С.Сейфуллин атындағы Қазақ агротехникалық зерттеу университетінің экономикалық факультетінің 60 жылдығына арналған **«Жаңа болмыс жағдайында экономика және қоғам»** Халықаралық ғылыми-практикалық конференциясының **материалдары,** 25 мамыр 2023 жыл, I бөлім= **Материалы** Международной научно-практической конференции **«Экономика и общество в условиях новой реальности»,** посвящённой 60-летию экономического факультета Казахского агротехнического исследовательского университета имени С.Сейфуллина, 25 мая 2023 год, I часть = **Materials** of the International scientific and practical conference **«Economy and Society in a new reality»** dedicated to the 60th anniversary of the Faculty of Economics of the S. Seifullin Kazakh Agrotechnical Research University, May 25, 2023, I part. – 2023. – Ч.1. – P.358-364.

DIGITALIZATION AS THE BASIS OF A MODERN APPROACH TO PROVISION OF RAW MATERIAL AND PRODUCT TRACEABILITY IN THE AGRO-INDUSTRIAL COMPLEX

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In accordance with the Law of Ukraine «On the Basic Principles and Requirements for Safety and Quality of Food Products» [1], the term «traceability» is defined as «the ability to identify a market operator, time, place, subject and other conditions of delivery (sale or transfer) sufficient for establishing the origin of food, food-producing animals, food-contact materials or substances intended to be included or expected to be included in food, at all stages of production, processing and circulation». The traceability of food products is provided for by the international quality management standards ISO 22000:2005, ISO 22005:2007 and the national standards of Ukraine DSTU ISO 22000:2019 «Food safety management systems – Requirements for any organization in the food chain» [2] and DSTU ISO 22005:2009 «Traceability of feed and food chains. General principles and basic requirements for the development and implementation of the system» [3].

In the «from field to fork» system, traceability covers the entire food chain from forage harvesting to consumption of finished products. The principal stages of the food chain are: feed production, cultivation / procurement of raw materials, processing / production of finished products, storage, transportation and retail trade / sale. The primary food chain encompasses four main areas of action: the economy, creation, environment and social and legal. Proper traceability in the raw material chain means the ability to effectively supervise food, feed, animals or food substances at all stages of production and distribution.

The issue of providing raw and product traceability has been one of the key issues for the world's leading food producers and retail chains for many years. Traceability systems allow you to quickly and at minimal cost withdraw products in

case of detection of their defects at any stage of production or delivery, establish the causes of defects and take the necessary measures to prevent further distribution of inappropriate raw materials and finished products [4].

There are three main concepts of traceability: identification, registration and data processing. The first concept, identification, refers to the association of a physical product with information about that product. Identification is necessary to distinguish it from other similar products. The second concept, registration, allows access – through the primary information needed to identify the product – to the secondary information about the product at the stages of production or processing, as well as distribution. The third concept, data processing, depends on the purpose of each specific traceability system, which is suitable for assessing crisis situations and controlling problematic products [5,6]. Of course, raw and product traceability, in one form or another, has been used by mankind at all stages of the development of civilization – both based on industrial and commercial feasibility and implying food safety and quality. In the pre-computer era, compliance with traceability requirements was implemented through the circulation of phytosanitary and veterinary certificates, as well as shipping documents in paper form. The development of informatics and computer technology, digitalization in general has become the material basis for a real revolution in ensuring the traceability of raw materials and products in the agro-industrial complex.

First of all, we should dwell on the use of blockchain technologies, which have already shown their effectiveness both in the agricultural sector of the agro-industrial complex [7] and the food industry [8]. Blockchain is a ledger operating on distributed accounting tools for making collective decisions with fully time-ordered and open access to operations in all nodes of the network. Each member of a certain circle of records is provided with a personal copy of the data, synchronization is also displayed for other users. Blocks are constantly created in the base, each new block containing a group of recently accumulated and ordered transactions. The lack of network centralization allows data to be transferred between nodes without intermediaries, which eliminates data forgery [9]. The use of blockchain technology makes it possible to go through the entire chain in a few seconds, detect and eliminate sources of contamination, and protect additional accompanying data, for example, information from temperature recorders, the data records of which are transmitted directly in real time [10]. Therefore, falsification of data on non-exceeding of threshold temperatures in cold supply chains is excluded. Blockchain technology not only significantly contributes to the achievement of food safety, but also helps to protect the interests of consumers in obtaining truthful information concerning it [11].

To build a modern system of raw and product traceability, it is proposed to combine blockchain technology with the IoT (Internet of Things) technology. This combination should reduce errors during data entry, contribute to the provision of reliable product traceability data and reduce the risk of tampering through the use of advanced technical solutions RFID (Radio Frequency Identification – high-frequency identification) and NFC (Near Field Communication – near contactless communication). Information provided by a particular subject or sensor in the chain

can be directly attributed to it without the possibility of extraction or modification. The data emanating from each node (component) of the supply chain can demonstrate the quality of all intermediate products and the conditions in which each participant works in the chain.

When equipping electronic traceability (ET) systems, the following fundamental points should be taken into account. By recording tracking and tracing data, the systems should, together with identification and data collection using AIDC (Automatic Identification and Data Collection) technology, be integrated at the company level with management and technological control systems to simplify data analysis and exchange (Fig. 1).

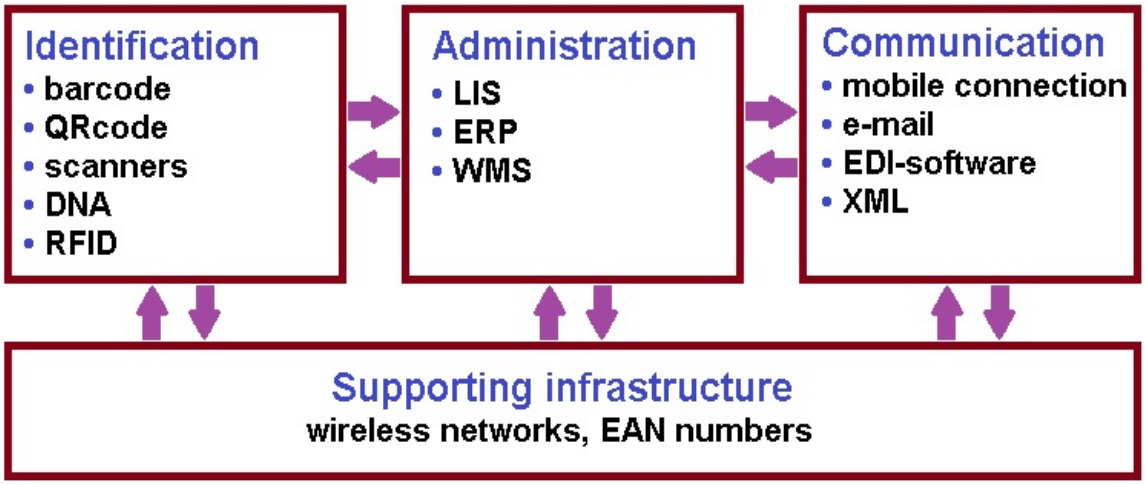

Figure 1. Information and communication: tracking and tracing systems – modified from

You can use this data to plan and evaluate production. Examples of process control systems include warehouse management systems (WMS), laboratory information management systems (LIS), and enterprise resource planning (ERP) systems. In addition, systems such as Electronic Data Interchange (EDI) or Extended Markup Language (XML) are necessary for the transmission of traceability data. Also, a common and standardized infrastructure is needed for efficient and effective data exchange in the supply chain. For example, the EAN Association (European Article Number), which develops standards for use in logistics systems, or a similar US organization GS_1 US [11,12] can be referred to as such.

Automated identification and data collection systems (AIDC) have proven to be effective in practice. An identification within AIDC can be a numeric or alphanumeric string in a read-only format that gives access to data stored elsewhere. However, the amount of information that can be transferred to the identification system can be efficiently and quickly increased [11]. Implemented AIDC technologies always provide with availability of detailed information about the product and its history, the said information can be checked and matched with purchase orders before shipment of product packaging, which contributes to quality assurance. In transportation, AIDC technology makes it possible to track the location of goods for timely delivery, prevent theft, and control the conditions of

transportation, thereby preventing food damage and spoilage. In retail outlets, AIDC technologies allow you to track the presence/absence of goods on the shelf in automatic mode and quickly eliminate the shortage of goods on the shelf. AIDC technologies contribute to prompt and secure payment for purchases, fully complying with the format of the CRM (Customer Relationship Management) system [13]. The main sectors of application of AIDC technologies are shown in Fig. 2.

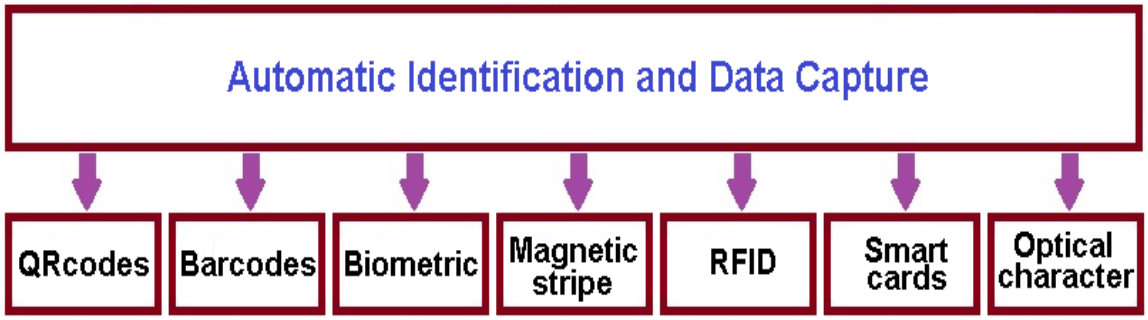

Figure 2. Principal methods to use AIDC systems – modified from

For several decades, the labeling of goods, including food products, has been widely used using machine-readable barcodes. Each barcode consists of a series of strokes and spaces printed in a specific order. The barcode scanner sees it and turns the visual image into an electrical signal. Barcode technology includes characters that encode data for optical reading, printing technologies that create machine-readable characters. Scanners and decoders take visual images and turn them into computer-compatible digital data, while verifiers check the quality of characters. A further development of the consumer barcode was two-dimensional QR codes, each of which consists of dark (logical "1") and light (logical "0") modules. The modules are evenly distributed in a square network of fields, where the size of the field is equal to the size of one module. The size of one module should be 4x4 pixels with a print resolution of 300 dpi. Such dimensions provide reading of the majority of optical devices [13].

The practice of developing raw materials and commodities traceability systems through Radio Frequency Identification (RFID) has already been sufficient, the said systems covering a number of methods for transmitting data from an identifier to a reader of a radio frequency communication line. Once the data is captured by the reader, it can be transferred via a standard interface to a server, printer, or PLC for storage or initialization of actions. RFID is increasingly being used in warehouses for logistics and food chains, such as tracking animals from birth to slaughter and processing, as well as recording/transferring feed data, antibiotic use, health data, weight data, etc. In animal husbandry, the information carrier is made in the form of an ear tag or a chip embedded in the animal's body in a different way [11,13,14].

Biometric methods of identification of living organisms are absolutely accurate and safe in relation to them. There have been numerous attempts to apply this method in the agro-industrial complex for the DNA identification of animals.

However, this method, despite its impeccable accuracy and other positive characteristics, is still too complicated and expensive. Optical Character Recognition (OCR) has not found wide practical application, mainly due to the complexity of software and reading devices [13, 14].

In conclusion, it should be noted that electronic systems for ensuring raw materials and commodities traceability based on modern automatic identification and data collection systems are constantly evolving and new technical innovations in this area are expected. A new important step in the availability of traceability data for both market operators and ordinary consumers has become the widespread use of mobile telephony, thanks to which the provision of raw materials and commodities traceability has become interactive.

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