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The Impact of the Quality of Laboratory Control of Grain on the Formation of Export Prices and Discounts: Economic Analysis

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ABSTRACT

The stability of grain quality parameters is a crucial prerequisite for ensuring the competitive position of domestic exports in the world market. The main objective of the study is to conduct an economic analysis of the impact of effective laboratory quality control of grain, focusing on pest infestation levels and other important quality parameters, on the determination of export prices and related discounts under free-on-board (FOB) contracts. The study intends to propose new methodological approaches and an econometric forecasting model aimed at increasing the accuracy of quality assessment and reducing economic risks for grain exporters. A variety of methodologies were used to facilitate this broad empirical study. These include standardized quality control protocols that comply with international standards, such as ISO, GAFTA, FOSFA and Codex Alimentarius, as well as rapid analytical methods (e.g., LFA, NIR/FT-NIR, machine vision, HSI) and advanced laboratory analyses (e.g., LC-MS/MS, HPLC, PCR). This is complemented by sophisticated econometric modeling. The scope of this study includes a systematic analysis of how critical attributes, namely moisture content, protein level, gluten content, vitreousness, impurity percentage, contamination level, and mycotoxin concentration, affect the formation of price discounts and potential economic losses incurred by exporters. The study uses both linear and log-linear regression models to predict the predicted FOB price and quantify discount adjustments, all dependent on laboratory-verified quality indicators. Finally, the authors advocate an integrated quality control paradigm. This approach combines standardized sampling protocols, automated inspection systems, and multi-level analytical algorithms to increase the accuracy of the assessment and reduce financial losses. Such a robust framework is designed to strengthen the competitiveness of Ukrainian grain exports in the global market.

KEYWORDS

quality control, infestation, grain quality, mycotoxins, ISO standards, GAFTA, FOSFA, Codex Alimentarius, grain export, econometric model, FOB.

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Вплив якості лабораторного контролю зерна на формування експортної ціни та дисконтів: економічний аналіз

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СТАТТЯ

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АНОТАЦІЯ

Важливою складовою забезпечення високого рівня конкурентоспроможності українського експорту на світовому ринку є стабільність забезпечення якісних показників продукції галузі зерновиробництва. Мета даного дослідження – аналітична оцінка впливу добротності проведення лабораторного аналізу якості експортованих партій зерна з позицій зараженості шкідниками (інфестованість) та вмісту мікотоксинів на формування цін експорту згідно контрактів FOB. Проведено бенчмаркінг-аналіз стандартів Codex Alimentarius, ISO, GAFTA, FOSFA та Codex з контролю якості зерна на світовому ринку. Серед показників якості обрано: вміст вологи, натуральна маса, протеїн, клейковина, склоподібність, засміченість, інфестованість, вміст мікотоксинів та жиру, забарвленість. Встановлено, що в світовій практиці стандартизації якості зерна не існує універсального підходу до ефективного оцінювання з 100% достовірністю. За даними експорту української пшениці та суміші пшениці й жита (меслину) за 2015–2024 рр. проведено розрахунок потенційних економічних втрат від інфестованості та невідповідності зерна міжнародним стандартам. Встановлено, що незначні порушення умов стандарту призводить до зміни дисконту на 2%. Проаналізовано існуючі методи визначення інфестованості та мікотоксинів у партіях зерна. Визнано ефективність експрес-методів контролю (LFA, NIR/FT-NIR, систем машинного зору) для оцінювання проблемних партій зерна. Доведено відсутність уніфікованого методу швидкої оцінки якості зерна з високим рівнем чутливості та низькою собівартістю. Розроблено універсальну економетричну модель з використанням двох видів формул (лінійних та лог-лінійних функцій) для подальшого прогнозування ціни FOB та визначення величини дисконту. Доведено, що в умовах обмеженості цінової кон'юнктури раціональним є використання piecewise-регресійного аналізу та моделей типу Tobit. Наголошується, що інтегрована економетрична модель базується на поєднанні протоколів відбору зразків зерна згідно міжнародних стандартів, автоматизованих систем менеджменту та контролю з метою підвищення конкурентоспроможності експорту української продукції на глобальному ринку.

