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IMPROVEMENT OF METROLOGICAL SUPPORT FOR THE PRODUCTION OF MILK AND DAIRY PRODUCTS

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The digital transformation of the economy already requires the creation of fundamentally new technologies for metrological support of key life support systems and means of production. Such systems are built using a large number of sensors that transmit huge arrays of measurement results. Metrological support is one of the fundamental conditions for their accurate and uninterrupted operation. Therefore, the system of ensuring the uniformity of measurements should become one of the drivers, and not a brake on the introduction of digital technologies in industry, which also requires its digital transformation.

Today, in advanced countries, from a metrological point of view, projects in the field of digital metrology are being implemented in their countries today. For example, in Germany, the main emphasis is on the creation of a metrological cloud, a digital calibration certificate, digital SI doubles to increase the reliability of the uncertainty assessment of measurement results.

To this end, it is advisable that in the future the following functions should be implemented in the metrological cloud:

- electronic platform for interaction of suppliers and consumers of SI and metrological services;
- a library of digital doubles, including mathematical models of SI, standards, measurement and testing processes, virtual measurements and tests; - a center for collecting, storing and processing data flows on metrological works (services) from performers of works (services) of their consumers and owners of SI (as part of the "transaction" of the regulator and the consumer);
- «smart» analytics of the system for ensuring the uniformity of measurements as a whole and individual measuring systems and complexes, including: assessment of potential risks of unfair actions of the organization's verifiers; monitoring, analysis of the state of the SI fleet and working standards;
- analysis of trends and dynamics of changes in the SI fleet and working standards; assessment of the needs for measurements of the country's economy and society. As other directions of digital transformation of the system of ensuring the uniformity of measurements, it should be noted the projects being implemented today in the field of remote verification of SI, the creation of digital twins in the field of measurements of geometric parameters of surfaces of complex shape.

An important trend in recent years is the emergence and growth of the number of «smart» systems: intelligent energy accounting systems, wireless digital measurement systems for oil refining management, production, equipment condition monitoring, intelligent collision prevention systems in transport, etc. The modern challenge to the system of ensuring the uniformity of measurements is the advanced development of the SI fleet - the transition from analog SI to «smart». So far, their share is small.

«Smart» SI and intelligent digital measuring systems are: adaptability and reconfigurability – the ability to change parameters and/or algorithm of operation depending on external signals during operation;

the ability to process and analyze measurement information and present it in the required form;

self-control – self-assessment of the condition (self-verification) and transfer of data about it to a higher-level system;

self-correction - automatic error correction, self-calibration and self-calibration;

versatility and information compatibility at the technical and software levels provide easy network connection to any systems and equipment, including information or measurement systems of a higher level, as well as the transmission of the required information; multi-channel measurements using different units of quantities.

Today, there is a contradiction between the trend of development of instrumentation with an emphasis on «smart» SI and the existing system of state regulation, which does not take into account and does not use the new qualities that «smart» SI and intelligent digital measuring systems created on their basis have received (will receive). The procedures of the state regulation system are built to work with analog SI with paper document management, which results in low efficiency of metrological services and incomplete controllability.

To successfully overcome this contradiction , it is necessary:

- creation of legislative bases for the use of digital technology achievements in metrological services (digital doubles, virtual measurements, virtual tests, etc.);

- development of mandatory requirements for intelligent measuring systems and the procedure for assessing their compliance with these requirements;

- creation of a mechanism for full-fledged feedback with manufacturers and operators of SI, to obtain data on the production of SI in the country, the composition and structure of the fleet of SI, an information «image» about instrumentation in general and about the owners of SI using them.

Another important area of work on the development of the regulatory and technical base in the field of ensuring the uniformity of measurements is standardization in the field of metrological support.

In the reporting period, the priority areas of standardization in the field of metrology remained ensuring the uniformity of measurements in such areas as the oil and gas complex, medicine, energy conservation, GLONASS system, optics and optical devices, non-destructive testing, mechanical engineering, development of metering and control devices, which allows to assist in solving social problems (such as improving public health care, environmental protection); ensuring the competitiveness and quality of products (works, services) and promoting compliance with the requirements of technical regulations.

Standardization activities were aimed at the development of standardization documents – standards, rules and recommendations on the basic norms and rules for ensuring the uniformity of measurements, SI, standards and verification schemes, SI verification methods, as well as the development of tables of standard reference data (SRD) on physical constants and properties of substances and materials.

The modern methodological base (GOST standards for control methods, existing guidelines, MVO) does not allow to fully assess the quality and safety of the product, to determine its identification features. One of the reasons is that for many defined parameters or components there is no methodological basis at all. Therefore, when developing a production control program at dairy enterprises, it is necessary to take into account, first of all, the peculiarities of production and technology, supplement it with instrumental methods, establish where rapid control is needed, and accumulate data on indicators in a significant amount.

The analysis of the literature data showed that in international practice the level of instrumentation for the analysis of milk and dairy products is quite high. Previously, such devices were used most often for scientific research. Now, as the literature analysis has shown, the trends of analytical instrumentation are associated with the introduction of high-quality devices directly into production conditions. [1-3]

The development and use of modern methods allows experimental procedures to be carried out quickly regardless of the presence of chemical reagents. With the use of modern equipment, milk and dairy products, due to their multicomponent composition, can be divided into individual chemical compounds, the quantitative analysis of which is provided by properly selected measuring equipment and data processing systems.

