ХАРЧОВІ ТЕХНОЛОГІЇ

FOOD TECHNOLOGY

UDC 664
DOI https://doi.org/10.32782/tnv-tech.2023.6.11

IMPROVEMENT OF THE EXTERNAL TRACEABILITY SYSTEM FOR CONFECTIONERY PRODUCTS WITH CAROB POWDER USING NFC-TAGS

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Market operators develop, implement and constantly improve the traceability system, which ensures an appropriate level of food product safety control. The elements of the traceability system are internal and external traceability.

The purpose of this work is to improve the elements of the external traceability system for the circulation of confectionery products with carob powder using NFC tags.

The production of confectionery products with carob powder is promising, as it allows reducing the amount of sugar in the recipe composition of the product. A block diagram of the traceability system of raw materials and finished products in the production of confectionery products with carob powder is proposed.

Presented the introduction of a traceability system in the production of flour confectionery products with carob powder in accordance with the requirements of the GS1.

The analysis of modern means of automated identification of food products, such as barcode encoding (1D, 2D), blockchain technologies, RFID, and NFC, has been conducted. Contemporary tools for ensuring traceability through the automation of information recording regarding the identification and traceability of food products at all stages of their production optimize the documentation system on various types of media.

NFC information scanning technology allows data exchange between devices at a distance of up to 10 cm. Due to its compact size and low power consumption, this technology is used in small digital mobile devices.

Improving traceability using NFC-technology is accessible to all market operators, as it does not require additional equipment and provides convenient access to a significant amount of information about the food product.

Key words: *confectionery production, carob powder, food safety, traceability system, NFC-tags.*

Божко А. Ю., Усатюк С. І., Сидор В. М., Тищенко О. М. Удосконалення системи зовнішньої простежуваності кондитерських виробів з порошком керобу при використанні NFC-тегів

Оператори ринку розробляють, впроваджують та постійно удосконалюють систему простежуваності, яка забезпечує належний рівень контролю безпечності харчового продукту. Елементами системи простежуваності є внутрішня та зовнішня простежуваність.

Мета даної роботи полягає в удосконаленні елементів зовнішньої системи простежуваності обігу кондитерських виробів з порошком керобу із застосуванням NFC-тегів.

Виробництво кондитерських виробів з використання порошку керобу є перспективним, оскільки дозволяє зменшити кількість цукру у рецептурному складі виробу. Запропоновано блок-схему системи простежуваності сировини та готової продукції у виробництві кондитерських виробів з використанням порошку керобу.

Представлено впровадження системи простежуваності у виробництві борошняних кондитерських виробів з використанням порошку керобу згідно вимог Глобального стандарту простежуваності GS1.

Проаналізовано сучасні засоби автоматизованої ідентифікації харчових продуктів, такі як штрихове кодування (одномірне, двомірне), технології блокчейн, RFID, NFC. Сучасні засоби забезпечення простежуваності шляхом автоматизації обліку інформації щодо ідентифікації та простежуванності харчового продукту на всіх етапах його виробництва оптимізують систему документування інформації на різних видах носіїв.

Технологія сканування інформації NFC дозволяє здійснювати обмін даними між пристроями, що знаходяться на відстані до 10 см. Завдяки компактним розмірам і низькому споживанню енергії дана технологія використовується в невеликих цифрових мобільних пристроях.

Удосконалення простежуваності за допомогою NFC-технології є доступним для всіх операторів ринку, оскільки не потребує додаткового обладнання та спиряє зручному доступу до значної кількості інформації про харчовий продукт.

Ключові слова: *кондитерське виробництво, порошок керобу, безпечність харчових продуктів, система простежуваності, NFC-теги.*

Introduction. The basis for any traceability system is the ability to track and identify food products as they move through the stages of supply. Currently, most countries have adopted the concept that national legislation should contain a requirement for traceability according to the principle «one step back – one step forward».

The confectionery area of the food industry of Ukraine provides a wide range of products that meet the needs of consumers. To ensure quality control and safety of confectionery products, market operators are interested in creating systematized tools that allow tracking and control of products at all stages of the technological production cycle.

