Veterinary and sanitary control during storage and sale of grain crops on the example of rye

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Abstract.The problem of grain preservation is extremely relevant today. Due to the increase in the population, the task of ensuring food security arises, based on the production and rational storage of grain, since a large number of agricultural products are stored without provision of the necessary storage conditions. The grain quality is maintained in compliance with the storage rules, and it becomes available throughout the year. The method of grain storage varies in temperature and humidity. Storage affects grain quality, percentage of moisture, protein and fat, color, lipoprotein content, biochemical and metabolic changes, germination rate at the end of storage. During storage, the moisture content of the grain should be minimal to prevent its germination and insect infestation.The main purpose of grain preservation is to prevent possible quantitative and qualitative losses by preserving and/or improving certain physiological characteristics.

1 Introduction

Grain is used as a staple food in many countries. Grain production is an important factor in ensuring Russia's food security. It is the main agriculture product, necessary for the successful development of all agriculture branches, increasing the number of crop and livestock products, for the production of food, feed, raw materials for industry [6].

The grain consists of proteins (10-20%), fats (2-4%), carbohydrates (60-70%). In addition, biologically valuable substances - amino acids, vitamins, minerals - are contained in different grain parts (embryo, shell, endosperm, aleurone layer). It is known that the chemical composition of grain depends on the agro-climatic zone, variety hereditary characteristics, agrotechnology, and storage conditions [9].

The seasonal nature of plant-based agricultural products requires its preservation for a long period of time, depending on the needs of the country's population. The main purpose of grain preservation is to prevent possible quantitative and qualitative losses by preserving and/or improving certain physiological characteristics.

Every year there is a large number of losses of grain reserves due to improper handling after harvesting and inappropriate storage conditions. As a result, volatile compounds are formed in grain during storage, primarily carbonyl chemical compounds (ketones, aldehydes, and alcohols). As the shelf life increases, volatile substances with medium polarity slowly increase, and volatile substances with low polarity decrease. If the storage

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conditions of grain cereals are not observed, its spoilage begins. There is an unpleasant smell, which generally affects the grain quality. Eating contaminated grain causes diseases and reduces its suitability for the consumer. Improper storage conditions cause certain enzymatic changes in wheat, worsening its quality [3].

When harvesting, the grain is heterogeneous and contains a number of impurities – this is the grain of other cultivated plants, weed seeds, main crop remnants (grain fragments), microorganisms (bacteria, fungi) on the surface, in shells or inside seeds, live insects, plant residues (fragments of stems, leaves, inflorescences), mineral impurities (soil, sand, dust, etc.) [6].

Given that most harmful organisms are transmitted through grain and soil, and their action can cause serious damage, sometimes even destroying the crop, comprehensive prevention and control measures are required, starting with the proper preparation of storage sites. The choice of grain storage systems depends on the yield state, climatic conditions, the duration, during which it is necessary to maintain germination and seed strength. Humidity and their value when stored in a dry, cool, or airless state can be ensured with the help of chemicals. These systems can be approached individually or combined, depending on the purpose. The most suitable is a system in which the grains are stored in a dry state. The yield quality, as well as other processed products, crucially depends on maintaining optimal humidity and air temperature, while it is absolutely necessary to regulate the humidity of seeds and air temperature in warehouses, since the duration of grain storage also depends on this [1,2,3].

The germination of cereal seeds can be maintained throughout the year only in cases when their moisture content does not exceed 13-14%. Constant monitoring of changes in temperature and humidity of the grain mass, the appearance of the mold smell and, possibly, pests is essential. The grain storage method in storage facilities varies in temperature and humidity. Storage affects grain quality, percentage of moisture, protein and fat, color, lipoprotein content, biochemical and metabolic changes, germination rate at the end of storage [7,8].

In this regard, the goal was set for us - to carry out veterinary and sanitary control during the storage and sale of grain crops on the example of rye.

2 Materials and methods

The collection of material and research was carried out in the laboratory of veterinary and sanitary expertise of the DSBI Troitskaya District Veterinary Station for the Control of Animal Diseases, the training interdepartmental laboratory of the FSBEI HE South Ural State Agrarian University.

