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GENERAL PROVISIONS AND PRACTICAL WAYS TO ENSURE TRACEABILITY OF RAW MATERIALS AND PRODUCTS IN BAKERY INDUSTRY

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The subject *is the introduction of raw materials and food traceability in bakery production, envisaged as part of the mandatory implementation of Hazard Analysis and Critical Control Points (HACCP) food safety systems, using the latest electronic technologies.* ***The purpose of the study*** *is to analyze the scientific foundations for the development and practical implementation of raw material and product traceability systems in bakery production, outline and scientifically substantiate the possible measures for its organizational improvement, the involvement of modern technologies and technical measures, etc.* ***The results of the study*** *An integral part of the HACCP protocols is raw material and product traceability, which means the ability to trace the movement of agricultural raw materials or food products through a certain stage of production, processing and distribution. For the bakery industry, the main stages in the implementation of this traceability are the preparation of the main raw materials (primarily flour), other ingredients, the production process, distribution of finished products, etc. Within the framework of traceability systems to ensure tracking and tracing, as well as to control and optimize the process in the supply chain, the collection and registration of data necessary for market operators is carried out to improve and reduce the cost of product recall procedures, improve risk assessment, etc. To achieve the appropriate raw materials and products traceability, blockchain and IoT technologies are used, which have shown their effectiveness. Currently, electronic traceability systems based on the use of barcodes, QR codes and high-frequency identification, mobile communications, etc. have become widespread.* ***Scope of research results.*** *The results of the studies performed will be used to improve the food safety of bakery products by improving raw materials and product traceability in the raw materials - production distribution chain, the introduction of new electronic technologies aimed at providing full objective information to all parties involved in this chain, as well as to consumers of bakery products.*

Key words*: bakery industry, food safety, HACCP systems, raw materials and food traceability, electronic traceability, blockchain technologies*

ЗАГАЛЬНІ ЗАСАДИ ТА ПРАКТИЧНІ СПОСОБИ ЗАБЕЗПЕЧЕННЯ СИРОВИННО-ПРОДУКТОВОЇ ПРОСТЕЖУВАНОСТІ У ХЛІБОБУЛОЧНОМУ ВИРОБНИЦТВІ

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Предмет дослідження *– запровадження передбаченої у рамках обов'язкового впровадження систем безпечності харчових продуктів HACCP (Hazard Analysis and Critical Control Points – аналіз ризиків та контроль у критичних точках) сировинної та продуктової простежуваності у хлібобулочному виробництві із застосуванням новітніх електронних технологій.* ***Мета дослідження*** *полягає у аналізуванні наукових засад розроблення та практичного впровадження систем сировинної та продуктової простежуваності у хлібобулочному виробництві, окреслення та наукове обґрунтування можливих заходів з її організаційного вдосконалення, залучення із зазначеною метою сучасних технологій та технічних заходів тощо.* ***Методи.*** *Під час досліджень використовували системний підхід до досліджень фактологічних матеріалів, зокрема наукової та науково-практичної літератури, нормативно-правових актів, нормативних документів тощо; абстрактно-логічний підхід щодо узагальнення результатів дослідження та формулювання висновків****.*** ***Результати дослідження.*** *Невід'ємною складовою протоколів HACCP є сировинна та продуктова простежуваність, під якою розуміють можливість простежити переміщення сільськогосподарської сировини чи харчового продукту через певний етап виробництва, обробки та дистрибуції. Для хлібобулочної промисловості основними етапами реалізації зазначеної простежуваності є підготовки основної сировини (насамперед, борошна), інших інгредієнтів, технологічний процес виробництва, дистрибуція готової продукції тощо. В рамках систем простежуваності для забезпечення супроводу та відстеження, а також для контролю та оптимізації процесу в ланцюжку поставок виконується збирання та реєстрація даних, необхідних для операторів ринку, задля покращення та здешевлення процедуру відкликання продукції, удосконалення оцінювання ризиків та ін. Для досягнення належної сировинної та продуктової простежуваності використовують блокчейн та IoT технології, які показали свою ефективність. Наразі розповсюдження набули системи електронної простежуваності, що базуються на використанні штрих-кодів, QR-кодів та високочастотної ідентифікації, мобільного зв'язку тощо.* ***Сфера застосування результатів дослідження.*** *Результати виконаних досліджень використовуватимуться задля підвищення харчової безпечності продукції хлібобулочної промисловості шляхом удосконалення сировинної та продуктової простежуваності у ланцюжку сировина – виробництво – дистрибуція, впровадження нових електронних технологій, спрямованих*

на повне забезпечення об'єктивною інформацією всіх залучених до зазначеного ланцюжка сторін, а також споживачів хлібобулочної продукції.