Formulation of the problem. According to the Law of Ukraine «Basic Principles and Requirements for the Safety and Quality of Food Products», traceability is the ability to identify the market operator, time, place, subject and other conditions of delivery (sale or transfer), sufficient to establish the origin of food products, animals, designated for the manufacture of food products, materials in contact with food products or substances intended to be added or expected to be added into food products at all stages of production, processing and circulation.

The implementation of the traceability system by the market operator takes place in order to achieve the following tasks and goals:

– timely recall and removal of non-compliant products;

– achieving product compliance with regulatory requirements;

– ensuring compliance with the specifications and requirements of market operators or suppliers;

– ensuring effective logistics management to provide information to end consumers and market operators or suppliers;

– confirmation of special characteristics or properties of food products;

– trademark protection [1].

The main steps to ensure traceability by Ukrainian market operators are:

– fulfillment of the legally established requirement «one step back – one step forward»;

– considering the possibility of introducing elements of internal and external traceability at the enterprise and determining the necessary information that must be recorded and stored to fulfill this requirement, based on the size of the enterprise, the type of products produced at it and the type of food products used in production;

– the identification by the food market operator of the batch of the food product and the batch of raw materials used for its production, in such a way as to allow the tracking of the actual movement of the food product along the food chain;

– establishing and maintaining in good condition traceability accounts that can be provided within a short period of time for planned or unplanned inspections or investigations carried out at the request of the competent authority.

The purpose of the study is to improve the elements of the external traceability system of confectionery products with carob powder using NFC tags.

According to the goal, the following tasks are defined:

– to conduct an analysis of modern means of automated identification of food products;

– improvement of the elements of the external traceability system for the circulation of confectionery products with carob powder using NFC-tags.

Analysis of recent research and publications. In Ukraine, traceability is regulated by the Law of Ukraine «Basic Principles and Requirements for the Safety and Quality of Food Products» and Order No. 590 dated 10.01.2012 (edition dated 12.25.2015) «Approval of Requirements for the Development, Implementation and Application of Permanently Effective procedures based on the principles of the Food Safety Management System (HACCP)».

In the European Union, food legislation is formed by EU Regulations: No. 178/2002 and No. 852, No. 853, No. 854, No. 882 of 2004. EU Regulation No. 178/2002 [2], which is the main food law for EU countries, establishes general requirements for ensuring the safety of food products. It was determined that for the full implementation of the HACCP system, it is necessary to implement a traceability system that covers all stages of production, processing and circulation of food products or ingredients used for the production of a food product.

Based on the current standards of the ISO 9000 and ISO 22000 series, the GS1 International Association has developed the GS1 Global Traceability Standard, which describes the traceability process in detail and provides a step-by-step model for its development, which enables a market operator to develop a traceability system.

The step-by-step methodology for implementing a traceability system for the production of flour confectionery products using carob powder in accordance with the requirements of the GS1 Global Traceability Standard includes the following stages:

I. Development of a traceability system by the market operator:

– Establishing the goals and tasks of the traceability of the production of flour confectionery products.

– Collection of traceability information at capacity.

– Analysis of the production process.

– Identification of all participants in the production process.

– Establish requirements for traceability data.

– Designing an archive of information to ensure traceability.

– Designing measures to use the necessary information on traceability.

II. Building a traceability system by the market operator:

– Analysis of shortcomings ("as is" vs "will be").

– Installation of traceability system components.

– Monitoring and testing of traceability system components.

III. Implementation and use of the traceability system by the market operator, such steps:

– Implementation of the system at the factory.

– Validation of traceability system documentation and personnel training.

– Monitoring and maintenance of the traceability system [3].

The block diagram of the traceability system of raw materials and food products during the production of confectionery products using carob powder is shown in fig. 1.

Among the systems of automated identification of objects that can be used for the traceability of food products, the most popular in EU countries today are: bar coding (one-dimensional, two-dimensional), blockchain technologies, RFID, NFC.

Bar code is a combination of vertical stripes and numbers that represents a particular food product in coded form. The code allows you to quickly and accurately read information about the food product using an electronic device – a scanner. A system with barcodes using scanners and a computer base allows you to associate a specific batch of food products with each technological stage, packaging and protocols. This system can be implemented at different levels: from simple reading of information on incoming raw materials and labeling of the finished product to a traceability system with full integration of all production equipment into it with recording of necessary accounting parameters of technological processes. This system contributes to the minimization of possible errors of production personnel, increasing efficiency by reducing labor costs, increasing the possibility of entering additional information, allows for proper control over raw materials, technological processes, product quality, facilitates the preparation of reports and protocols, etc [4].

There are two main bar coding standards:

1. A linear (one-dimensional or 1D) barcode is read in one direction (horizontally). The most common are the following linear symbols: EAN, UPC, Code39, Code128, Codabar, Interleaved 2 of 5. Linear symbols allow encoding a small amount of information (up to 20...30 symbols) using simple barcodes read by inexpensive scanners.

2. Two-dimensional (2D), which is designed to encode a large amount of information (up to several pages of text). The two-dimensional code is read using a special two-dimensional code scanner and allows you to enter a large amount of information quickly and without mistakes. The decoding of such a code is carried out in two dimensions (horizontally and vertically). It is used to encode large amounts of data, as well as when there is not enough space to place the linear code [5].

QR coding (Quick Response Code) – a two-dimensional (matrix) barcode has become the most widespread among two-dimensional barcodes. It is a simple, convenient and