The duration of the experiment was three months. Veterinary and sanitary control was carried out at the stage of sale and storage of rye grain in market conditions. Grain comes to the market from farmers of the Troitskiy district of the Chelyabinsk region with all necessary documents.

Standard storage (control) was carried out at a temperature of 25.3±5.2 °C, relative humidity of 60.4±10.8%. Storage with additional conditioning (experiment) was carried out at a temperature of 5.1±1.7 °C, relative humidity of 50.3±5.7%.

Samples were taken for veterinary and sanitary control of rye grain during storage and sale. Sampling, organoleptic and laboratory studies (color, appearance, and smell of grain, nature, grain moisture and vitreousness, weed and grain impurities) were carried out by conventional methods.

The content of macro- and microelements was determined by atomic absorption method using a spectrophotometer, a Quant 2 device according to GOST 26933-86 "Raw materials and food products. Methods for cadmium determination", GOST 30178-96 "Raw materials

and food products. Atomic absorption method for the determination of toxic elements", GOST 26929-94 "Raw materials and food products. Sample preparation. Mineralization for determining the content of toxic elements", GOST 26932-86 "Raw materials and food products. Methods for lead determination".

The sanitary assessment of grain of cereal crops was carried out in accordance with the requirements of the Rules of veterinary and sanitary examination, standards, and Technical Regulations [4,5].

Statistical processing of the obtained data was carried out using the Biometrics 2010 program.

3 Research question

Grain storage technology is due to the fact that grain is a living organism, the main vital functions of which are not completely interrupted in a hemibiosis state.

In the course of veterinary and sanitary control of rye grain, compliance with its basic conditions was determined. The results obtained are shown in Table 1.

The following was revealed: rye grain in a healthy, non-warming state; color and smell - characteristic of healthy grain; grain falling number - within the normative range and accounts for 167.9 s, grain nature - 725.3 g/dm^3, this is above the lower limit of the norm by 6.7%; the moisture level in the grain is below the upper restrictive norm by 1.3%.

Table 1. Compliance of rye grain with basic conditions.

Indicator	Requirements of regulatory documentation	Actual results
Condition	In a healthy, non-warming condition	In a healthy, non-warming condition
Color	Characteristic of a healthy rye grain	Characteristic of a healthy rye grain
Smell	Characteristic of healthy rye grain, without mold, malt, musty, and other foreign odors	Characteristic of healthy rye grain, without mold, malt, musty, and other foreign odors
Falling number, s	141—200	167,9±5,2
Nature, g/dm^3	at least 680	725,3±12,7
Moisture, %	no more than 14,0	12,7±0,2

The results of rye grain evaluation for the presence of impurities are presented in Table 2.

Table 2. Results of rye grain evaluation for the presence of impurities.

Indicator	Requirements of regulatory documentation	Actual results
Impurity, %:	no more than 2,0	0,7
including: mineral impurity	0,3	0,1
among the mineral impurities: - pebbles	0,1	-
- spoiled grains	1,0	0,4
- cockle	0,5	0,2
Grain impurity, %	no more than 4,0	2,3

As can be seen from the data in Table 2, the content of weed impurity was below the restrictive norm by 1.3%, mineral impurity - by 0.2, spoiled grains - by 0.6, cockles - by 0.3, grain impurity - by 1.7%.

The content of impurities in rye grain is presented in the form of a diagram, which reflects the contamination level in relation to the restrictive norm (Fig. 1).

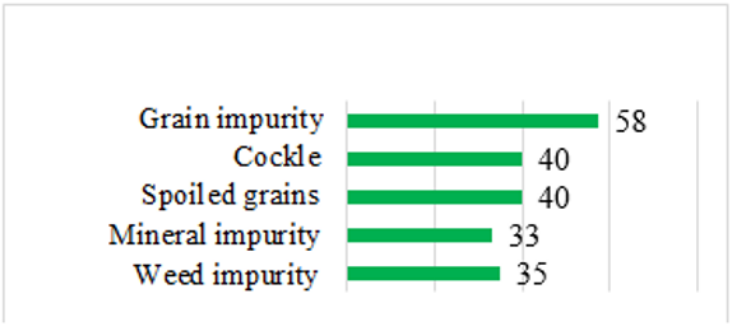

Fig. 1. The content of impurities in rye grain, % of the permissible level.

As part of the weed impurity in rye grain, a fairly high level of *Agrostemma githago* was noted. Indeed, since the beginning of the XX century, cockles in Russia are found everywhere throughout the European part, in the Caucasus, in Western and Eastern Siberia, in the Far East. As a typical segetal weed of cereals and flax, it is distributed from the north-west of European Russia south to the Caucasus and east to Primorye. In the 70s of the twentieth century, this species was often found throughout the Crimea as a weed-ruderal plant. In most of the modern range, the species occurs in crops extremely rarely and sporadically. It is noted in agrocenoses of the Stavropol Territory, Orenburg region. In recent years, it has often been grown as an ornamental plant in private plots, sometimes found along roads as wilding.

The data obtained indicate that rye grain in terms of quality and sanitary indicators, due to the lower number of falls, belongs to Class 2.

The results of the assessment of rye grain safety by the content of heavy metals are presented in Table 3.

Table 3. Results of rye grain safety assessment by content of heavy metals, mg/kg.

Indicator	Requirements of regulatory documentation, no more than	Actually found
Copper	5.0	0.53
Iron	50.0	11.9
Zinc	25.0	3.6
Nickel	0.5	0.02
Cadmium	0.1	0.001
Lead	0.5	0.01

As can be seen from the data presented in Table 3, the content of heavy metals in rye grain met the requirements of TR TS 015/2011.

The concentration of heavy metals in rye grain is shown in Figure 2.

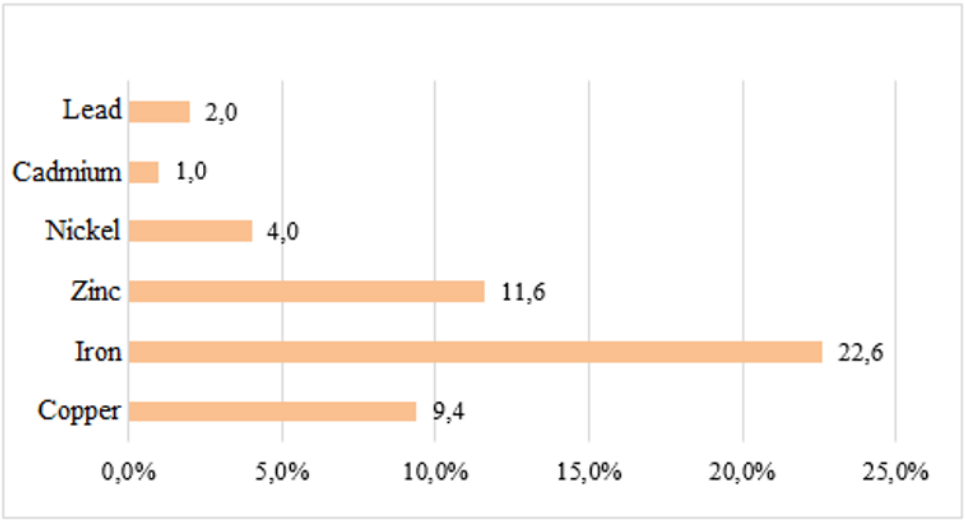

Fig. 2. The level of heavy metals in rye grain, % of the permissible level

The data presented in Figure 2 show that the level of lead in the studied rye grain samples reached 2%, cadmium - 1, nickel - 4, zinc - 11.6, iron - 22.6, copper - 9.4%, which indicates that the grain complies with quality and safety indicators, in particular for contaminants (heavy metals) [10].

Thus, grain with these basic conditions meets the requirements of the Rules of veterinary and sanitary examination of plant foods, GOST 16990-2017 and TR TS 015/2011.

The results of grain organoleptic studies that has undergone experimental storage are presented in Table 4.

Table 4. Results of organoleptic studies of rye grain before and after storage.

Indicator	Requirements of regulatory documentation	Conditioned storage		Standard storage	
		At the beginning of experimental storage	At the end of experimental storage	At the beginning of experimental storage	At the end of experimental storage
Condition	In a healthy, non-warming condition	In a healthy, non-warming condition	In a healthy, non-warming condition	In a healthy, non-warming condition	In a healthy, non-warming condition
Color	Characteristic of healthy grain of this type and subtype.	Characteristic of a healthy rye grain	Characteristic of a healthy rye grain	Characteristic of a healthy rye grain	Characteristic of a healthy rye grain
Smell	Characteristic of healthy rye grain, without mold, malt,	Characteristic of healthy rye grain, without mold, malt, musty, and other foreign	Characteristic of healthy rye grain, without mold, malt, musty, and other foreign	Characteristic of healthy rye grain, without mold, malt, musty, and other foreign	Characteristic of healthy rye grain, without mold, malt, musty, and other foreign

Indicator	Requirements of regulatory documentation	Conditioned storage		Standard storage	
		At the beginning of experimental storage	At the end of experimental storage	At the beginning of experimental storage	At the end of experimental storage
	musty, and other foreign odors	odors	odors	odors	odors

At the beginning and at the end of the shelf life, the organoleptic characteristics of grain conditioned and standard storage have not changed. The grain was in a healthy, non-warming condition, of light amber color; the smell was characteristic of healthy rye grain, without mold, malt, musty, and other foreign odors.

The results of laboratory studies of rye grain are presented in Table 5.

Table 5. Results of grain laboratory studies (before and after storage);n=3; M±m.

Indicator	Requirements of the regulatory documentation	Conditioned storage		Standard storage	
		At the beginning of the experimental storage	At the end of the experimental storage	At the beginning of the experimental storage	At the end of experimental storage
Falling number, s	141—200	167.9 ± 5.2	163.5 ± 4.3	167.9 ± 5.2	162.1 ± 5.9
Nature, g/dm^3	at least 680	725.3 ± 12.7	713.8 ± 11.3	725.3 ± 12.7	709.7 ± 13.1
Moisture, %	no more than 14.0	12.7 ± 0.2	12.9 ± 0.1	12.7 ± 0.2	13.4 ± 0.2

According to the results obtained, under conditioned storage, the changes in physico-chemical parameters in rye grain were less pronounced. This is confirmed by the fact that over 3 months of storage, the falling number decreased by 2.6%, the grain nature - by 1.6, the moisture increased by 0.2%. Standard storage had a stronger negative impact on physical and chemical indicators - the falling number decreased by 3.5%, the nature - by 2.2, and moisture increased by 0.7%.

In addition, grain conditioning made it possible to slow down the biochemical processes occurring in raw materials during storage: in grain at low temperature, the falling number was 0.8% higher, the grain nature was 0.6, and at lower moisture - 3.9%, compared with standard storage.

4 Conclusion

Veterinary and sanitary control over rye grain condition during storage revealed the following: rye grain in a healthy, non-warming state, color, and smell – characteristic of healthy grain, the falling number within the regulatory range is 167.9 s, grain nature was 725.3 g/dm^3, which is 6.7% higher than the lower limit of the norm, the level of the moisture content in the grain was below the upper restrictive norm by 1.3%.

The content of weed impurity was 35% of the permissible level, mineral impurity – 33, spoiled grains - 40, dolls - 40, grain impurity - 58%.

Rye grain in terms of quality and sanitary indicators was assigned to the Class 2.

The level of heavy metals in the studied samples of rye grain indicates that the grain meets the quality and safety indicators.

Rye grain, with established conditions, met the requirements of the Rules of veterinary and sanitary examination of plant foods, Class 2 according to GOST 16990-2017 and TR TS 015/2011.

During conditioned storage, the changes in physico-chemical parameters in rye grain were less pronounced. For 3 months of storage, the number of drops decreased by 2.6%, the nature of grain - by 1.6, moisture increased by 0.2%. Standard storage had a stronger negative impact on physical and chemical indicators - the falling number decreased by 3.5%, the nature - by 2.2, and moisture increased by 0.7%.

Conditioning of rye grain during storage allows to maintain high veterinary and sanitary indicators of plant products and, consequently, to sell quality products for a long time.

Veterinary and sanitary control of rye grain allowed to establish compliance of plant raw materials with regulatory documentation.

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