Ключові слова: *хлібобулочна промисловість, харчова безпечність, системи HACCP, сировинна та продуктова простежуваність, електронна простежуваність, блокчейн-технології*

Formulation of the problem. The most important task for food industry specialists is the production of useful products in compliance with all the necessary food safety standards. In the recent past, the solution to this problem was achieved through the development and implementation of sanitary and industrial control systems. The proper implementation of the procedures provided for by these systems required the appropriate technical means and the involvement of a large number of personnel, since these systems functioned on the principle of inspection control of raw materials and their transformation during production, packaging, storage and distribution [1]. The reliability of inspection control systems is a positive feature, but these are too complex and expensive to implement. These disadvantages are not characteristic for the HACCP (Hazard Analysis and Critical Control Points) systems, based on the need to optimize the cost of product safety. Since the vast majority of food safety problems arise from the unsatisfactory quality of raw materials and improper processing modes, unauthorized changes in formulations established by technological documentation, non-compliance with the requirements for the sanitary state of personnel, technological equipment and production facilities, the core of the HACCP system is a thorough analysis of possible biological and physical risk factors, therefore the possibility of incidents at the established critical control points (CCP) is constantly minimized [2]. In Ukraine, HACCP systems are mandatory for implementation at all enterprises that produce food products, in accordance with the current Laws of Ukraine [2,3]. Also, these issues are regulated by a number of acts [4,5], which determine the practical aspects of the implementation by market operators of the requirements of the legislation on permanent procedures based on the principles of the hazard analysis and control system in critical points [6,7].

In this sense, the issue of food traceability is extremely important. For many years this issue has been a key one for the leading global manufacturers and retail chains. Traceability systems make it possible to promptly and at minimal cost to withdraw products in case of detection of their deficiencies at any stage of production or delivery, to establish the causes of deficiencies and take the necessary measures to prevent the further spread of inappropriate raw materials and finished products. Food safety of foods and their traceability are at the forefront of government and industry concerns around the world. While consumers want to know which region or enterprise the raw materials come from, how those have been got, what technologies were used in the production of food products, etc.

Traceability can be defined as the ability to track and trace vegetable and animal products, food and feed, the animals or plants from which the food is obtained, a substance intended or expected to be found in food and feed, throughout all stages of production, processing and distribution. Traceability covers all stages from primary production to final consumer sales, including production and distribution stages, and aims to protect human health at the highest level in the relevant food. The traceability system is a system that starts with the exit of a certain product or input from the enterprise, and then follows the intermediate stages, transactions, and the new products into which they are transformed until they reach the consumer. The basic elements of a traceability system are: identification of all products and inputs, units or lots; collecting and storing information about theirs transfers; finally – the establishment of a system mutually associating the above features [8].

The maintenance of traceability is all the greater relevance for Ukrainian producers and merchandisers post-production workers. In order to ensure that the traceability is passed by the legislation, it is safe for living products in the European Union and in the countries of the world.

The ease of use of products is transferred to the international standards for management of quality systems ISO 22000:2005, ISO 22005:2007 and the correspondent national standards of Ukraine DSTU ISO 22000:2007 "Food safety management systems – Requirements for any organization in the food chain" [9] and DSTU ISO 22005:2009 "Traceability in the feed and food chain – General principles and basic requirements for system design and implementation" [10].

In the Law of Ukraine "On the basic principle of that, until the safety and quality of food products" [3] the term "traceability" is defined as "the ability to identify the market operator, time, place, item and other conditions of delivery (sale or transfer) sufficient to establish the origin of food products, animals intended for the manufacture of food products, materials or substances in contact with food products, intended for inclusion, or are expected to be included in food, at all stages of production, processing and circulation."

An effective traceability system is a means by which a food market operator can track food products along the entire food chain, from raw material production to retail distribution.

The main purpose of traceability is to find the source of a food safety problem as quickly as possible and take all necessary steps to recall / remove a particular food from circulation. In the event of an incident with a food product, in the absence of a traceability system, the process of withdrawing / recalling a food product is more complex, time-consuming and requires more efforts and resources than with such a system.

The lack of a traceability system and, as a result, the prompt response of the food market operator to a certain problem can damage the business entity and pose a threat to the entire raw material chain.

The trust of market operators in each other is also impossible without an effective traceability system in each of them.

The large number of food market operators, the volatility of supply and the perishability of food products have increased the relevance of the use of traceability systems on the broadest basis in order to ensure a quick response in the event of food safety problems.

The information captured during the application of the traceability system allows:

- to provide the consumer of the food product with accurate information on the purpose, composition and origin of the food product;
- improve and reduce the cost of the food recall procedure;
- improve risk assessment for competent control authorities.

Therefore, the introduction of an effective traceability system is an important component of guaranteeing food safety [11-15]. The skepticism about food safety, unfortunately, often quite reasonable, is typical for consumers in all civilized countries. This necessitates the creation of sufficiently effective and trustworthy traceability systems in order to successfully control the physical flow of products throughout the supply chain. These systems must be able to identify every unit of food produced from field to fork [16-17].

Materials and methods. The subject of this material is the improvement of raw material and product traceability in bakery production, as an indispensable component of the mandatory HACCP food safety systems. In order to carry out the research, a systematic approach to factual materials was used, in particular, scientific and scientific-practical literature, regulatory legal acts, regulatory documents, etc., an abstract-logical approach to generalize research results and formulate conclusions.

Results and discussion. Each of the created traceability systems must meet a number of requirements. First, all products that are traceable in the supply chain must be identified. In addition, the method for identifying a product must be the same for all participants in the supply chain. Otherwise, data synchronization is necessary, which will lead to increased data cost and poor quality [16-18]. The recognition level determines the accuracy and quality of traceability. The highest level of analysis in the chain is the identification of a single element – in this case, the cost and complexity of information management increases significantly. A lower level of

accuracy is the identification of containers, shipping pallets or batches. Accordingly, in this case, the costs are much lower [16,17,19]. Traceability concerns the product, that is, raw materials, processing history, sales and location, as well as data – calculated and obtained within the quality loop [16,17,20]. The actual replenishment of traceability depends on the characteristics of the life cycle of the food product. If food raw materials and food masses for the production of food are processed, information on batch distribution, raw materials is required for complete traceability, etc. In contrast, in the case of unprocessed products such as fresh vegetables, complete tracking requires only information about the growing farm and the specifics of the sale, including information about the batch and about the packaging [16,17]. According to [21], traceability is formed by three main concepts: location, state and quality. The location is determined in the course of logistics processes with the physical flows of products, including the time and characteristics of the logistics itself. State refers to the processes that take place in the physical flow of the product and determine the conditions and stages of processing during production and sale. The quality of the product being moved is also determined by the supply chain. Quality is especially important for the fresh produce system as in this sector quality is in a dynamic state and constantly changing. In [22], it is noted that when developing a tracking system for fresh products, it is important to define quality characteristics and corresponding indicators that will characterize changes in product quality at all stages of delivery.

In [21], three main tasks of a traceability system are identified: identification, registration and data processing. Identification refers to the association of a physical product with information about that product, and is important to distinguish it from other similar products. Registration allows access, through the primary information required for product identification, to secondary information about the product at the stages of production or processing, as well as sales. Data processing depends on the purpose of each specific traceability system. At a minimum, such a system should be suitable for assessing crisis situations and controlling problem products; a model for the development of traceability systems (Fig. 1) is proposed in [16,21].

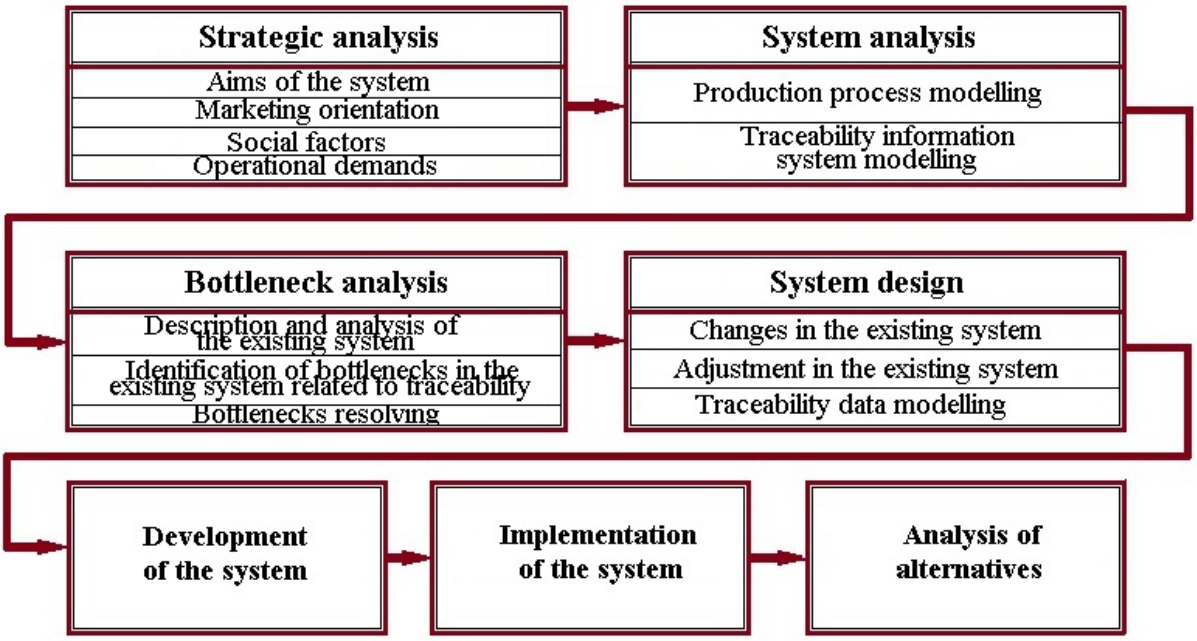

Fig. 1. Development model of a traceability system – modified from [16,21]

In order to ensure the proper functioning of the traceability system in a processing plant along the entire raw materials / products chain, both external and internal traceability should be ensured. An internal traceability system is organized within the enterprise itself, and an external

one – along the entire food chain. External and internal traceability diagram is shown in Figure 2 [23].

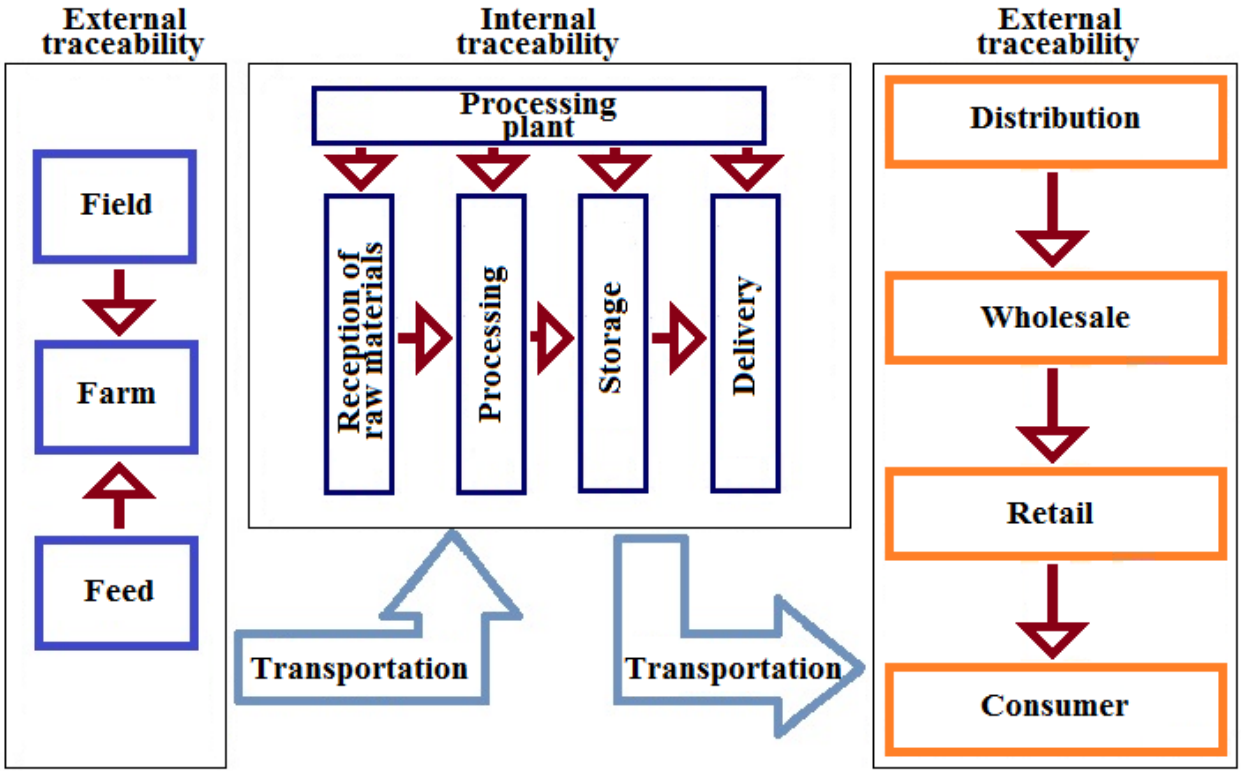

Fig. 2. Internal and external traceability [23]

Each partner in the food chain must fully integrate an internal traceability system, establish appropriate baselines, standard operating procedures, and maintain links between inputs and outputs (Table 1).

Table 1

Components of the internal traceability system

Object	Operational Procedures
Data on raw materials	1. Systems and types of media: paper media 2. Entries: • From whom it was received, the name of the raw material, quality indicators • Accompanying documents, Date of receipt • Where is the raw material sent
Data on production	• How the product components are used and the mixing procedure; • What other ingredients were used when mixing; • When was the processing; • Identification tags of raw materials, ingredients and finished product.
Data on shipping the products	• To whom, how much, when; • Shelf life of traceability documentation

Each internal traceability system implemented should combine:

- ability to promptly recall a product and protect the consumer (and brand reputation) if the product safety does not meet the established standards (requirements);

- ability to minimize the amount of products subject to rejection, reducing the cost of recovery / disposal of products;

- information about the efficiency of the production process, such as the quantity of products produced, at each stage of production;

- ability to identify faults in production and reason to ignore the source of the problem where possible.

Fully complying with the basics of ensuring traceability in the raw food chains of agro-industrial production, the creation of a traceability system in bakery production has certain special features. As described below, the bakery industry can be described in many different ways, either by the type of products made, their position along the value chain, or customer segment. Bakery products can be found in the following forms: ingredients; dry mixes or kits; fillings; icings; pastries; croissants; sweet rolls; bread; buns; rolls (for example, French breads); crackers; cookies; bars; cakes; cupcakes; tarts; pies; biscuits; scones; muffins. The products can be found at one or more of the following positions in the value chain: ingredients (domestic and imported); mixes or kits; ready-to-bake (that is, batter/dough); ready-to-use (that is, filling/icing); ready-to-serve; retail self-serve bulk; retail prepackaged thaw and serve [24]

The system of forming the quality of bakery products from growing grain to selling bread and bakery products includes the following main stages: ensuring the quality of grain at the stage of growing the crop; 2) quality assurance at the stage of grain processing at the elevator; 3) ensuring the quality of processing grain into flour at the mill; 4) ensuring the quality of production of bread and bakery products (bakery enterprise); 5) ensuring and maintaining the quality of products in the processes of preparation for implementation and sale (enterprise, store). Each of these stages includes a number of processes, the implementation of which determines the quality of the final product obtained within this stage. The finished product of each preliminary stage is the next raw material. Therefore, at each stage, an effective assessment of the compliance of the resulting product with the requirements established by the regulatory documentation must be organized. Only with due conformity at all stages can the quality and safety of finished products be guaranteed. For each stage, there are requirements for the quality of the initial product, which is the raw material for the processes carried out within this stage. So, at the first stage, requirements are imposed on the quality of the seed fund, which is the raw material for this stage. The quality of the grain determines the processing method and the efficiency of the processes. Well-cleaned and sorted seeds have the best germination, which makes it possible to provide conditions for obtaining a high yield and reducing the contamination of the harvested grain (stage I). The less contamination of grain is, the lower the cost of processing it. This is due to the fact that the most common method of compensating for the insufficient efficiency of grain-cleaning separators with high grain contamination is the sequential passage of the grain mixture through several machines of the same operating principle. After processing at the elevator, the quality of the grain is determined by the quality of the technological processes of purification, drying, disinfection and the creation of homogeneous batches of grain (batches of seed grain and grain with the highest technological properties). At the same time, the quality and level of training of technical personnel who carry out these processes play an important role. The end product of the elevator is grain with high technological parameters (stage II). At the stage III (as well as at the stage IV), the influence of the quality of technological equipment sharply increases. Stage IV (bakery) is characterized by a sharp increase in the complexity of product quality assurance, since additional components (yeast, salt, water, ingredients, etc.) are used, technologies and equipment are used that require constant monitoring and adjustment of the initial data. Control at this stage covers the entire technological chain – from kneading the dough to controlling the oven temperature. Correction of formulations, technological regulations and process parameters is also carried out when using flour, the characteristics of which differ from the provided technologies. At the fourth stage, the conformity assessment is carried out in the same way as described in the second and third stages.

At the fifth stage, the safety of the quality of bakery products should be ensured during their preparation for the retail sale [25]. The general scheme of the production process for developing a traceability system at a small bakery enterprise for the production of confectionery baked goods is shown in Figure 3 [26].

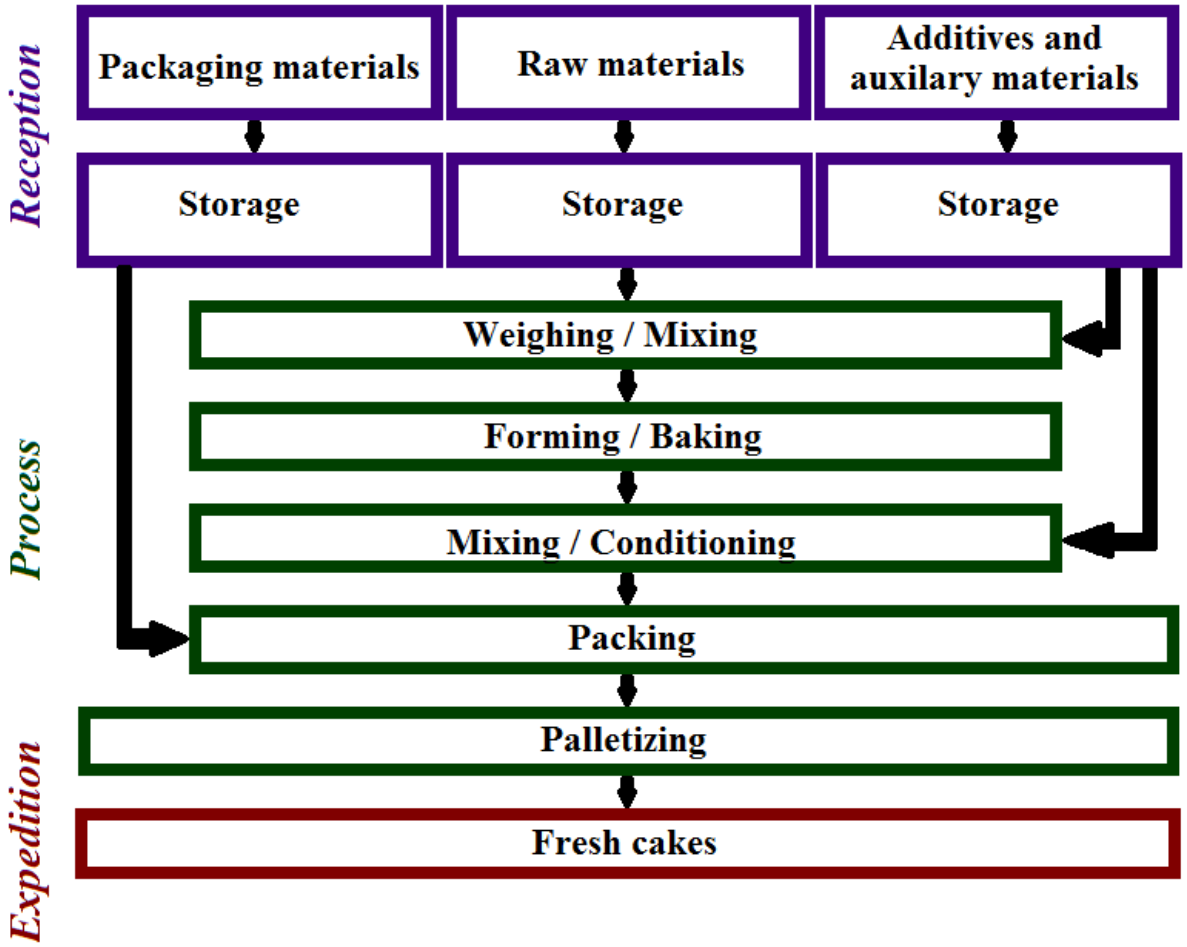

Fig. 3. The scheme of the production process for assigning a traceability system at a small bakery enterprise for the production of confectionery baked goods – modified from [26]

The most important component of the general raw material and product traceability in the production of bakery products is the pre-production stage – the traceability of the origin of raw materials, especially flour, which is the principal ingredient in the formulations of these products. According to [27], the problem of the unstable quality of flour is urgent. Some flour mills do not provide adequate product quality, and bakeries are forced to use flour with reduced technological properties, low or unsatisfactory gluten quality, increased or decreased enzyme activity [27, 28]. One of the most common forms of counterfeiting bakery products is distorted information about flour. When receiving a batch of flour, special attention should be paid to labeling, paying attention to the name of the product, the type of flour, and the amount of flour. In the consignment note, special attention should be paid to the name of the goods, manufacturer and quantity. Assortment fraud of flour most often consists in replacing some varieties of flour with others. The most common assortment fraud of wheat flour is the supply of first grade flour instead of premium grade flour [27,29].

An algorithm for organizing a traceability system (Fig. 3) at an enterprise for the production of bakery products is proposed in [26]. It is necessary to make sure that each raw material received and accompanying documents are correct and match the order communicated

to the supplier, and it is also important to ensure that all raw materials are labeled with a batch (1). To simplify the system, it is appropriate to group several supplier lots into one or assign a separate name to it with due maintenance of traceability between the assigned code and the lot designation provided by the supplier (2). If the supplier does not indicate the raw materials that he provides to the company, this should be requested in accordance with the requirements set out in Regulation 178/2002 [30] (3). Data related to each batch of raw materials must be controlled and recorded (4). Warehouse order should be maintained using the logistic principle of FIFO (first in, first out), proper labeling will facilitate the identification and / or retrieval of raw materials, if necessary (5). Information describing the exact location of certain raw materials can also be recorded in the traceability control system when raw materials are received [26].

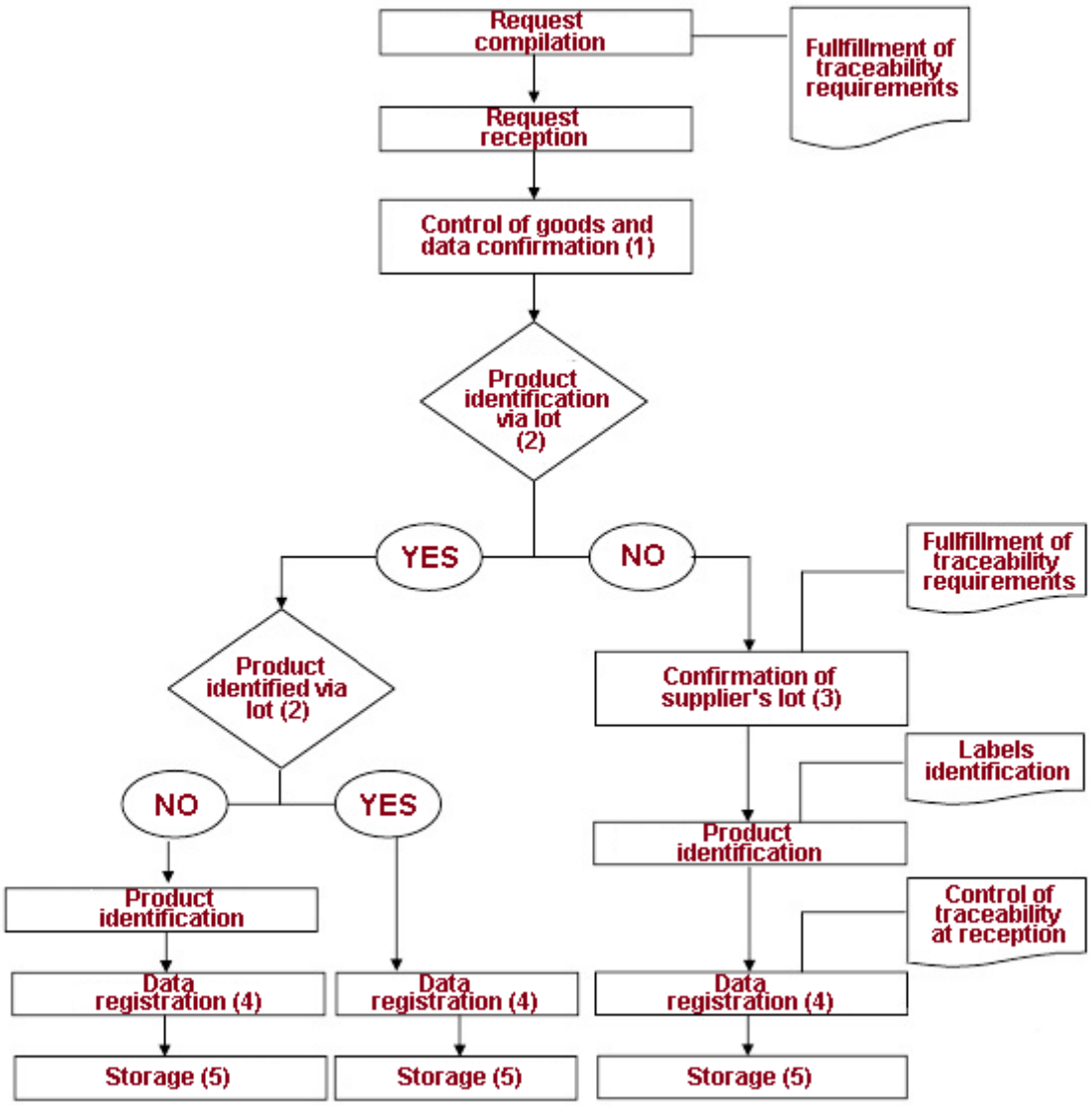

Fig. 4. Algorithm for ensuring screening at the stage of receiving raw materials – modified from [26]

Of course, the production stage is also important in terms of developing the traceability system. When an ingredient or primary packaging material arrives at the production site, the quantity received and the batch details must be confirmed on the accompanying document. Any inconsistencies should be corrected and no further action should be taken until the traceability inconsistencies have been corrected. The best practice is to bring in just the right amount of

ingredients to meet the planned production cycle. This will reduce the number of returns that need to be considered at the end of the production cycle. If an enterprise cannot identify an ingredient or component in the primary packaging with a specific batch, then at a minimum, all batch codes of raw materials should be linked to a specific batch of the finished product. After the end of the production cycle, the loss of the product during processing, the amount of finished products produced and the amount of raw materials that will be returned to the warehouse (proprietary or the client's one), shall be taken into account. When shipping to an internal warehouse, the batch codes and the number of bulk packages should be recorded. The goods will be stored in the warehouse until they are ready for shipment. If the warehouse is owned by a customer, or if finished goods are shipped directly to a retail outlet, the customer's shipping requirements must be followed. After placing the purchase order, the warehouse is notified of the quantity required to fulfill the order. When the product has been accumulated in sufficient quantity to meet the purchase order requirements, the batch code should be checked and the number of bulk packs to be shipped must be counted, the bulk pack quantity and the batch code are passed on to the next recipient in the supply chain. In the absence of an electronic registration system, an invoice is drawn up, which indicates the name and address of the next recipient, the ordered quantity, the shipped quantity and all associated batch codes. The manner in which products are packaged and the number of items per package should also be recorded [24].

To achieve proper raw materials and food traceability, well-known blockchain technologies are increasingly being used, which have shown their effectiveness both in the entire agricultural sector of the agro-industrial complex [31] and in the bakery industry [32]. Blockchain is a ledger that operates on distributed accounting tools for collective decision-making with fully time-ordered and open access to transactions across all nodes in the network. Each member of a certain circle of records is provided with a personal copy of the data, synchronization is displayed for other users as well. Blocks in the base are created constantly, and each new block contains a group of recently accumulated and ordered transactions. Decentralization of the network allows data transfer between nodes without intermediaries, which excludes data forgery [33]. Even with a well-organized system for the circulation of shipping documents, it takes several days, while the use of blockchain technology allows you to go through the entire chain in a few seconds, detect and eliminate sources of contamination, and also protect additional accompanying data – for example, information from temperature recorders, data records of which transmitted directly to blockchains [34]. This prevents counterfeiting of temperature threshold data in cold supply chains. Blockchain technology not only significantly contributes to the achievement of food safety of products, but also helps to protect the interests of consumers in obtaining truthful information about it. Sometimes manipulations with consumer information do not directly harm health, but only contribute to the inflation of retail prices, the excuse for which is, for example, the inflated quality of raw materials, a falsified place of origin, or special processing methods that were not actually used. But this fraud does not always turn out to be completely innocent. For example, if surrogates with allergenic properties are used for products, this can be fatal for allergy patients [35].

To build a modern system of raw materials and food traceability in the bread production chain, it is proposed [32, 36] to combine blockchain technology with IoT (Internet of Things) technology. This combination should reduce the number of data entry errors, facilitate the provision of reliable product tracking data and reduce the risk of tampering through the use of advanced RFID (Radio Frequency Identification) and NFC (Near Field Communication) solutions. The information provided by a specific 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 operates in the chain [32].

Sophisticated electronic means of today provide broad possibilities to make the traceability connection instant and precise. The provided Electronic Traceability (ET) refers to electronic,

rather than paper-based, food tracking and traceability systems that enable participants in the supply chain to effectively respond to potential food incidents that go beyond mandatory ones. The "a step forward and a step back" format also assumes a detailed collection and transmission of information about the attributes of quality and product authenticity [37-39].

The systems that record tracking and tracing data should, along with identification and data collection, using AIDC (Automatic Identification and Data Capture) technology, be integrated at the company level with administrative and technological control systems in order to simplify the analysis and exchange of data (Fig. 5). This data can also be used for production planning and valuation. Examples of process control systems include warehouse management systems (WMS), laboratory information management systems (LIMS), and enterprise resource planning (ERP) systems. In addition, systems such as Electronic Data Interchange (EDI) or Extended Markup Language (XML) are required for the transmission of traceability data. It also requires a common and standardized infrastructure for efficient and effective data exchange in the supply chain. For example, this includes the EAN (European Article Number) Association, which develops standards for use in logistics systems, or a similar US organization GS_1 US [37,40].