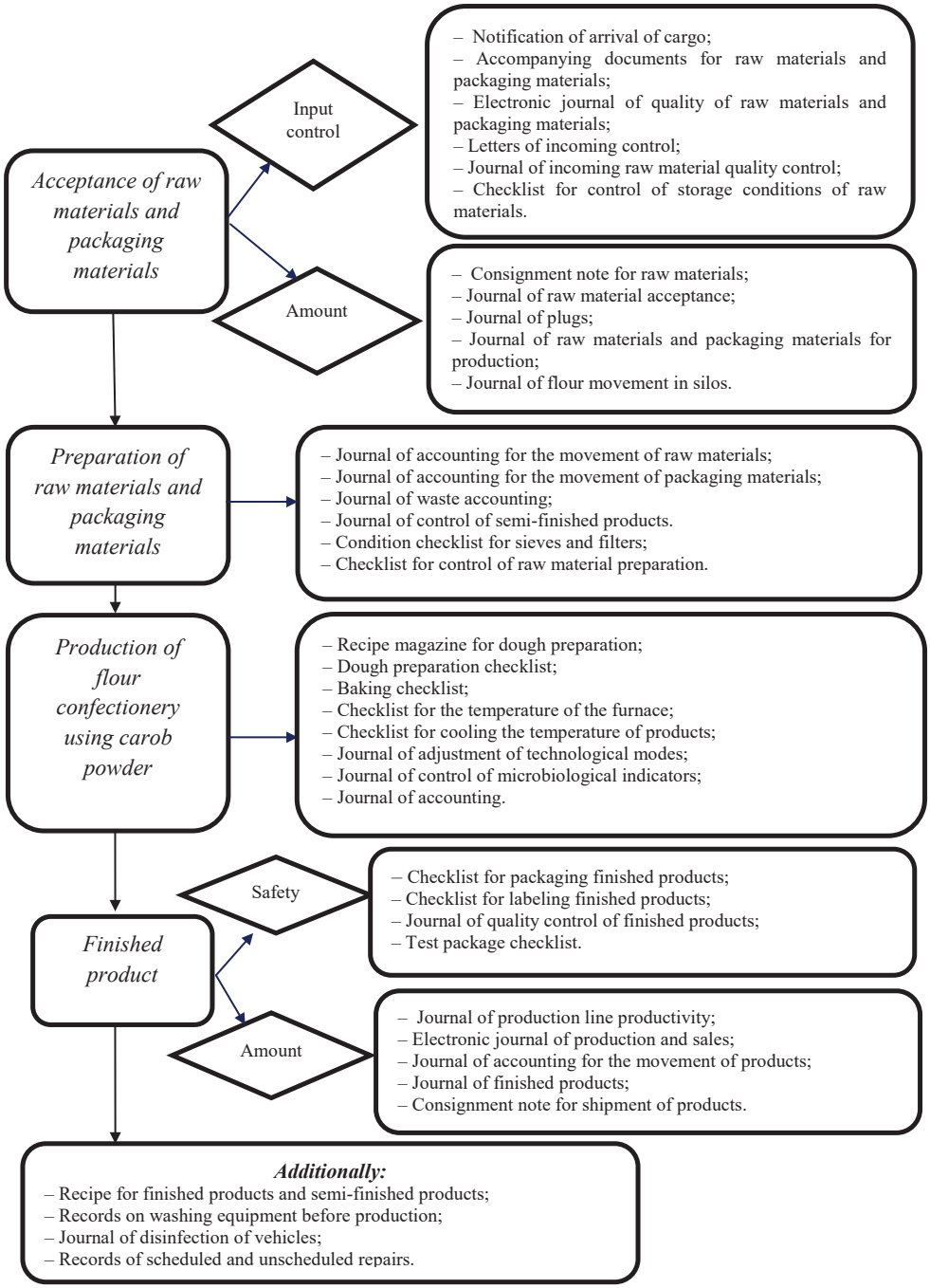

Fig. 1. Flow chart of ensuring traceability during the production of confectionery products with carob powder

interactive way of distributing and receiving information. The use of this system for the traceability of food products makes it possible to encode a significant amount of information and quickly access it using scanning and recognition by cameras of modern mobile devices [6]. To read information from a QR code, you need a smartphone or tablet with a camera and special software that is distributed free of charge over the Internet.

This QR code is printed on each packaging unit of the finished food product and entered into the unified information system. In this system, the movement of the batch of products is tracked throughout the entire delivery stage. In trade networks, after scanning and purchasing the product by the consumer, the system notes that the product has been withdrawn from circulation. The consumer can independently scan the QR code that is printed on the package in order to find out complete information about the food product that he intends to purchase. Control authorities may also have such information about the food product, starting from the stage of packaging of the final product at the plant to entering the retail trade and withdrawal from circulation [6].

Blockchain technology is a way of storing and exchanging information in a network of users located in an open virtual space [7]. At the initial stage, a code is applied to the product packaging to read the information. Data about a food product is entered into the blockchain network and tied to a specific tracking code. This technology makes it possible to improve control of food products at the manufacturing stage in real time, which significantly reduces the need for inspections of the finished food product. Blockchain brings the transparency of supply stages to a completely new level [8].

For each food product, its own passport on the blockchain is developed, which contains information that can be divided into two large blocks. The first block contains information about the counterparties: the manufacturer of the product (location. charter), the enterprise that sells it (location, charter), the consumer of the product (location. charter), counterparties according to the agreement (declarant, carrier, forwarder, etc.) [7]. The second block contains information about products: commercial documents (contract or agreement with annexes, invoice, supply contracts, etc.), permits (certificates of origin, quality certificates, etc.), transport documents (bill of lading, transport invoices, etc.) [8].

RFID technology (radio frequency identification) is a technology that allows you to automatically collect information about a particular food product, for example, various products, their location, keep a temporary record of events involving them and receive information about operations that took place with products, quickly and simply , without human intervention and with a minimum number of errors [9].

The radio frequency system consists of a reading device (reader) that has an antenna, and radio tags (tags) that contain data. The antenna of the reader emits a low-power radio signal, which is picked up by the antenna of the radio tag and is a power source for the microcircuit (chip) built into the radio tag. Using this energy, the radio tag located in the radio field of the interrogator enters into radio exchange with him for self-identification and data transmission. The reader sends the information received from the radio tag to the controlling computer for processing and management [10].

The electronic product code (EPC) is stored on the radio frequency tag. By reading the EMF code, you can determine, for example, the origin of food products or the date of their production. In all these cases, RFID links a certain physical object with digital attributes (for example, the description of the product, its cost, date and order of shipment). In this sense, RFID technology is similar in function to a barcode,

but has significant advantages in operation and allows the use of more complex, cryptographically protected protocols.

NFC technology («near field communication», "near non-contact communication») is radio frequency identification, which provides the opportunity to significantly expand the limits of food quality control. Its essence is the presence of a special NFC tag on the package, which becomes a kind of «passport» of the product, proof of its high quality and legal origin [11].

Presenting main material. To improve the external traceability system of confectionery products with carob powder, that is, to improve and automate the system of tracking the movement and location of products «from the producer to the consumer», in order to identify inappropriate products, the use of packaging of confectionery products based on NFC technology is proposed. The use of NFC-tags will make it easier to track the movement of products from the stage of their production to consumption and, if necessary, speed up the processes of recalling or removing products from retail networks.

NFC technology is a short-range (about 10 cm) wireless data transmission technology that enables data exchange between devices. NFC works at a frequency of 13.56 MHz. Due to its compact size and low power consumption, NFC is used in small devices. The NFC device can support communication both with existing smart cards and with readers of the DSTU ISO/IEC 14443 standard. This technology is primarily aimed at use in digital mobile devices [12].

Fig. 2 shows an image of an NFC-tags and examples of tagging methods.

Fig. 2. Image of an NFC-tags and examples of marking methods

An important advantage of implementing packaging based on NFC technology is free access to software. Thus, traceability based on NFC technology is available for small and medium market operators. The use of the NFC-tag on the labeling of confectionery products will facilitate convenient access of the end consumer to the information programmed by market operators during the technological process of production.

Improving the traceability system for the production of confectionery products with carob powder based on NFC technology does not require the purchase of an expensive NFC reader, as this technology is available in 80% of modern smartphones. Fig. 3 shows a schematic application of an NFC-tag.

With the help of these marks, the administration of the retail establishment can monitor the «delivery stages» online. With the help of personal cards with NFC tags, it is possible to identify company employees participating in the production process.

NFC technology and QR codes actually have a similar functional purpose, but the former has a much higher speed, as well as the ability to rewrite data several times and encrypt it with codes. A significant advantage is the absence of optical readers, but only

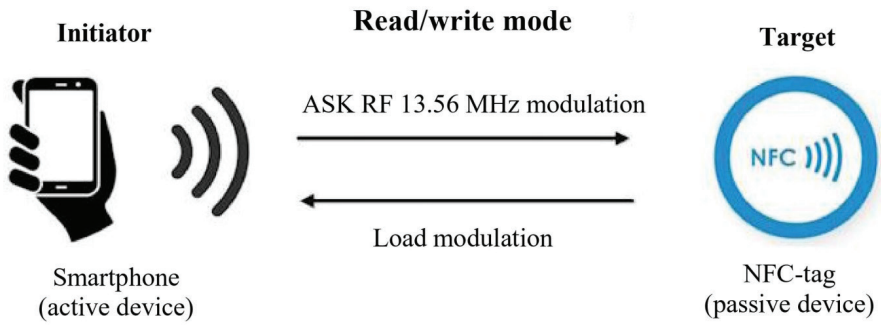

Fig. 3. Schematic illustration of NFC-tags application

the presence of NFC scanners integrated into most smartphones, which does not require additional costs. NFC technology does not require special lighting conditions, unlike QR codes, the user does not need to perform complex operations to read NFC tags, which will facilitate the use of non-competent smartphone users. In addition, NFC tags can ensure the authenticity of a food product.

The main advantage of using NFC technology in the production of food products is the minimization of the use of paper documentation by automating the accounting of information on the identification and traceability of the food product at all stages of its production. In addition, this data will be displayed to the consumer at the stage of implementation, which will significantly increase his trust in this product.

Conclusion. The conducted analysis of modern means of automated identification of food products indicates a variety of convenient and inexpensive means for improving the elements of external traceability of the production of ready-made confectionery products using carob powder.

The use of NFC technology in the labeling of confectionery products with carob powder will improve the traceability of finished products in retail chains and increase the level of consumer awareness of the characteristics and properties of the food product.

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