Along with the development and implementation of new experimental methods, the developed classical measurement techniques are constantly being improved. In order to identify products at the stage of input control, it is necessary to apply an integrated approach, i.e. to evaluate the main quality assessment criteria by standardized methods, and in the absence of evaluation methods, to apply developed and metrologically certified measurement methods. [4-6]

According to modern requirements for measurements, the control method is selected in accordance with the developed production control program, as well as with the possibility of laboratory control of enterprises, a feature of the technology.

At the entrance control, express methods can be used (especially for raw milk), indicator and other control methods that allow you to quickly assess the quality, but provided that they are accompanied by certified measurement methods (MVI). Otherwise, the measurement results may be incorrectly evaluated and interpreted. [6]

The entire control procedure is focused on meeting the requirements of legislative and regulatory documents "On technical regulation", "On ensuring the uniformity of measurements", national and interstate standards, regulatory documentation for the product. At the same time, the main task of technochemical (production) control at the enterprises of the food and processing industry is the production of products of guaranteed quality.

Its solution can be imagined by dividing the entire system, primarily the input control of raw materials, into component parts: [7]

- evaluation of products by quality indicators (organoleptic, physico-chemical, microbiological);
- assessment by safety indicators;
- evaluation by additional quality and safety indicators, knowledge of which is necessary to comply with all the requirements of the production process (thermal stability, rennet-fermentation sample, preservatives, lactate content, citrates);
- identification by the components of the product (by the composition of proteins, fat).

All this entails the need to improve the methodology of research on milk and dairy products in the direction of their accuracy and reproducibility of results using highly effective methods of analysis. [5]

In recent years, such methods as gas and liquid chromatography, atomic adsorption spectrometry, photometry, capillary electrophoresis have also been used more and more widely abroad.

In particular, the following research methods are being introduced into analytical practice:

- to determine the composition of proteins and polysaccharides - gel filtration and exclusive chromatography;
- amino acid composition - ion exchange chromatography and capillary electrophoresis. [8]

To prepare the product for measurements, there are a number of modern equipment - furnaces for mineralization of samples, ultrasonic baths, laboratory homogenizers that allow the sample to be uniformly crushed.

Let's look at several methods in more detail.

As you know, milk is one of the most frequently adulterated products.The easiest way to adulterate milk is deliberate dilution with water. Cryoscopic and hydrometric methods of analysis and other instrumental devices are used to detect flooding. [8]

Cryoscopic determination methods based on measuring the lowering of the freezing point of a solution compared to the freezing point of a pure solvent.

To date, a type of cryoscopic method has been studied – laser cryoscopic viewomilliosmometry. Modern cryoscopic osmometry, based on measuring the depression of the crystallization temperature of solutions and biological fluids in milliosmometers-cryoscopes that allow determining the freezing point (in the USA, such devices are called "freezingpointdepressionosmometers"), is an accurate additive method for measuring the concentration of osmotically active substances in micro-volumes. [9]

This method allows you to work in automatic mode. Implementation of this type is available for dairy farms and laboratories with full-time engineering staff. The configuration and, consequently, the cost of modernization are flexible and depend on the customer's tasks.

The handbook of many English-speaking food producers "HandbookofIndicesofFoodQualityandAuthenticity" in the section "Milk&MilkProducts" repeatedly emphasizes the importance of using osmometry-cryoscopy for milk quality control. In the classic textbook "MethodsforProteinAnalysis", methods of osmometry of freezing temperature depression are considered in application to enzymatic (enzymatic) lactose hydrolysis in milk. The quintessence of this approach is the technology of nanoliter osmometry, in which measurements are made in extremely small volumes of liquid and can be carried out under a microscope. [9]

One of the actively developing methods of measuring milk and dairy products is IR Fourier spectroscopy, especially in the near PC region. An essential feature of IR analyzers is the need to use a representative array of natural product samples for calibration. [10-12]

Optical methods based on the ultraviolet, visible and near infrared spectra to assess the fat and protein content in raw milk.

Optical methods are used to monitor the quality of milk on dairy farms in order to increase productivity and reduce costs. The most commonly used method for determining fat is the Gerber laboratory method and the Lowry method for determining protein; in addition to its sensitivity, a large amount of time is required for analysis. It is also susceptible to interference caused by compounds used in sample preparation. The chemicals used are in many cases harmful to laboratory personnel.

