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International Wheat Trade– Proteinor Gluten?

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ABSTRACT

The authors compare the parameters characterizing the quality of wheat in Russia and other countries. It is noted that in international trade the grain quality is mostly evaluated by protein mass fraction. The article indicates that trading is rarely based on wet or dry gluten content, while the analysis of protein content is considered a simpler, quicker and more reliable method with sufficient accuracy and objectivity. The paper presents experimental data that characterize the protein-to-gluten ratio in various Russian wheat classes. The article concludes that Russia should use the national and foreign experience related to Near-Infrared Spectroscopy (NIR spectroscopy) and other modern physical and chemical analysis methodsto evaluate the quality of grain crops by their protein content which will spur Russian wheat export.

Keywords: wheat, international trade, quality, protein, gluten, NIR spectroscopy

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INTRODUCTION

Until quite recently, the relevant authorities of Russia have many times declared that Russia needs to harmonize the domestic grain standards with the standards of grain importing countries. It is widely known that when the grain is exported by Russia, the buying side makes its own analysis that might produce results different from the Russian analysis. This inconsistency might cause the discussion about the reduction of price. In general, the imperfection of some Russian standards and their incompliance to international requirements leads to disagreement between buyers and exporters, and the Russian side usually ends up losing. Nowadays, when market factors play a key role, it is crucial to harmonize Russian State Standards (GOSTs) in the field of quality evaluation with their Western counterparts.This work represents an attempt to compare the parameters used to evaluate the wheat quality in Russia and other countries despite the differences in the parameters themselves and their interpretation. It is suggested that wheat grading is less important than the results of determination of quality parameters, in accordance with which the grading is performed.

Comparison of grain quality parameters used in various countries.Protein and gluten.

Protein content is not the basic grain grading parameter in developed countries, but it is taken into consideration when setting the price for high-quality milling wheat varieties, especially durum wheat. Grain standardization system in the European Union is more complex than the North American standards, but both stipulates determining protein content only for durum wheat and does not suggest determining gluten content at all[1-3].Only a few countries use gluten content as the basis for wheat grading system.

In Russia, the wheat quality system is based on its gluten content. In accordance with Russian standard (GOST), wet gluten can be washed out by hand or mechanically [4]. Thereby, the results of measurements can be very subjective. International standards stipulate that gluten must be washed out on special equipment — a silk sieve. Additional washing out by hand is performed very rarely. When the buying side imports grain from Russia, it analyzes the grain quality on its own. The difference between analysis results might reach half of one per cent, and sometimes it might be used as a substantiation for reducing the grain price. Russian (GOST 10846-91) and international (ICC 105/1)standards use the same Kjeldahl method to determine the protein content. This brings hope that the results might be comparable. However, the protein content in Russia and Europe is given for grain with 14% moisture content, and in the USA and Canada — with 12% moisture content. That's why ignoring this difference leads to lower results of wheat protein content analysis according to American requirements than the results of analysis in Russia. Even when we compare the terminology, it is easy to note that GOST stipulates that wet gluten content is measured in "grain", and international standards presume that it is estimated in wheat flour.

Gluten content does not characterize the commercial quality of grain in general — instead, it characterizes the quality of flour produced from that grain. Gluten content evaluation is more suitable for the grain that is intended to be milled into flour. However, grains can be used in multiple ways, and many of them do not involve grinding: in the USA, high-quality spaghetti is made not from gluten-rich wheat, but from durum wheat, which may have even less gluten than soft wheat varieties, and this gluten may be of medium grade [5-7].

There is a certain correlation between the gluten and protein wheat content, however, it is rather arbitrary. As well as gluten content, protein content is often not a decisive factor that determines the wheat quality, although the best alimentary productsare believed to be produced from very protein-rich wheat [8].

However, grain with high protein content often becomes too lightweight, which results in reduced flour or macaroni semolina yield. Producing flour from such grain is less cost-efficient. Therefore Western manufacturers prefer wheat with average protein content. Commercial wheat varieties from Western countries contain 9 to 15 % protein (at 14 % moisture content); the most popular wheat for macaroni production has 13.5 to 14 % protein content (not the highest possible value).

In Western countries, wheat is not graded (for instance, as forage wheat)on the basis of its protein or gluten content. Wheat categorization is based on grain volume weight, and this approach is much simpler. The grain volume weightand flour yield are directly correlated (durum is the only exception), therefore it is totally justifiable that if grain processing for food products is unfeasible, for example, due to low flour yield, the grain

should be fed to cattle [9]. Therefore, Western grain grading is based on its commercial qualities characterizing the intended use of grain.