КЛЮЧОВІ СЛОВА

контроль якості, інфестованість, якість зерна, мікотоксини, стандарти ISO, GAFTA, FOSFA, Codex Alimentarius, експорт зерна, економетрична модель, ціна FOB.

1. Introduction

In the context of the globalization of world agricultural markets and the intensification of competition between exporting countries, there has been a significant increase in the requirements for the quality characteristics of grain crops, which are a leading export resource. Under these circumstances, the laboratory control system acquires the status of not only a tool for verifying the compliance of products with international standards, but also becomes a determining factor in setting reasonable pricing for export supplies. The precision, objectivity and representativeness of the conducted analytical studies directly affect the level of trust on the part of external counterparties, the size of potential commercial risks and the tendency of importers to apply price adjustments (discounts).

Imperfection of laboratory measurements, methodological inaccuracies or non-compliance with established sampling protocols lead to systematically unreliable quality indicators. Such shortcomings inevitably lead to disputes between market participants, the spread of price compromises in commercial contracts and, in some cases, the loss of market segments. The capabilities of laboratories will contribute to a significant reduction in economic losses of exporters and increase the competitiveness of Ukrainian grain exports in the market [22].

Despite the undoubted strategic importance of the above-mentioned aspects, the problem of economic determination, which is due to the quality of laboratory assessment of grain crops, on the formation of export prices, the size of discount deductions and price risks, remains the object of further in-depth systematic study. Therefore, this determines the relevance of the study aimed at a comprehensive analysis of the relationship between laboratory control criteria and economic indicators of export operations in the grain industry.

2. Literature Review

Modern studies demonstrate that the qualitative characteristics of grain – both standard (moisture, test weight, impurities, purity) and final end-use (protein, properties for grinding, flour, sintering) – have a statistically significant and economically important impact on the market price of grain. Thus, in the study of S. Roberts et al. [29] on the example of US durum winter wheat, it was shown that the price varies depending on quality: the market adjusts the price as quality information is received during the harvest. Another study focused on the markets of middle-income countries shows that increased grain quality gives premiums of 1–8% compared to the basic standard, although not all quality characteristics are transparent to the buyer. Y. Miao et al. [21] emphasize that the growing demand for higher quality grain encourages farmers and traders to invest in standardized quality control, which opens up the possibility of price premiums ("premium pricing") and increases the market value of products.

Studies show that quality parameters may not directly correlate with the quantity of the crop – i.e., high volume does not guarantee high quality. For example, in a study by M. J. Tilse et al. [33], it was traced that yield fluctuations do not coincide with fluctuations in protein content, and grain with higher protein receives a premium in the market. O. S. Parkhomenko and O. S. Kuleshova [27] emphasize that the formation of the export price of grain is determined by a complex of economic and political factors that affect export volumes and price dynamics. From this position, laboratory quality control is a key prerequisite for a reliable determination of grain class, the size of discounts and competitiveness in world markets. It follows that the accuracy and methodological consistency of laboratory analyses are of paramount importance for reducing price volatility and ensuring the stability of Ukraine's export operations. Therefore, the commercial attractiveness of grain depends not only on production volumes but also on verified quality control, which makes laboratory research an integral factor of successful foreign trade activity.

From the point of view of the formation of added value of grain production, the studies of O. Svitovyi et al. [32] also indicate the need to introduce organizational and economic mechanisms that ensure standardization and quality control of grain, which is a prerequisite for obtaining market premiums and competitive advantages in the international market. That is, for adequate forecasting of the export price and the level of discounts, economic models have to take into account not only yield or market conditions, but also objective results of laboratory control – they act as an information bridge between products and the market.

3. Problem Statement

The article is aimed at carrying out an economic analysis of the impact of the quality of laboratory control of grain, in particular the determination of contamination and other critical quality indicators, on the formation of export prices and discounts under FOB contracts, as well as the development of author's methodological approaches and an econometric model for forecasting the price of grain per ton in the presence of specific deviations in quality indicators, and to convert this change into the expected absolute discount per batch to increase the accuracy of estimation and minimize economic losses of exporters.

4. Methods and Materials

To study the detection of pest infestation and the presence of mycotoxins, as well as to assess the physical and chemical properties of grain in accordance with international standards, in particular Codex Alimentarius, ISO, GAFTA and FOSTA, the information of the State Statistics Committee of Ukraine on the export of wheat and wheat-rye mixture (meslin) for the period 2015–2024 was used. These standards were selected from the point of view of the most widely used in international practice regulatory norms for sampling and methods for assessing grain quality. The study used an integrated approach of combining laboratory methods (LC-MS/MS, HPLC, PCR) with screening methods (LFA, NIR/FT-NIR, Machine Vision, HSI). Such integration makes it possible to more thoroughly assess the degree of riskiness, optimize the costs of export operations and forecast the pricing policy for the future with a probability of effectiveness of up to 70% and

To assess the impact of grain quality on FOB contract prices, an econometric (economic and mathematical) model was used. The model is based on the actual indicators of grain quality according to laboratory surveys (volume of shipped products, logistics, market indicators, adjustments for geographical location and seasonality). The model has two options: log-linear and linear. The first shows by what percentage the price changes, the second shows the estimated discount value at the FOB price. The value of the model is to forecast the price of final export products in the future with the ability to take into account predictable and unpredictable risks and develop possible scenarios for their leveling. The econometric model provides for compliance with standard sampling requirements, the use of automated control systems, laboratory analysis and analytical algorithms to increase the reliability of assessing the quality and competitiveness of Ukrainian grain in the world market

5. Results and Discussion

A high level of competitiveness of grain in the world market primarily depends on compliance with international standards and protocols according to scientifically based and standardized procedures for accurate measurement of physical and chemical parameters and the level of contamination of exported products [25]. After all, business reputation in the international arena, commercial value and further pricing policy of possible discounts under FOB contracts depend on this.

Today, ISO standards, GAFTA rules and guidelines, FOSFA requirements, as well as the provisions of the Codex Alimentarius are widely used in the world practice of grain valuation. Each of these systems regulates sampling procedures, methods for determining moisture, protein, gluten, vitreousness, impurities, as well as infestation and the presence of mycotoxins. They establish clear criteria for permissible deviations, define methodological approaches to control, and provide a framework for arbitration and certification procedures used in foreign trade transactions.

A generalized comparative analysis of the main physical and chemical indicators of grain quality demonstrates a comparison of their regulation according to the specified international systems of standards (Table 1) allows you to understand in which aspects international requirements coincide and where there are differences, which can be useful for the development of internal laboratory procedures, optimization of quality control and minimization of economic risks in the export of grain crops.

The analysis of the table data shows that all the considered international regulations have one goal

– to provide a reliable assessment of grain quality on the basis of laboratory tests in compliance with all sample requirements provided for by the regulations. The presented benchmarking analysis serves as the foundation for the formation of the standard of the national system for assessing the quality of grain, the formation of the author's approaches and methods in order to predict the value of the discount, optimize costs and ensure the competitiveness of exported products in the world market.

Table 1. Benchmarking analysis of the main international standards for grain quality control on the world market

Quality Score	ISO	GAFTA	FOSFA	Codex Alimentarius	Application features
Grain moisture	ISO 712; ISO 24333	GAFTA Sampling Rules	FOSFA Contract Terms	–	Moisture control to maintain quality and prevent mold growth.
Natural weight (test weight)	ISO 7971	GAFTA Quality Standards	FOSFA – for oilseeds	–	Determines the density and physical quality of grain, which affects the price.
Protein content	ISO 16634; ISO 12099	GAFTA – Wheat Protein Content Rules	FOSFA – Protein Content for Oilseeds	Codex Standards for Cereals	Determines the nutritional value and quality of wheat, barley and soybeans
Gluten content	ISO 21415; ICC 137	GAFTA – Gluten Quality Rules	–	–	The main indicator for the baking properties of wheat
Vitreousness of grain	ISO 520; ICC 129	GAFTA – Vitreous Kernels	–	–	Determines the varietal and technological properties of wheat
Clogging (impurities)	ISO 5223; ISO 663	GAFTA Sampling & Admixture Rules	FOSFA Contract Terms	Codex Cereal Grading	Affects batch cleanliness and commercial risks
Infestation	ISO 663; ISO 7971	GAFTA Sampling Rules; Pest Control	FOSFA Pest Control Clauses	–	Pest detection, impact on discount and export price
Mycotoxins (DON, aflatoxins)	ISO 18787	GAFTA – Mycotoxin Limits	FOSFA – Mycotoxin Limits	Codex Maximum Levels	Control of toxic substances, in accordance with legislation and contract
Oil/fat content (for oilseeds)	ISO 659	GAFTA Oil Content Rules	FOSFA Contract Terms	–	Determines the extractivity and commercial value of oilseeds
Color, characteristics of the variety	ICC 105/2; NIR	GAFTA Color & Grade Rules	FOSFA – Quality Grades	Codex Cereal Classification	Affects batch class and processing application

Source: Compiled by the author based on data from [1–20].

As a result of the study, a systematic analysis of methods for detecting infestation (pest infestation) and determination of mycotoxins in grain batches, their suitability for use in export conditions under FOB contracts and impact on the formation of discounts was carried out (Table 2).

The analysis of the table data shows the absence of a combined method for assessing the quality of grain, taking into account such important parameters as the level of sensitivity, speed of analysis, and low cost. The model should adequately reflect the results of laboratory analysis of selected samples of grain batches using screening tests, as well as appropriate quantitative methods. It is laboratory analysis that provides 50–70% of the objectivity and accuracy of the results obtained in the quality of the exported batch grain. Failure to comply with the sampling procedure and violation of international standards leads to an increase in the discount value and deterioration of partnership relations [24]. According to the results of the study, a sufficiently high level of efficiency of the use of such control express methods as NIR/FT-NIR, LFA, and machine vision systems was established. These methods make it possible to determine the quality of a particular batch of grain in a short time using minimum volumes of samples with goal of saving the total cost of expensive analyses to confirm the reliability of the data. It is the LC-MS/MS and HPLC methods that are currently the most necessary for determining the accuracy of inspection, resolving contradictory situations by counterparties to export contracts in order to comply with quality requirements in part, contamination and mycotoxin content. In the context of the development of digitalization, it is PCR diagnostics and automated optical control systems that provide a high level of efficiency in sampling for analysis in production and elevators [23].

Thus, the results of the study prove the effectiveness of a combined approach to quality control of exported grain, which is based on the use of high-precision analysis methods using unified sampling procedures in accordance with Codex Alimentarius, ISO and other standards using multi-level digital algorithms, which include screening tests and LC-MS/MS. An important role is given to the systematic calibration of spectroscopic samples. As a result, reliable results of assessing the quality of the batch of exported grain and maximum leveling of the risk of non-compliance with the terms of concluded contracts will be obtained, and the projected export price will be determined.

Table 2. Analysis of methods for determining infestation and mycotoxins in grain batches

Method	Type	Dignity	Limitations	Applications
LFA (immunolinear tests)	Express method	Fast results; low cost; Ease of Use	Low accuracy; Needs confirmation	Preliminary screening for mycotoxins
NIR/FT-NIR	Spectroscopy	Fast; does not destroy the sample; Suitable for large batches	Requires calibration; Average accuracy	Grain quality screening, preliminary assessment of infestation
LC-MS/MS	Chromatography + Mass Spectrometry	High precision; Legally significant result	High cost; requires equipment and qualifications	Confirmation of mycotoxin levels
HPLC	Chromatography	Accurate qualitative analysis	Longevity; High cost	Confirmation of toxin concentrations
HSI	Hyperspectral inspection	Stability; automation; absence of human factor	High cost of equipment	Automatic sorting and quality control
Machine vision	The image is analyzed by a computer	Efficiency; Automation	Less accurate than laboratory methods	Detection of infected grain on the lines
PCR	Molecular diagnostics	High precision; Pathogen detection	Needs a laboratory; High cost	Identification of fungal pathogen infestation

Source: Compiled by the author based on data from [28; 30; 26].

The analysis of the dynamics of Ukrainian exports of wheat and a mixture of wheat and rye (meslin) for 2015–2024 shows a significant economic sensitivity of external supplies to grain quality parameters, primarily to indicators of infection and compliance with international standards ISO, GAFTA, FOSFA and Codex Alimentarius. Based on official data of the State Statistics Service of Ukraine [31] regarding export volumes and the average contract price, the total cost of export deliveries was calculated and potential economic losses of exporters were modeled in case of application of price discounts due to the non-compliance of grain with the regulated requirements (Table 3).

Table 3. Calculation of potential economic losses of exporters from grain contamination and non-compliance with international standards, 2015–2024

Year	Export volume, thousand tons	Price, USD/t	Export value, USD million	Losses at a discount of 2%, USD million	Losses at a discount of 5%, USD million	Losses at a discount of 10%, USD million
2015	13452	166	2233.03	44.66	111.65	223.30
2016	17921	152	2723.99	54.48	136.20	272.40
2017	17313	159	2752.77	55.06	137.64	275.28
2018	16373	183	2996.26	59.93	149.81	299.63
2019	20022	183	3664.03	73.28	183.20	366.40
2020	18060	199	3593.94	71.88	179.70	359.39
2021	20071	253	5077.96	101.56	253.90	507.80
2022	11216	239	2680.62	53.61	134.03	268.06
2023	16152	182	2939.66	58.79	146.98	293.97
2024	20665	181	3740.37	74.81	187.02	374.04

Source: Calculated by the author based on data from [31].

The results show that even minimal deviations from the standards, which lead to the application of a discount at the level of 2%, form annual direct losses in the range of 45–100 million USD. With an increase in the level of non-compliance to medium (5%) and high (10%), losses increase to USD 150–250 million and USD 300–500 million, respectively. The largest volume of potential losses was recorded in years with a high level of export revenues (2021 and 2024), which is due to both an increase in the contract price and an increase in supply volumes.

In cases of delay of a batch of goods in ports, additional costs for fumigation and testing are incurred, and logistics costs increase (about 0.5–3% of the total cost), which negatively affects the level of profitability of exporters. The results of approbation of the econometric model show that for the period under study (2015–2024), Ukrainian producers received less than 3.4–3.7 billion. US dollars. This once again proves the importance of compliance with international standards, which can be ensured through the sustainable functioning of the certification system for grain products for export.

In order to determine the value of the future discount as close as possible to reality, it is proposed to use an econometric model, which is based on the relationship between the contract price (on FOB terms) and a set of quality indicators established by laboratory analysis. The model is of an applied nature and is designed for use by participants in export operations – manufacturers, analysts, and transport companies. The model is based on the principle of approximation, i.e., determining the impact of changes in one of the quality factors (in this case, infection and mycotoxin content) on the change in the export price (in case of a decrease in the use of discount). This allows commodity producers to neutralize the threat of loss of grain quality along the entire logistics route to the destination Free on Board.

The model takes into account that the FOB price (board price the vessel, USD/t) is formed at the intersection of supply and demand, macro-energy and logistical conditions and on the quality of a particular batch. Laboratory-determined indicators (humidity, protein content, volume of damaged or infected grains, mycotoxin level, etc.) have a direct impact on the buyer’s desire to pay the full price or use a discount. controlling external factors. The log-linear variety of the model shows the price change as a percentage, which can be calculated using the formula:

$$\ln\left(FOB_{it}\right) = \alpha + \beta_1 Q_{it} + \beta_2 X_{it} + \gamma_t + \delta_j + \varepsilon_{it} \tag{1}$$

The linear variety of the model is aimed at determining the discount value (USD/t). The calculation formula is as follows:

$$FOB_{it} = \alpha + \sum_k \beta_k Z_{kit} + \sum_m \theta_m C_{mit} + \gamma_t + \delta_j + u_{it} \tag{2}$$

where:

i– supply batch index, t– time (month/year), j– importer;

Z_k– a set of laboratory-confirmed quality indicators;

C_m– controlled variables (batch volumes, market indices, port, exchange rate fluctuations, etc.);

γ_t– time fixed effects (season, year), control over market trends;

δ_j– fixed effects by directions/counterparties (different standards/terms of acceptance);

ε_{it}, u_{it}– stochastic terms.

The evaluation strategy of the model is based on a combination of classical and advanced econometric approaches, which ensure the reliability of the results obtained under conditions of heterogeneity and potential bias of the data. Baseline assessment is carried out using OLS with clustered standard errors by direction or year, which makes it possible to correct for possible autocorrelation and heteroscedasticity. In the presence of a large number of batches from the same exporters or routes, models with fixed effects are used, which make it possible to control the hidden characteristics of suppliers or logistics directions that remain unchanged over time. Since the quality of the batch can be endogenous – for example, when better samples are directed to more profitable contracts – instrumental variables are additionally used, including natural weather indices at harvest time, the duration of grain storage before shipment, or yield indicators of the region. In the case of nonlinear coupling factors (excess of mycotoxins, moisture, contamination, etc.), it is rational to use regression of the “piecewise” or “spline” type and algorithms such as Tobit. This approach is especially relevant in the case of the disqualification of a batch of exported grain due to the influence of natural factors. The reliability of such results can be verified by cross-validation using statistical testing.

After evaluating the coefficients, you can directly predict the price change (USD/t) or absolute discount for a given direction of determining quality indicators. In linear form, the expected discount (USD/t) for a batch with Z indicators is calculated according to the formula:

$$\Delta FOB = \sum_k \beta_k \left(Z_k - Z_k^{ref}\right) \tag{3}$$

where Z^{ref} – baseline values (e.g., humidity 14%; DON = 0.5 mg/kg; infestation = 0%).

Table 4. Recommended list of variable indicators for the econometric model

Designation	Name	Unit of measurement	Impact on price
FOB	Price FOB	USD/t	Reduction
MOIS	Humidity	%	The higher the humidity, the lower the price
DMG	Damaged grains	%	Reduction
INF	Infestation	% or quantity (t)	Reduction
FM	Impurities (foreign matter)	%	Reduction
PROT	Protein content	%	Growth of food wheat
TW	Density (test weight)	kg/m3	Growth
DON	Mycotoxin esoxynivalenol (DON)	mg/kg	Usually has a non-linear effect
ZEA	Various mycotoxins, including zearalenone	mg/kg	Reduction
CERT	Compliance with the standard	1 – yes, 0 – no	Growth
QTY	Batch volume	thousand tons	The effect is oscillatory
DIST	Distance to the port (additional logistics costs)	km (USD)	Reduction
WRLD	World Price Index (basis)	USD/т	Growth
EXR	Exchange rate (UAH/USD)	UAH / USD	The effect is oscillatory

Source: Developed by the author.

In the log-linear form, the percentage change in the price is calculated according to the formula:

$$\%\Delta FOB \approx 100 \times \sum_k \beta_k \,(Z_k - Z_k^{ref}) \quad (4)$$

In this case, the magnitude of the absolute change is calculated by the formula:

$$\Delta FOB = FOB_{pred} - FOB_{ref}. \quad (5)$$

In practice, for each batch, the "price forecast" module produces two numbers – the expected FOB price according to current laboratory data and the expected price according to the "reference" quality level; The difference is the expected discount.

With the help of the proposed econometric model, it is possible to predict in time the impact of the estimated grain quality indicators on the FOB price. The model is based on the use of correlation equations in linear on log-linear form, which helps the exporting company to determine the discount value for each specifically defined batch of grain, as well as to modify scenarios depending on the variability of indicators of laboratory analysis of product quality and the requirements of international standardization. Another advantage of the model is the formation of an effective risk management strategy and a national policy of grain quality control at the state level.

Taking into account the above, it is proposed to apply an integrative methodological approach to the sampling procedure. In the context of mass digitalization of all sectors of the economy, it is appropriate to use automated management and control systems, digital platforms with data of accurate laboratory analysis of samples of each batch of grain on a certain date, as well as an economic and mathematical model for assessing the degree of riskiness in case of changes in market conditions and force majeure. The strategic management of grain exports should be based on a single protocol for confirming the reliability of the analysis data to strengthen confidence in the implementation of the export agreement and minimize the risks of losses.

6. Conclusions

The study confirmed the importance of assessing the quality of grain using laboratory analysis to determine its export price. It has been established that the correctness of sampling and rational use of analytical methods ensures the accuracy of measuring the infestation and content of mycotoxins, which proves the reliability of the quality of the product according to international standards (Codex Alimentarius ISO, GAFTA and FOSFA. Benchmarking analysis has demonstrated the complementarity of each standard, which necessitates consistency between Ukrainian quality protocols and these standards. However, each of the universal approaches is not effective enough.

Analysis of the dynamics of grain exports in Ukraine for 2015–2024 revealed that the annual loss incurred by commodity producers due to non-compliance with international quality standards is measured in hundreds of US dollars, resulting in a discount. This suggests the need to employ reliable laboratory analysis methods in conjunction with digital algorithms. In this regard, a combined approach is proposed, which is based on the use of rapid screening and laboratory methods with elements of accurate measurement. The approach is based on an econometric model, which includes measurement by laboratory analysis of the main quality indicators: moisture, protein, infestation, mycotoxins, etc. All of the above indicators are the basis for the formation of FOB prices in the consignment agreement, and the model allows you to predict with maximum accuracy the number of possible deductions and discounts in the future in accordance with the quality characteristics of the batch of exported grain. The integration of the national grain export quality assessment system and the international certification system will contribute to the improvement of laboratory infrastructure and the formation of a high level of competitiveness of grain products in Ukraine.

References

1. Do Nascimento Miguel, J. (2024). Returns to quality in rural agricultural markets: Evidence from wheat markets in Ethiopia. *Journal of Development Economics*, (171), 103336. https://doi.org/10.1016/j.jdeveco.2024.103336
2. FAO (2024). CODEX International Food Standards. https://www.fao.org/fao-who-codexalimentarius/codex-texts/list-standards/en/
3. FOSFA (2025). *Contracts. Oils. Seeds. Fats.* FOSFA International. https://www.fosfa.org/contracts/
4. GAFTA (2024). *Sampling and Analysis*. GAFTA. https://www.gafta.com/trade-policy/food-and-feed-safety/sampling-and-analysis/
5. ICC (2025). *International Association for Cereal Science and Technology – Standards overview*. International Association for Cereal Science and Technology – Home. https://icc.or.at/icc-standards/standards-overview
6. ISO (1995). *ISO 5223:1995 Test sieves for cereals*. ISO – International Organization for Standardization. https://www.iso.org/standard/11225.html
7. ISO (2006). *ISO 21415-3:2006. Wheat and wheat flour – Gluten content. Part 3: Determination of dry gluten from wet gluten by an oven drying method*. ISO – International Organization for Standardization. https://www.iso.org/standard/35864.html
8. ISO (2009a). *ISO 24333:2009 Cereals and cereal products – Sampling*. ISO – International Organization for Standardization. https://www.iso.org/standard/42165.html
9. ISO (2009b). *ISO 659:2009 Oilseeds – Determination of oil content (Reference method)*. ISO – International Organization for Standardization. https://www.iso.org/standard/43169.html
10. ISO (2009c). *ISO 7971-1:2009 Cereals – Determination of bulk density, called mass per hectolitre. Part 1: Reference method*. ISO – International Organization for Standardization. https://www.iso.org/standard/44524.html
11. ISO (2010). *ISO 520:2010 Cereals and pulses – Determination of the mass of 1 000 grains.* ISO – International Organization for Standardization. https://www.iso.org/standard/52270.html
12. ISO (2016). *ISO 16634-2:2016 Food products – Determination of the total nitrogen content by combustion according to the Dumas principle and calculation of the crude protein content. Part 2: Cereals, pulses and milled cereal products.* ISO – International Organization for Standardization. https://www.iso.org/standard/66661.html
13. ISO (2017a). *ISO 12099:2017 Animal feeding stuffs, cereals and milled cereal products – Guidelines for the application of near infrared spectrometry.* ISO – International Organization for Standardization. https://www.iso.org/standard/67352.html
14. ISO (2017b). *ISO 18787:2017 Foodstuffs – Determination of water activity.* ISO – International Organization for Standardization. https://www.iso.org/standard/63379.html
15. ISO (2017c). *ISO 21415-2:2015 Wheat and wheat flour – Gluten content Part 2: Determination of wet gluten and gluten index by mechanical means*. ISO – International Organization for Standardization. https://www.iso.org/standard/62221.html
16. ISO (2019a). *ISO 7971-2:2019 Cereals – Determination of bulk density, called mass per hectolitre. Part 2: Method of traceability for measuring instruments through reference to the international standard instrument.* ISO – International Organization for Standardization. https://www.iso.org/ru/standard/70016.html
17. ISO (2019b). *ISO 7971-2019. Cereals – Determination of bulk density, called mass per hectolitre.* ISO – International Organization for Standardization. https://www.iso.org/standard/70016.html

