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SEMA Oksana
Yuriy Fedkovych Chernivtsi National University
https://orcid.org/0000-0003-0159-2151
e-mail: o.sema@chnu.edu.ua
SACHKO Anastasiia
Yuriy Fedkovych Chernivtsi National University
https://orcid.org/0000-0002-3364-4297
e-mail: an.sachko@chnu.edu.ua
BABUKH Ilona
Yuriy Fedkovych Chernivtsi National University
https://orcid.org/0000-0001-8274-5716
e-mail: i.babuh@chnu.edu.ua

APPLICATION OF EXPRESS ANALYSIS METHODS IN COMMODITY SCIENCE AND COMMODITY EXPERTISE OF FOOD PRODUCTS

In the current conditions of food market globalisation, intensification of trade turnover and tightening of regulatory requirements for product quality and safety, the introduction of rapid analysis methods into the practice of commodity science and commodity expertise is becoming particularly relevant. The growth in the range of food products, the complexity of recipes, the use of multi-component raw materials, as well as the spread of cases of counterfeiting and unfair competition necessitate the rapid acquisition of analytical information for management and expert decision-making. In this context, rapid analysis methods are seen as an effective tool for initial control, allowing for the rapid assessment of product compliance with established regulatory requirements and preventing the spread of poor-quality or dangerous goods.

The purpose of the article is to summarise and systematise modern scientific approaches to the application of rapid analysis methods in commodity science and commodity expertise of food products, as well as to justify their role in ensuring the quality, safety and authenticity of food products. The paper provides an analytical review of literary sources that highlight the theoretical foundations, methodological features and practical aspects of using rapid research methods at different stages of the food product life cycle. It is shown that rapid analysis methods are an important element of the modern quality management system, as they combine sufficient analytical information with minimal time and material costs. Unlike classical laboratory methods, which are highly accurate but require significant resources and time, rapid methods are focused on quick decision-making in real time. This is especially important when working with perishable goods, during the acceptance of raw materials, production control, storage, transportation and sale of food products.

Keywords: rapid methods, commodity science, expertise.

СЕМА Оксана, САЧКО Анастасія, БАБУХ Ілона
Чернівецький національний університет імені Юрія Федьковича

ЗАСТОСУВАННЯ ЕКСПРЕС-МЕТОДІВ АНАЛІЗУ В ТОВАРОЗНАВСТІ ТА ТОВАРОЗНАВЧІЙ ЕКСПЕРТИЗІ ПРОДУКТІВ ХАРЧУВАННЯ

Доцільність використання експрес-методів аналізу в товарознавстві та товарознавчій експертизі полягає у їх здатності забезпечити швидке, достатньо точне та економічно вигідне визначення якості товарів, що особливо важливо у практичній діяльності підприємств, лабораторій і контролюючих органів. Актуальність дослідження полягає у необхідності оптимізації процесів ідентифікації та експертної оцінки товарів шляхом впровадження інноваційних експрес-технологій. У роботі розкрито сутність та функціональне значення оперативних методів аналізу в межах товарознавчого аудиту харчової продукції. Розглянуто конвергенцію інструментальних та сенсорних методів як базису для оперативного визначення параметрів автентичності та відповідності стандартам безпеки. Наведено доказову базу переваг використання мобільного аналітичного обладнання порівняно з традиційною лабораторною базою, зокрема в аспектах часової детермінації та зниження собівартості експертних процедур для суб'єктів господарювання та контролюючих інституцій.

Ключові слова: експрес-методи, товарознавство, експертиза.

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PROBLEM STATEMENT

In conditions of high competition in the food market and increasing consumer requirements for quality and safety, enterprises are forced to ensure fast and reliable quality control of their products. Traditional analytical approaches are often characterized by low economic efficiency due to a combination of factors: long analysis duration, high resource intensity, and the need for expensive equipment. A significant factor increasing the cost of research is also their high labor intensity and the need to involve highly specialized experts with the appropriate level of competence, which creates an additional financial burden on the payroll and requires significant investment in personnel training.

From a marketing perspective, the speed of obtaining control results allows for a faster response to changes in product quality, increasing consumer brand trust and ensuring a stable product image. Express methods contribute to the formation of a positive perception of the trademark, as they guarantee quality control at all stages — from production to sale.

Thus, the application of express analysis methods in commodity science and product expertise has not only scientific and technical but also economic and marketing significance, as it ensures cost reduction, optimization of logistics processes, increased competitiveness of the enterprise, and improved customer satisfaction.

The current direction of modernizing commodity expertise is the transition to using mobile analytical platforms adapted for operation in both laboratory and production conditions. The request from industry specialists and regulatory authorities is formed around the need for resource-saving and highly sensitive methods that allow for the minimization of time spent on conducting expertise. The multifunctionality of such approaches should cover a wide range of analytical tasks: from monitoring technological processing parameters to detecting counterfeits and detailed determination of the nutrient profile of food products [1, 2].

ANALYSIS OF RESEARCH AND PUBLICATIONS

The key role of express methods is that they allow: quickly evaluating product quality without the use of complex laboratory equipment; conducting monitoring of quality indicators without aggressive methods of violating sample integrity; reducing the time of expertise, which is especially important when working with perishable goods; detecting external and hidden defects that may be imperceptible during organoleptic evaluation; maintaining an appropriate level of safety for goods in retail chains; identifying falsification of food and non-food products; providing preliminary control during the acceptance of goods and their transportation.

In practical activity, express methods are often used as the primary stage of expertise, after which detailed laboratory studies are conducted if necessary. Such an approach implements a preliminary screening strategy, allowing for the differentiation of research objects at early stages. This ensures the concentration of stationary laboratory resources exclusively on the verification of anomalous results or arbitration studies. Furthermore, express diagnostics serves as a tool for operational decision-making on a "Go/No-go" basis, which is critical for the logistics chains of food products with limited shelf life [3].

Express methods are classified depending on the principle of their action and the object of analysis. They are classified as follows:

1. By the nature of the analysis method:

1.1. Sensory (organoleptic) express methods:

- Analytical tests: used by experts to identify differences between products (triangle test, duo-trio) or for profiling characteristics (flash profiling, ranking) [4, 5].

- Affective (consumer) tests: aimed at determining the degree of acceptability or preference of the product by consumers (hedonic scales) [4].

1.2. Physico-chemical instrumental methods:

- Electrochemical methods: include cyclic voltammetry, square-wave voltammetry, and chronoamperometry. They allow for the rapid determination of the antioxidant capacity of food products and beverages, as well as the content of specific additives, such as nitrites [5].

- Optical methods and refractometry: measuring the refractive index to determine sugar content (Brix degree) using manual or digital refractometers [6].

- Spectroscopic methods: the use of near-infrared spectroscopy (vis/NIR) for non-destructive monitoring of fruit and vegetable ripeness, as well as the chemical composition of wine and beer [7, 8].

1.3. Biosensory and nanosensory methods:

- The use of electrochemical biosensors (e.g., based on glucose oxidase) for monitoring fermentation processes or determining the freshness of fish and meat by pH levels and histamine [9].

- Electronic tongue: an array of sensors for recognizing complex flavor profiles of products [10].

2. By relation to the integrity of the object (destructiveness):

- Non-destructive methods: allow for analysis without damaging the commercial appearance [11]. These include NIR spectroscopy, magnetic resonance imaging (MRI), and certain types of ultrasonic analysis.

- Destructive methods: require sample preparation (extraction, juice squeezing, or grinding) [11, 3]. For example, the use of traditional hydrometers, refractometers for juices, or QuEChERS methods for determining residues of pesticides and pollutants.

3. By the target purpose of the expertise:

3.1. Safety analysis:

- Immunochromatographic analysis (Lateral Flow Assays – LFA): rapid test strips for detecting pathogens (Listeria, Salmonella), toxins, antibiotic residues, or pesticides [12].

- Molecular genetic methods: loop-mediated isothermal amplification (LAMP) and real-time PCR for rapid identification of parasites (e.g., Anisakis) or bacteria [13].

3.2. Adulteration Detection:

- Methods based on the detection of specific marker substances or deviations of components from the norm [14].
- Use of DNA barcoding for the identification of biological species (e.g., replacing one type of meat or fish with another) [15].

4. By place and method of implementation:

- Portable (Field-based / In-situ): mobile devices (nitrate meters, portable spectrometers) used in markets, warehouses, or in the field [16].
- Flow-through (In-line / On-line): built directly into the production line for continuous quality control during processing [11].
- Desktop laboratory express systems: automated analyzers providing results in minutes (e.g., express milk analyzers like "Laktan" or "Ekomilk") [17, 18].

The classification of express methods is critically important, as it allows the commodity expert to choose the most effective tool: from a simple "litmus paper" in the form of an LFA test strip to the complex "digital vision" of NIR spectroscopy.

FORMULATION OF ARTICLE OBJECTIVES

The aim of the work is an analytical review of literature sources describing modern methods of product quality management and control, which allow for the early detection and prevention of product quality degradation problems.

MAIN BODY OF MATERIAL

Appearance, color, consistency, and odor often indicate spoilage or substandard quality of food products. Despite some subjectivity, sensory analysis is a fast and convenient method for assessing the quality of raw materials, semi-finished products, and finished products. It allows for the timely detection of deviations from the recipe, violations of manufacturing technology or the presentation of food products, and, accordingly, prevents substandard products from reaching the consumer.

he organoleptic express method is used when quick decisions about acceptability/unacceptability are needed (e.g., checking incoming raw materials, quality control on the production line, random shelf-life checks, or market surveillance) or when limited resources (time, availability of a qualified commission) make a full descriptive analysis impossible. Rapid methods can also serve for sorting: identifying samples that require more full descriptive or instrumental control [6]. However, this method is best suited for relative assessment (e.g., which sample differs from the reference or standard), rather than for absolute quantitative measurement of the intensity of many indicators.

There is a range of sensory tools, and often a certain goal or research task can be achieved through several correctly conducted sensory tests. Many of these tests are simple and easy to apply, while others are more complex and require training and experience. The choice of an appropriate sensory test and testing conditions ensures convincing results.

Test systems are fast and practical in a large production facility or a quality control environment when product quality decisions must be made quickly. Training of specialists is conducted to calibrate their senses according to specific features [19].

The use of "electronic nose" (E-nose) technology is one of the leading directions in the field of rapid non-destructive testing (NDT), allowing for the assessment of product quality without damage [10, 20]. E-nose technology works similarly to a digital sommelier: instead of tasting the product, it captures subtle "nuances" of aromas (gases) that signal the internal state of the product even before changes become visible to the human eye. The use of the "electronic nose" is possible for monitoring spoilage and as an early warning system (using apples as an example). Work [20] describes the development of a monitoring system for apple spoilage during storage based on the analysis of volatile components released by the product. This technology combines a prototype gas sensor and an early warning model based on multifactorial synthesis. Such an approach ensures real-time freshness assessment, which is critical for preventing product losses in supply chains.

In addition to physical-chemical methods (titrimetry, gravimetry) providing quantitative and semi-quantitative assessment of quality, there are instrumental methods of food safety analysis: photometric (optical, absorption, fluorescent), electrochemical (voltammetry), chromatographic (liquid, gas chromatography), and spectral (vibrational spectroscopy, atomic emission, absorption). These methods allow for faster, more automated, or higher-throughput quantitative analysis and screening than many classical methods, while in many cases maintaining acceptable accuracy for control or screening purposes. Instrumental express methods of analysis use simple, often portable equipment and provide a quantitative result in a short time. Examples include:

- portable pH meters (used for measuring pH in milk, cheese, meat under conditions of proper calibration and maintenance, and often used for controlling fermentation, freshness, and product spoilage) [9]. For example, the pH value is an informative indicator of the freshness of meat and fish: in fresh meat, the pH is 5.6–6.2, while during microbiological spoilage it increases due to the formation of ammonia, amines, and other alkaline protein breakdown products. The use of portable pH meters directly in storage or sales locations allows for the rapid detection of initial stages of spoilage [21];

- handheld refractometers. The refractometric method determines the concentration of dry substances and sugars in juices, purees, jams, honey, tomato products, and the fat content in vegetable oils. For example, determining sweetness (in Brix) of fruits, juices, and alcoholic beverages [11];
- testers for determining acidity, nitrates in vegetables and fruits, and hardness;
- rapid moisture analyzers (infrared or microwave moisture meters) and rapid protein/starch analyzers or portable analyzers providing approximate estimates of macronutrient content[22];
- luminescopes, which allow for the detection of substances in samples even in extremely small concentrations. For example, visual luminescence allows for determining the presence of fruit and vegetable diseases, assessing milk freshness, cheese maturity degree, and controlling the freshness of meat, fish, and eggs, establishing the type of flour, and detecting adulteration of vegetable oils [23, 24]. Depending on the degree of freshness of products, different shades and intensities of luminescent glow are observed;
- portable voltammeters and voltammetric sensors. Voltammetric methods allow for high-sensitivity determination of heavy metals (lead, cadmium, mercury, copper) in food products. In commodity expertise, these methods are used to monitor the safety of vegetables, fruits, cereals, fish, and seafood. Control can be carried out directly at raw material acceptance points or during customs inspection of imported products [25, 26];
- polarographic apparatus for detailed analysis of trace nitrites and nitrates in liquid solutions and solutions with extracts of product samples. Polarography is used to study the redox properties of food components. In commodity science, this method is used to determine nitrites and nitrates in meat products, vegetables, and semi-finished products. Increased nitrite content may indicate technological violations and potential health risks, making polarographic express methods an important tool for expert assessment [5, 27].

Immunological and enzyme immunoassays in the form of kits, bioluminescent surface/hygiene ATP tests, and colorimetric/enzymatic kits have become indispensable tools in commodity science and food control. They trade some analytical depth for speed, ease of use, low cost, and suitability for decentralized testing in production, retail, and inspection points [4]. Residues, additives, and contaminants can be detected with simple colorimetric and immunological kits [28].

In recent years, traditional culture-counting tests for microorganisms have become obsolete for real-time applications as they are labor-intensive, while immunological assays are known for their speed and accurate quantification of target organisms [4].

Disadvantages of test systems include low analytical specificity and sensitivity compared to laboratory reference methods, semi-quantitative or qualitative results, and the need for careful validation. Therefore, positive or borderline express test results must be confirmed by standardized laboratory methods [12].

CONCLUSIONS FROM THIS STUDY

The analysis of literature and the synthesis of modern approaches to food quality and safety control demonstrate the growing role of rapid analysis methods in commodity science and expertise. In a highly competitive food market, characterized by stricter regulatory requirements and increased consumer focus on quality and safety, the speed of obtaining reliable analytical data has become a critical factor for the effective operation of food industry enterprises and retail chains.

Rapid analysis methods should be regarded as an integral component of the modern system for commodity evaluation and food expertise, bridging scientific, technical, economic, and marketing perspectives. Their integrated use, in conjunction with classical analytical approaches, enhances the safety and quality of food products, strengthens consumer trust, and increases the competitiveness of food industry enterprises.

The application of express methods significantly reduces expertise time, decreases material and energy costs, optimizes logistics, and ensures continuous quality control throughout the entire product lifecycle - from raw material acceptance to final sale. A key advantage of rapid methods is the possibility of their implementation directly within production environments, storage facilities, and retail points, which improves the efficiency of preventive control and mitigates the risk of low-quality or hazardous products reaching the consumer.

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