In Russia, the gluten quantity and quality is the main parameter that determines the wheat grade and is regulated by the state standard, because the diversity of soil and climatic conditions, considerable year-to-year weather changes, as well as insect damage (especially by chinch bug) make such characteristic as protein content, insufficient to evaluate the grain quality. Wheat can differ in gluten content and quality and be equal in protein content at the same time. For example, when grain is damaged by chinch bug, the protein content remains unchanged, but the contentof gluten is lower compared to undamaged grain, because the proteolytic enzymes injected into grain by the bug cause very rapid gluten degradation[10-13].

The degree, to which the grain in a batch is damaged by the chinch bug, and the behavior of normal grain when damaged grain is added, may be very complex. Therefore it is considered reasonable to evaluate the degree of grain batch damage only after determining the properties of washed-out gluten, and gluten quality is the main parameter characterizing the extent, to which grain is damaged by chinch bug. Grain damaged by frost on various growth stages (which is rather common in eastern regions of Russia) has increased enzyme complex activity. Its gluten protein properties also change considerably – wet gluten yield from grain reduces, and it becomes “short” and spongy. Gluten quantity is determined both manually and by mechanic method based on the MOK-1M system. The mechanical method was standardized for washing out gluten from flour (GOST 27839-88. “Wheat flour. Methods for determination of gluten quantity and quality”). A more modern standard that has the same purpose is GOST R 54478-2011 “Grain. Methods for determination of quantity and quality of gluten in wheat” [4].Gluten quality is measured in conditional units on the IDK instrument, and, depending on the instrument data, gluten is referred to one of three quality grades:

Grade I–gluten with good elasticity, which allows to produce high-aerated dough with good shape stability. Bread baked from such gluten has large volume and high porosity;

Grade II –gluten with good or satisfactory elasticity. Bread baked from such gluten has smaller volume then bread baked from Grade I, but it has good quality in the majority of cases;

Grade III – gluten is too strong (the bread is bound, it has cracks on the upper crust, and crumb is too porous) or very weak and fluid (the bread is runny, has low volume, and dense crumb).

In the USA, the datathat determine the protein-proteinase wheat complex are not regulated by the standard, not included into the list of wheat class classification, and the qualitative and quantitative parameters of gluten are additionally defined to obtain more comprehensive and trustworthy grain quality characteristics and determine its optimal intended use.

The method of determining the wet gluten content and the gluten index based on Glutomatic and Gluten Index system is used as an express test to determine the quantity and the quality of gluten (gluten index). This method is used in Western Europe and the USA and included into the ICC-137 and ICC-155 international standards, and into the AACC-38-12 American standard[14-19]. It is worth noting that in the USA the combination of physical gluten properties – extensibility, strength, elasticity, viscosity, the ability to maintain physical properties over time is evaluated according to the test based on farinograph, alveograph and extensograph results and sample baking. Analytical methods provide objective data that characterize the wheat baking value.

The difference in the methods of gluten quality evaluation and data interpretation makes impossible establishing clear correlation between the results of measurements on IDK instrument (gluten group, conditional IDK units) and the gluten quality evaluated on the Gluten Index system (gluten index). As joint researches of the VNIIZ (Russian Scientific Research Institute for Grain and Grain products) and North Dakota University (the USA) show, the majority of wheat produced in the USA has the first gluten quality grade (43-77 IDK units). Therefore, when we specify the gluten parameters for grain imported from Russia, it is necessary to pay special attention to the gluten measurement methods that are used [20-21].

Trade operations based on the dry or wet gluten contentare rather rare on the international market. In international trade, protein content analysis is considered to be easier, quicker, more reliable and less

expensive. Although automated gluten quantity determination methods are more accurate, they will unlikely substitute protein content analysis and become popular in international wheat trade practices – in spite of their importance for the evaluation of the end product quality on mills and bakeries.

Due to Russia's WTO membership, as well as the fact that this country is one of the largest wheat exporters in recent years and became the leader in this field in 2015/16, leaving Canada and the USA behind, the wheat baking value evaluation system should be harmonized with the best global practices. Protein content is in fact the main parameter used to form commercial wheat batches. In the domestic market, protein content in wheat is determined only by the buyer's demand, while in the countries of European Union this is a mandatory parameter, and in the USA the protein mass content is included into shipment documents. Furthermore, the ISO 7970 international standard stipulates the restrictions applied to weight protein fraction.Therefore, domestic and international regulatory and legislative frameworks in the field of grain quality evaluation do not comply with each other. In turn, these discrepancies reduce the competitive ability of Russian products in the global market.

RESULTS AND DISCUSSION

As it was stated above, Kjeldahl method is the standard method used to determine the protein fraction by weight in wheat grain in Russia. Despite the low cost of such analysis and recently achieved high automation of all analysis stages, this method still remains unreasonably labor-consuming. Furthermore, analysis time exceeds 1 hour, and sometimes it is impossible to achieve satisfactory reproducibility of results in the conditions of various laboratories. A more efficient approach is determining the grain protein content by a photometric method based on the measurement of optical density of Acid Orange 12 dye solution remaining in the sample after it is bound by the grain protein. This method has been approved by the American Association of Cereal Chemists (AACC, method 46-14A) and the Association of Official Analytical Chemists (AOAC, method 16.037). Russian scientists have developed a software and hardware system SORBFIL-BELOKthat automates this method.

Besides that, a number of new methods for determining the grain protein content have been suggested [22-23]. Near-infrared diffuse reflectance spectroscopy method (NIR spectroscopy) is successfully used to determine not only the protein fraction by weight, but also grainmoisture content, gluten quality and quantity [24-25]. The correlation between the reflectance intensity in various spectral bands and concentration of specific components in grain has been established.

Table 1 shows the data of Plekhanov Russian University of Economics characterizing the correlation between the gluten and protein content (measured by NIR spectroscopy) in grain of various grades (in Russia, this classification has 5 grades). NIR transmittance spectra have been measured on the Infralum FT 10 device (8000-14000 cm^{-1}). Gluten was evaluated in accordance with GOST R 54478-2011 "Grain. Methods for determination of quantity and quality of gluten in wheat", which stipulates washing gluten in dough with mechanical tools and determining the gluten quality based on its strength and elastic properties.

Table 1: Correlation between the protein and gluten content in wheat of various grades

Grade	Gluten (%), by GOST R 54478-2011	Protein (%), by NIR spectroscopy
I	31.9	15.1
II	28.1-32.3	14.2-15.8
III	25.2-28.1	13.4-14.6
IV	22.3-25.6	12.5-13.1
V	18.9-23.4	10.5-12.8

It is worth noting that the acquired results comply with the red winter wheat characteristics measured by U. S. Wheat Associates (in that research, the gluten-to-protein ratio was approximately 2.36:1). Nevertheless, it does not seem yet possible to define a universal conversion ratio for these parameters.

In recent times, novel NIR analyzer models have been developed. They register the transmittance spectra without preparing the sample for analysis, while for the diffuse reflectance measurement methods the grain sample should be grinded up to homogenous consistency. Furthermore, a number of works show the interrelation of grain hardness with NIR spectra parameters and some studies have been dedicated to the possibility of predicting the wheat flour baking qualities based on the in-depth analysis of NIR diffuse reflectance spectra[26-27].

Despite the significant advances in the development of grain protein mass content measurement methods, these methods are not yet standardized in Russia. One of the main reasons of this is the existence of objective factors that impede the wider application of the proposed methods. The main drawbacks of the photometric method that make its implementation more difficult are the need to use a wide spectrum of chemical reagents with limited shelf life (glacial acetic acid, specific dye, potassium dihydrogen phosphate) and the role of human factor in the sample preparation for analysis. The NIR spectroscopy method has no such drawbacks, but, however, it requires preliminary removal of tainted grain (frost-damaged, germinated, bug-infested grain, etc.), as well as regular recalibration, because the infrared spectrum characterizes the entire sample chemical composition, and, therefore, definite reversedecryption of such spectra is impossible, because calibration settings often differ for various classes of wheat and crop years. Searching the optimal protein content measurement modes in wheat of various botanic varieties and classes with both near-infrared spectroscopy and other modern physical and chemical analysis methods is an important scientific and practical task.

CONCLUSION

In summary, strict domestic requirements to the quality of wheat based on legislation of some countries often create considerable problems for international wheat trade. On the international market, the primary food grain evaluation parameter is the protein mass fraction. The representatives of grain industry need to conduct negotiations on the subject of harmonizing the analyticalmethods and making the inspection results and the grain quality parameters more compatible with the requirements of the trading countries. Such organizations, as ICC, AACC, ISO and WTO, must play the key role in international grain trade facilitation, studying the issues that may be caused by the discrepancies between the quality evaluation systems and national legislations. Wheat exporters should take into account the possible use of the grain that they sell, and avoid restricting themselves with evaluation of the grain quality only based on its protein or gluten content: comparing the quality of milling product and other commercial characteristics is by no means less important. Complete standardscoincidence of different countries is impossible, because the methods used to determine the grading parameters are rather different. To foster its wheat export, Russia needs to leverage the domestic and global experience of NIR spectroscopy application to evaluate the grain crop quality by protein content, and standardize the corresponding methods.

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