18. ISO (2019c*). ISO 7971-3:2019 Cereals – Determination of bulk density, called mass per hectolitre Part 3: Routine method.* ISO – International Organization for Standardization. https://www.iso.org/standard/70015.html
19. ISO (2024). *ISO 712-1:2024 Cereals and cereal products – Determination of moisture content.* ISO – International Organization for Standardization. https://www.iso.org/standard/85395.html
20. ISO (2025). *ISO 6639-2:2025 Cereals and pulses – Determination of hidden insect infestation Part 2: Sampling.* ISO – International Organization for Standardization. https://www.iso.org/standard/85402.html
21. Miao, Y., Sun, J., Liu, R., Huang, J., & Sheng, J. (2025). Bridging the Quality-Price Gap: Unlocking Consumer Premiums for High-Quality Rice in China. *Foods, 14*(7), 1184. https://doi.org/10.3390/foods14071184
22. Nesterenko, S. (2025). Adaptation of Ukrainian grain quality and safety standards to international requirements based on the example of implementing the HACCP system. *Science and Technology Today*, *6*(47), 1458–1474. https://doi.org/10.52058/2786-6025-2025-6(47)-1458-1474
23. Nesterenko, S. A. (2025). Economic efficiency of implementing SMBHP at grain elevators in the context of international export. *Current Issues in Economic Sciences,* (13). https://doi.org/10.5281/zenodo.16253930
24. Nesterenko, S. A. (2025). Innovative approaches to wheat standardization based on the analysis of global value chains. *Scientific Notes of Lviv University of Business and Law*, (45), 354–364. https://doi.org/10.5281/zenodo.16706763
25. Nesterenko, S., & Kryvokhyzha, Y. (2023). Harmonization of Ukrainian wheat quality standards with codex requirements for integration into the global market. *International scientific journal "Internauka". Series: "Economic Sciences*", *8*(100). https://doi.org/10.25313/2520-2294-2025-8-11287
26. Nesterenko, S. A., & Prykhodko, V. O. (2025). Agronomy as science and practice: Modern approaches. *Tavria Scientific Bulletin*, (144), 142–149. https://doi.org/10.32782/2226-0099.2025.144.19
27. Parkhomenko, O. S., & Kuleshova, O. S. (2024). Determinants of grain exports in Ukraine: A quantitative assessment of the impact of key factors. *Agrosvit*, (20), 117–123. https://doi.org/10.32702/2306-6792.2024.20.117
28. Verkhovna Rada of Ukraine (2024). *On approval of the Methods of sampling and laboratory research (tests) for determining the levels of mycotoxins in food products for the purposes of state control*. Official website of the Verkhovna Rada of Ukraine. https://zakon.rada.gov.ua/laws/show/z1007-24/en/ed20240531/sp:side:max25#Text
29. Roberts, S., Brooks, K., Nogueira, L., & Walters, C. G. (2022). The role of quality characteristics in pricing hard red winter wheat. *Food Policy*, (108), 102246. https://doi.org/10.1016/j.foodpol.2022.102246
30. SSPP FCPU (2018). *Sampling methods for determining maximum permissible levels of mycotoxins in food products for the purposes of state control*. State Service for the Protection and Promotion of Food and Consumer Protection of Ukraine. https://share.google/EpWGH9Hll8UHHvsiF
31. SSSU (2025). Foreign trade in certain types of goods by countries of the world. State Statistics Service of Ukraine. *Economic statistics*. https://www.ukrstat.gov.ua/operativ/operativ2025/zd/e_iovt/arh_iovt2025.htm
32. Svitovyi, O., Kirdan, O., & Gechbaia, B. (2022). Organizational and economic principles of creating added value in grain production. *Agricultural and Resource Economics: International Scientific E-Journal*, *8*(3), 200–223. https://doi.org/10.51599/are.2022.08.03.10
33. Tilse, M. J., Bishop, T. F. A., & Filippi, P. (2025). Quantity vs. quality: does wheat grain yield or protein contenthave a greater opportunity for precision management? *Precision Agriculture*, *26*(67). https://doi.org/10.1007/s11119-025-10263-z