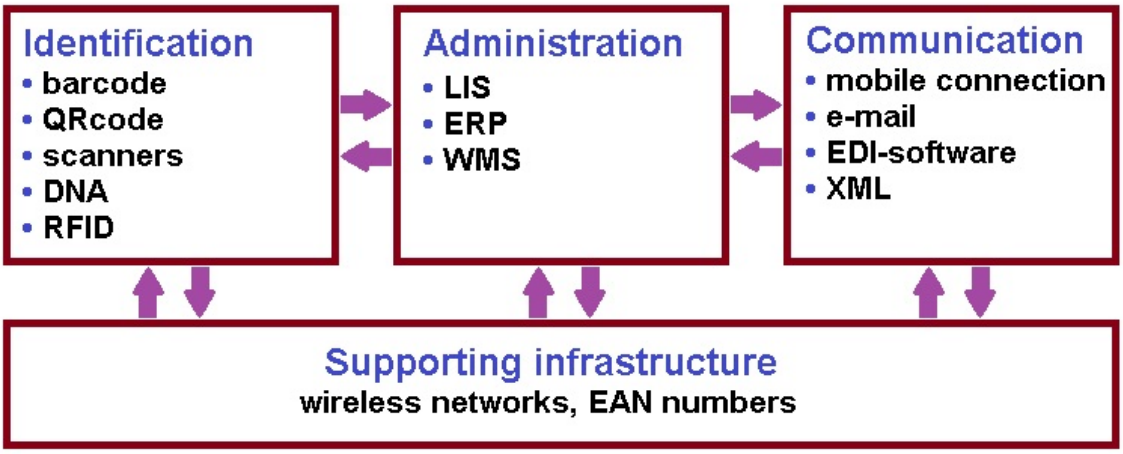

Fig. 5. Information and communication: tracking and tracing systems – modified from [41]

In its simplest form, AIDC identification can be a numeric or alphanumeric, read-only string that allows access to data stored elsewhere. However, the amount of information that can be transferred to the identification system can be efficiently and quickly increased [39]. At the industrial facilities, AIDC technology ensures that detailed product information and history are constantly available, product packaging can be checked and matched against purchase orders before shipment, contributing to quality assurance. These technologies allow to increase labor productivity in the packing and packaging areas, and to use technological equipment more efficiently. In large wholesale warehouses, AIDC technologies allow you to optimize the control of inventories, quality assurance and reduce the time for accounting and inventory, products inside the shipping container can be identified and inventoried without opening it. Content identification and information updating is done automatically, reducing the need for manual labeling, and simplifying order picking and packing – eliminating the human factor, that is, inevitable errors. During transportation, AIDC technologies make it possible to track the location of goods for timely delivery, prevent theft, as well as control the conditions of transportation, thereby preventing damage and spoilage of food. In AIDC retail outlets, technology enables virtually all products to be presented to customers, resulting in increased sales and improved service. The absence of goods on the shelf is automatically monitored and promptly eliminated. AIDC technologies facilitate prompt and secure payment for purchases, fully complying with the format of the CRM (Customer Relationship Management) system [37,42].

A machine-readable code made up of a series of dashes and spaces, printed in a specific order is known as a barcode, it is seen and converted into an electrical signal by barcode scanner the signal being then processed by the decoder by referring to a barcode product guide, which is similar to the brain's processing of information from the human eye. The barcode technology includes characters that encode optical readable data, printing technologies that create machine-readable characters. Scanners and decoders take visual images of symbols and convert them into computer-compatible digital data, and verifiers check the quality of the symbols [43].

Today another type of code, the QR code, is widely used this being a two-dimensional barcode defined by the industry standard ISO / IEC18004: 2006 [44]. Each QR code consists of dark (logical "1") and light (logical "0") modules. The modules are evenly distributed in a square grid of fields, where the field size is equal to the size of one module. According to [44], the size of one module should be 4 x 4 pixels with a print resolution of 300 dpi. These dimensions provide readability on most optical devices. A 3 x 3 module size is satisfactory for readability if a higher resolution camera is used. Each QR code symbol consists of function templates and coding areas [45]. A QR code captures data on packaging with quick responses at key points in the product lifecycle. For the effective functioning of the system, it is important to ensure fast and reliable operation due to the correct placement of the QR code on the packaging during production, as well as quick and easy reading of the data by the consumer of the product, for example, using smart phones. The concept of a QR code traceability system is universal and can be used for various products [45].

Conclusion. For the entire food industry of Ukraine and for the bakery industry in particular, national legislation provides for the mandatory implementation of HACCP food safety systems. An integral part of the HACCP protocols is raw material and product traceability, which means the ability to trace the movement of agricultural raw materials or food products through a certain stage of production, processing and distribution. For the bakery industry, the main stages in the implementation of this traceability are the preparation of the main raw materials (primarily flour), other ingredients, the production process, distribution of finished products, etc. Within the framework of traceability systems to ensure tracking and tracing, as well as to control and optimize the process in the supply chain, the collection and registration of data necessary for market operators is carried out to improve and reduce the cost of product recall procedures, improve risk assessment, etc. Traceability systems should also provide accurate information to consumers of baked goods of a food product's destination, composition and origin of the food product. To achieve proper raw materials and food products, well-known blockchain and IoT technologies are increasingly being used, which have shown their effectiveness both in the entire agro-industrial complex and in the bakery industry. Technological progress has led to the widest spread of electronic traceability systems. These systems, along with identification and data collection, record tracking and tracing data using automatic identification and data collection technology. The most widely applicable in modern practice are electronic identification and data collection systems based on the use of barcodes, QR codes and high-frequency identification. The proliferation of electronic systems for raw materials and product traceability has been positively influenced by the ubiquity of mobile communications.

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