Commercial milk analyzers are used by global milk processing corporations to assess the quality of milk; the most common in practice are MilkoScan (FossElectric A/S, Hillerød, Denmark) and Lactoscan (MilkotronicLtd., Nova Zagora, Bulgaria). Despite their common use, both systems are stand-alone analyzers. MilkoScan is based on infrared Fourier Transform (FTIR) analysis of the wavelength range between 2500 and 25,000 Nm. On the other hand, the determination of Lactoscan is based on an ultrasound method that measures the time during which the sound crosses the milk sample. In both cases, milk samples must be delivered to the laboratory where the system is installed, and then, after a few seconds, the results are shown. Finally, the milk sample is disposed of. As a result, in recent decades, a number of research groups have developed many techniques, the principles of which are based on nuclear magnetic resonance (NMR); traditional digital imaging; ultraviolet (UV) illumination, visible (VIS) light effects and infrared (IR) spectroscopy; electrical conductivity; fiber-optic sensors, etc. [9]

Measurement of the fat content in milk by a simple UV spectrophotometric method: an alternative screening method.

The authors [11] have developed simple microtechnics for measuring lipids in milk using UV spectrophotometry. This method is based on the property of fatty acids to absorb ultraviolet light in proportion to their concentration. The accuracy estimated using recovery and replication techniques is also very acceptable. This method is suitable as a fast and cost-effective alternative screening method for assessing the milk fat content in small samples without preliminary extraction of lipids.

Milk phospholipids are gaining more and more interest due to their nutritional and technological properties. A new HPLC method has been developed using an evaporative laser light scattering detector, which made it possible to perfectly separate glucosylceramide, lactosylceramide, phosphatidine acid, phosphatidylethanolamine, phosphatidylinositol, phosphatidylserine, phosphatidylcholine, sphingomyelin and lysophosphatidylcholine in less than 21 minutes, including column regeneration. No loss of column performance was observed after 1500 runs due to the use of an acid buffer. [11]

Measurement of the total solids content in milk using microwave heating.

The milk trade has long been based on the fat content in milk. A recent problem is the increase in the number of cows whose milk shows no correlation between fat content and non-fat solids (SNF). Therefore, a measuring device is needed that allows you to quickly determine the total dry matter content in milk (TMS). Solids that are not fat are obtained by subtracting the fat content measured by the existing method from the ISM.

A method of dynamic measurement of the input impedance of a microwave oven is described in [12]. The method uses the magnetron itself as a signal source instead of a fixed frequency generator used to measure static impedance.

Analytical methods of specific identification of milk and dairy products.

Recently, Raman spectroscopy has become a powerful and popular tool for analyzing food systems. Based on the characteristic fluctuations of the studied material, it is possible to get an answer to the question of its content and structure.

In [13], Raman spectroscopy was investigated in order to assess the lactose content in milk. Currently, about 70% of the adult population worldwide suffer from lactose intolerance. To avoid the exclusion of milk and dairy products from the diet, manufacturers are forced to produce lactose-free products.

To fulfill this requirement, it is necessary to have the appropriate equipment for fast, simple and prompt determination of the lactose content in milk or dairy products. Raman spectroscopy is one of the rapidly developing modern spectroscopic methods, extending to many industries, including the dairy industry.

Thus, the task of improving the quality and safety of milk and dairy products is impossible without improving metrological support. Dairy enterprises are in urgent need of the development and implementation of modern means and methods of control of raw materials, parameters of technological processes, finished products, etc.

In these conditions, further improvement and development of the entire system of metrological support of milk production is required, taking into account the requirements of the Laws of the Republic of Kazakhstan «On Standardization», «On ensuring the uniformity of measurements». It should be noted that confirmation of conformity of milk and dairy products is also impossible without scientifically based methods and means of its metrological support.

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IMPROVEMENT OF METROLOGICAL SUPPORT OF MEANS OF NON-DESTRUCTIVE MEASUREMENT OF CONCRETE STRENGTH

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There is a direct relationship between product quality and measurement quality. In enterprises where the measuring business is established as required, the quality of products and services, as a rule, is higher. And, conversely, where the quality of measurements does not meet metrological requirements, high quality products and services cannot be expected. Thus, the level of metrological support of measurements at the enterprise directly affects the quality of products and services. In this regard, the improvement of metrological support of measurements is the most important task, the quality and competitiveness of products and services largely depends on the solution of which.

Metrological support of construction is activities related to the use of scientific and organizational methods, norms and rules, equipment necessary to achieve the unity and accuracy of measurements in the design, construction and operation of buildings and structures.[1]

The main objectives of metrological support of construction are:

- improving the quality and environmental safety of construction products;
- improving the efficiency of construction production management;
- provision of metrological support for product certification;
- improving the efficiency of experiments and tests [1].

The number of control and measurement operations in construction is constantly increasing, exceeding in some cases the number of technological operations, and errors in their implementation equally reduce the quality indicators of construction.

Measurements are the main source of information on the quantity, properties, physico-mechanical and geometric characteristics of building materials, structures and technological processes, on the basis of which accounting, management and technical improvement of all stages of the construction of buildings and structures are carried out.

The most important element of the uniformity of measurements is compliance with the uniformity of measuring instruments by ensuring that their characteristics meet the specified requirements during operation. Another component of metrological assurance - measurement accuracy - is characterized by the proximity of the results to the true value of the measured value and is achieved by establishing standards of accuracy and certification of measurement techniques.

Thus, in accordance with the definition given earlier, metrological support is practically reduced to the functioning of metrological bodies and metrological control over the design, manufacture and operation of construction products. The objectives of metrological support for the construction of buildings and structures are: