, 3%                  | 12.72       | 11.60     | 3.23    | 33.67  | 9.03  |
| 7   | Meadow grass, 2%            | 12.45       | 11.52     | 3.94    | 43.92  | 9.17  |
| 8   | Meadow grass, 3%            | 11.07       | 10.74     | 2.84    | 51.28  | 8.96  |
| 9   | Fireweed, 3%                | 11.85       | 11.67     | 3.15    | 36.13  | 8.99  |
| 10  | Mixture of pine and moss, 2% | 12.64       | 11.93     | 2.19    | 49.79  | 9.01  |
|     | HCP0.5                      | 1.2         | 0.6       | 0.5     | 0.7    | 0.02  |

4. Results and discussion

It can be seen from Table 1.1 that with increasing humidity of barley grain fodder its acidity increases with increasing pH value from 5.25 to 4.13, which is explained by increasing lactic and acetic acids content.

Proceeding from the data of Table 1.1 we can conclude that the grain did not spoil during storage, because the pH value decreases to a certain level (from 5.25 to 4.13).
No oil acid was found in the examined samples and its appearance was not observed during the whole storage period. The content of other acids (lactic acid, acetic acid), as well as their percentage ratio were in optimal quantities, which corresponds to the normative requirements for feeding farm animals.

Most of the acids were lactic acid, a fraction of which, depending on grain moisture, was 86-93%. Traditionally, moss sphagnum has been used fresh and crushed (moss moisture equal to that of moss) 83%).

The results of the study of changes in acidity of grain depending on the type of additives and its storage period are presented in Table 1.2 (barley).

As the humidity of wheat grain increases, its acidity also increases with the introduction of various additives in the amount of 3% of the mass of raw materials (Table 1.3).

Determination of dry and organic matter, raw protein, fat, fibre, starch and sugar (Table 1.4, 1.5).

The analysis of the given data shows (Table 1.4), that using additives in grain slightly increases the quantity of mineral macro- and microelements in comparison with the control variant that is caused by their higher content in additives. The main part of mineral elements was occupied by potassium, the quantity of which was from 6,53 (variant: mixture of needles and moss, 2%) to 7,93 mg (variant: nettle, 3%).

Organic substances (proteins, fats, carbohydrates, etc.) in cells of living organisms play an important role in metabolic processes in a living organism. They supply the animal with the necessary energy for vital activity, and such compounds as coenzyme A, acetylcholine, individual enzymes, etc. are formed from them.

The analysis of nutrients content is given in Table 1.5.

The analysis of the content of nutrients presented in table 1.5 shows that there is a tendency of increasing of the raw protein content from 10,72 % in control without additives to 12,72 % in variants with meadow grass and 12,84 % in variants with pine needles.

The raw fiber and fat content in the trial versions was also slightly higher than in the control, however, we associated this increase in protein, fiber and fat content with higher levels of additives used.

As for the content of starch and sugar, the opposite tendency is observed in comparison with the control, which is the result of their consumption for the processes of breathing and acidification of grain in the creation of anaerobic conditions and storage.

5. Conclusion

The data from the laboratory tests were compared with the data from the production test (Aurora Breeding Farm-Colkhoz, Gryazovetsky District, Vologda Region) and showed the same results.

Therefore, the tested types of additives for feeding agricultural animals together with grain can be recommended.

References
[1] Mangesov V I, Popov I A, Shchedrin D S, Kalashnikova S V, Tertychnaya T N, Khabarov N N, Kurchaeva E E and Sysoeva M G 2010 Technology of storage, processing and standardization of the plant production: textbook (St. Petersburg. - Troitskiy bridge)
[2] Voyskova A I, Zubov A B and Gursk O A 2008 Storage about quality estimation of grain and seeds (Moscow: Kolos)
[3] GOST 10844-74 1975 Grain. Acidity determination method by boltushka (Moscow: Standard Publishing House)
[4] Naliukhin, A N, Glinushkin A P, Khamitova S M and Avdeev Yu M2018 The influence of biomodified fertilizers on the productivity of crops and biological properties of soddy-podzolic soils Entomology and Applied Science Letters 5 (3) 1-7
[5] Kozlov A V, Uromova I P, Koposova N N, Novik I R, Vershinina I V, Avdeev Y M, Hamitova S M, Naliukhin A N, Kostin A E and Mokretsov Y V 2018 Optimization of the Productivity
of Agricultural Crops at Application of Natural Minerals as Ameliorants and Mineral Fertilizers on Sod-Podzolic Soils *Journal of Pharmaceutical Sciences and Research* **10**(3) 667-680