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SUBSTANTIATION OF THE UNIVERSAL ADAPTIVE TECHNOLOGICAL SYSTEM OF COMPLEX LABORATORIES FOR QUALITY AND SAFETY ASSESSING OF GRAIN AND OIL CROPS

Abstract

The materials of the article provide data on the export of domestic grain, oil crops and their processing products, the commodity structure of the export of domestic agricultural products and a dozen export countries during the operation of the grain corridor from March 2022 to August 2023. The main requirements for modern laboratories and their functions are listed. The components of a comprehensive analytical approach to assessing the quality and safety of grains and oilseeds according to modern international requirements are presented. It has been established that, in addition to the technical and economic component, the activities of complex laboratories are affected by a large number of technological limitations, among which an important place is occupied by the problems of quality control of test results. Today, the functioning of native laboratories that assess the quality and safety of grains and oilseeds has some shortcomings that may affect the effectiveness of testing activities. In particular, there is a lack of a unified approach to addressing systemic requirements, a large number of regulators, conflicting requirements, and limited international harmonization. The requirements of industry regulations and contract specifications pose challenges for laboratories. All of this emphasizes need to develop a universal adaptive technological system for quality control of integrated laboratories for assessing the quality and safety of grains and oilseeds. The main components of quality management of laboratories for quality assessment of grains and oilseeds are considered and analyzed. It was found that only 11% of accredited domestic laboratories can comprehensively meet the current demand for conformity assessment services for agricultural raw materials. Based on the analysis, a roadmap of quality management components of laboratories for quality assessment of grains and oilseeds was developed. The development of such guidelines will help to meet diverse requirements and systematically demonstrate competence in line with current needs. Processes such as analytical method validation, measurement uncertainty assessment, metrological traceability, and accreditation support require significant financial investments. The creation and implementation of a universal adaptive technological system will help to rationalize the use of resources, thanks to logistical advantages, efficiency, reliability of results, and vertical management system. The creation and implementation of a universal adaptive technological system will help to rationalize the use of resources, thanks to logistical advantages, efficiency, reliability of results, and vertical management system.

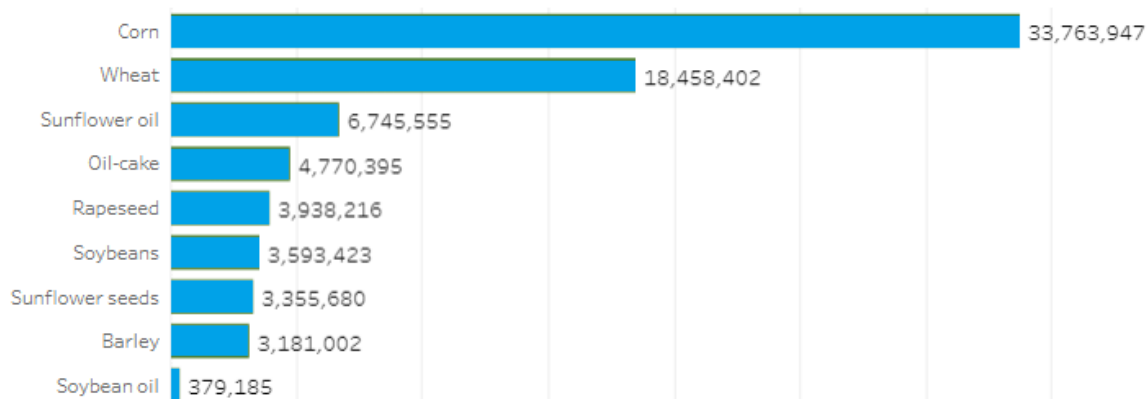
Key words: testing laboratories, quality, safety, quality management, grain and oil crops.

Introduction

Ukraine is an agrarian country with great potential for international trade engagement. According to the Ukrainian Grain Association [1], even during the war period, from March 2022 to August 2023, more than 33 million tons of corn grain, 18 million tons of wheat grain, and 3 million tons each of barley, soybean, sunflower seeds, and rapeseed were exported (Fig. 1). The commodity structure of exports of domestic agricultural products and a dozen exporting countries during the op-

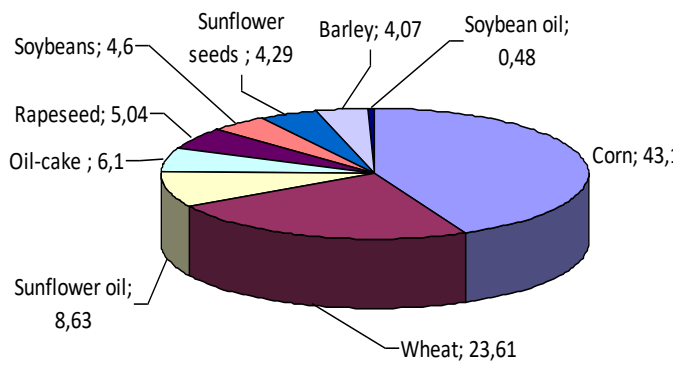
eration of the grain corridor [1] are presented in Fig. 2. Data analysis of Fig. 1 and Fig. 2 once again confirms the high quality, demand and interest of the world in our agricultural products.

However, in order to achieve the maximum level of competitiveness in the global market, a prerequisite is to ensure the appropriate level of quality and safety of exported agricultural raw materials and products, which is confirmed in production and research laboratories.

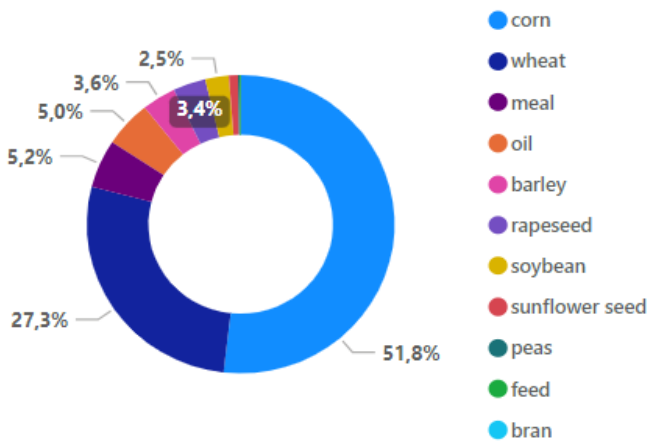


a) Export volume, million tons

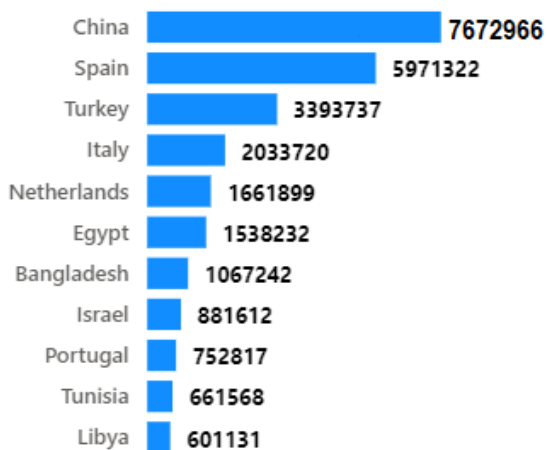
Fig. 1. The structure of exports of domestic grain, oil crops and products of their processing from March 2022 to August 2023 [1]



a) *Export share, %*



b) *Commodity structure of export, %*



c) *Export geography, tons*

Fig. 2. Export indicators of domestic agricultural products from March 2022 to August 2023 [1]

Modern laboratories at grain processing enterprises must meet the following requirements:

- confidentiality and impartiality;
- standardization;
- competence;
- controlled quality.

The main functions of modern laboratories in the grain processing industry are:

- sampling and transportation of samples;
- assessment of quality and safety indicators of grains and oilseeds;
- research and development activities.

Modern laboratory activities aimed at assessing the quality and safety of grains and oilseeds are based on a large number of national and international requirements, industry regulations, and are controlled by a wide range of regulators. This is primarily due to the fact that meeting even the minimum list of contractual requirements according to The Grain and Feed Trade Association (GAFTA) [2] and The Federation of Oils, Seeds and Fats Associations (FOSFA) [3] requires a systematic, interdisciplinary approach and significant resource potential (Fig. 3).

Consistency of approaches to data analysis and interpretation is a guarantee of confidence in the results of laboratory tests. Therefore, in addition to the indicators themselves, it is important to carefully consider the methodological and technical components of their definition.

Formulation of the problem

The current activity of domestic laboratories for assessing the quality and safety of grain and oil crops has a number of shortcomings that can affect the effectiveness of testing activities [4]. In particular, there is a lack of a unified approach to solving system requirements, a large number of regulators, conflicting requirements and limited international harmonization. The situation is complicated by the requirements of industry regulations and the challenges posed by contract specification laboratories [4]. All this emphasizes the need to create a universal adaptive technological system of quality control of complex laboratories. The development of such guidelines will allow us to meet the various requirements and systematically demonstrate competence according to current needs. Processes such as validation of analytical methods, assessment of measurement uncertainty, metrological traceability and accreditation support require significant financial investment.

The goal is to substantiate the development of a universal adaptive technological system of integrated laboratories for assessing the quality and safety of grain and oil crops.

To achieve the goal, the following tasks were solved:

- to analyze the existing certified laboratories for assessing the quality and safety of grain and oilseed crops for compliance with modern international requirements for comprehensive analysis of the quality and safety of grain and oilseed crops;
- to analyze the main sources of international requirements for the activity of laboratories for assessing the quality and safety of grain and oil crops;
- to create a "road map" of the quality management components of laboratories for the assessment of the quality of grain and oil crops for the formation of directions for further research.

Objects of research - domestic laboratories that assess the quality and safety of grains and oilseeds, **subject of research** - compliance of the system of ensuring the functioning of integrated laboratories for assessing the quality and safety of grains and oilseeds with modern international requirements.

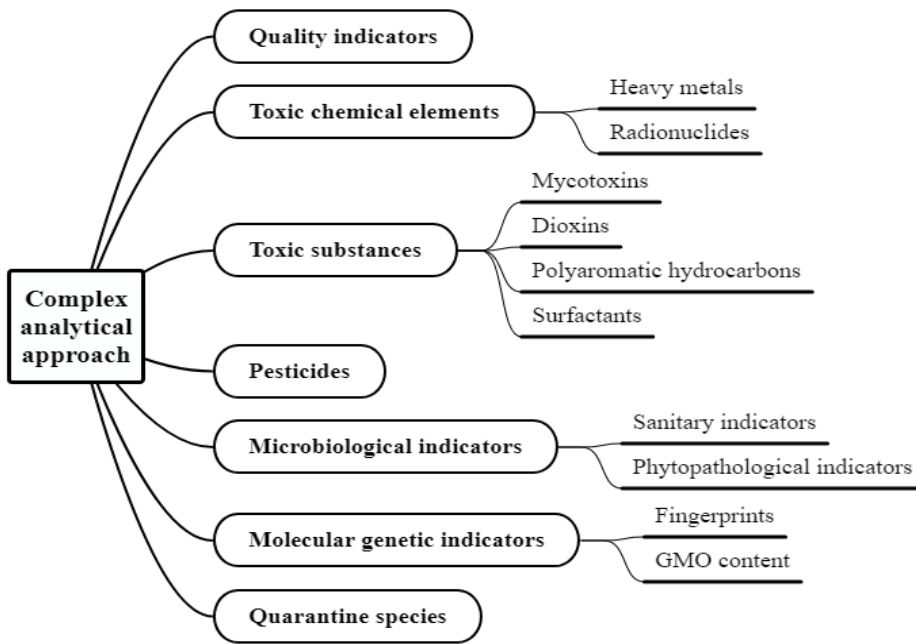


Fig. 3. Components of a comprehensive analytical approach to assessing the quality and safety of grains and oilseeds, according to modern international requirements

Research materials and methods

The research materials were:

- 313 areas of accreditation of conformity assessment organizations, according to the list of the National Accreditation Agency of Ukraine (NAAU), which carry out activities about quality and safety indicators of grains and oilseeds, for the first half of 2023;
- national and international regulatory documents governing laboratory activities to assess the quality and safety of grains and oilseeds.

Standard analytical and statistical processing methods were used to analyze regulatory and technical documentation for compliance.

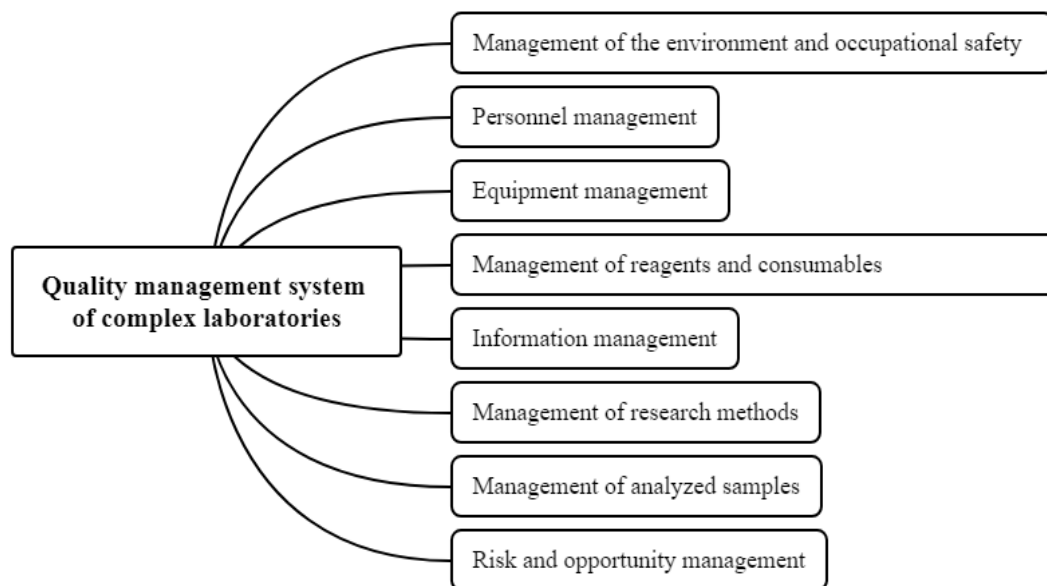


Fig. 4. Roadmap of quality management components of laboratories for quality assessment of grains and oilseeds

Research results and discussion

We analyzed 313 testing laboratories that assess the quality and safety of grains and oilseeds and are accredited by NAAU [4]. According to the results of the study of the areas of accreditation of these laboratories, only 33 offer a comprehensive approach to the assessment of these parameters, by modern international requirements.

In this regard, it is almost impossible to exhaustively satisfy the need for certification of an export product within one institution. This situation leads to the need to involve additional service providers and the long transportation of the sample, which is likely to negatively affect its performance.

While the functioning of complex laboratories is subject to comprehensive state regulation

both in terms of quality assurance and safety of their activities, the requirements for the implementation of laboratory activities are based on a wide range of international regulations aimed at building confidence in the competence of the conformity assessment body and the results it provides. Among the most important ones are ISO 9001 [5]; ISO/IEC 17025 [6], ISO 22000 [7], ISO 31000 [8], EA Regulations [9] and ILAC [10]. Additionally, there are a large number of industry-specific regulations that establish rules for the implementation of specific areas of research.

Providing comprehensive testing services poses serious challenges for laboratories. One of the fundamental problems in the provision of interdisciplinary analytical services is the sustainable functioning of the quality

management system. The implementation of laboratory activities by modern quality management models (Fig. 4) and systematic proof of the laboratory's competence at the international level that guarantees international trust and effective trade cooperation.

An appropriate quality management system is critical, as it ensures the accuracy, correct-

GRAIN, PROCESSING GRAIN: TECHNOLOGY AND QUALITY



ness, and reproducibility of test results. However, the current quality management of testing laboratories has some shortcomings. Among them, the most influential are four:

1. Lack of a single global system of standards.

Internationally, there is no single system of standards for quality management of testing laboratories. Countries and regions may have their own national standards, which require additional efforts from laboratories to meet the requirements of various regulations.

2. A large number of regulators.

Testing laboratories operating in an international context are often faced with a large number of regulations, standards and requirements from different countries. This can lead to difficulties in implementing and following all the necessary procedures and protocols, as well as require significant costs for preparing and updating laboratory equipment and infrastructure.

3. Contradictory requirements.

Different countries and industry associations may have different requirements for procedures, methodologies and documentation. This can create inconsistencies and ambiguity, especially when testing is conducted in an international environment. Such discrepancies can lead to unpredictable results and make it difficult to cooperate between different laboratories and countries.

4. Limited harmonization of international standards.

Implementing a single global system of standards for quality management in testing laboratories is challenging because different organizations and countries have different approaches and priorities. This leads to limited harmonization and insufficient interoperability between different standards, which affects the overall quality and comparability of test results.

In addition, the requirements for quality management of testing laboratories are constantly improving and changing. For example, the change of DSTU ISO/IEC 17025:2017 to DSTU EN ISO/IEC 17025:2019 and the implementation of HACCP requirements at the national level.

In Ukraine, accreditation for compliance with the requirements of certain management systems, such as 17025, Good Manufacturing Practice (GMP+), and Verband Lebensmittel ohne Gentechnik (VLOG), is a voluntary procedure. However, international trade is impossible without proving the competence of the testing laboratory. Therefore, the provision of comprehensive conformity assessment services for agricultural raw materials

should be based on modern requirements, including requirements for quality systems.

Conclusions and prospects for further research

The analysis of the conformity of laboratories for assessing the quality and safety of grains and oilseeds by modern international requirements showed that only 11% of accredited domestic laboratories in Ukraine can comprehensively meet the current demand for conformity assessment services for agricultural raw materials.

Quality and safety assurance is a key element in creating value for Ukrainian agricultural raw materials for foreign consumers. Harmonization of the approaches used in the analysis and interpretation of their results helps to increase confidence in the results of laboratory tests. Due to the fact that the safety and quality indicators of grains and oilseeds have a wide range of parameters that are subject to assessment and regulation at the national and international levels, meeting all these requirements is possible only with a comprehensive analytical approach. Only comprehensive laboratories are able to perform a sufficiently wide range of analyzes and allow the consumer to receive all the necessary services in one institution. Due to their versatility, comprehensive laboratories can perform the entire range of tests and flexibly adapt to changing requirements and tasks. The creation and implementation of a universal adaptive technological system will help to rationalize the use of resources, thanks to logistical advantages, efficiency, reliability of results, and a vertical management system..

However, due to the complexity and interconnectedness of analytical procedures performed within complex laboratories, establishing an effective and functional quality management system for analytical results is a challenge. A large number of regulatory requirements and regulators, contradictory approaches and insufficient international harmonization, along with regular review and improvement of industry technologies, form the current context for laboratory activities.

Given this, it is important to work to overcome limitations and continuously improve management processes for the successful operation of integrated laboratories for quality and safety assessment of grains and oilseeds. The development of a universal technological concept for quality management of testing laboratories is of great relevance and importance for ensuring the reliability and credibility of test results at the international level.

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ОБГРУНТУВАННЯ УНІВЕРСАЛЬНОЇ АДАПТИВНОЇ ТЕХНОЛОГІЧНОЇ СИСТЕМИ КОМПЛЕКСНИХ ЛАБОРАТОРІЙ З ОЦІНКИ ЯКОСТІ ТА БЕЗПЕЧНОСТІ ЗЕРНОВИХ ТА ОЛІЙНИХ КУЛЬТУР

Анотація

В матеріалах статті наведено дані експорту вітчизняних зернових, олійних культур та продуктів їх переробки, товарної структури експорту вітчизняної агропродукції та десятка країн з експорту під час роботи зернового коридору з березня 2022 по серпень 2023 року. Перелічені основні вимоги до сучасних лабораторій та її функції. Представлено компоненти комплексного аналітичного підходу до оцінки якості та безпечності зернових та олійних культур, згідно з сучасними міжнародними вимогами. Встановлено, що окрім техніко-економічної складової, на діяльність комплексних лабораторій впливає велика кількість технологічних обмежень, серед яких важливе місце посідають проблеми контролю якості результатів випробувань. Сьогодні, стан функціонування вітчизняних лабораторій, які здійснюють оцінку якості та безпечності зернових та олійних культур, має ряд недоліків, що можуть вплинути на результативність випробувальної діяльності. Зокрема, можна виділити такі фактори як відсутність єдиного підходу до вирішення системних вимог, велику кількість регуляторів, суперечливість вимог та обмежена міжнародна гармонізація. Ситуацію ускладнюють вимоги галузевих нормативних документів та виклики, які ставляться перед лабораторіями через контрактні специфікації. Усе це підкреслює необхідність розробки універсальної адаптивної технологічної системи контролю якості комплексних лабораторій з оцінки якості та безпечності зернових та олійних культур. Розглянуті та проаналізовані основні складові менеджменту якості лабораторій з оцінки якості зернових та олійних культур. Встановлено, що лише 11% акредитованих вітчизняних лабораторій здатні комплексно задовільнити сучасний попит на послуги оцінки відповідності сільськогосподарської сировини. На основі проведеного аналізу розроблено дорожню карту складових менеджменту якості лабораторій з оцінки якості зернових та олійних культур. Розробка таких рекомендацій дозволить задовольнити різноманітні вимоги та систематично демонструвати компетентність з урахуванням актуальних потреб. Процеси, такі як валідація аналітичних методів, оцінка невизначеності вимірювань, забезпечення метрологічної простежуваності та підтримка акредитації, потребують значних фінансових вкладень. Створення та впровадження універсальної адаптивної технологічної системи допоможе раціонально витратити ресурси, завдяки логістичним перевагам, оперативності, надійності результатів та вертикальній системі управління.

Ключові слова: випробувальні лабораторії, якість, безпечність, менеджмент якості, зернові та олійні культури.

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