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THE RELEVANCE OF TRACEABILITY IN THE FOOD CHAIN

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Abstract

Traceability is a modern concept that allows following a product's route from raw materials to the selling stage, taking into consideration its complete flow by means of identifying and tracking procedures and documents.

Recently, food traceability has gained significant importance as it allows efficient identification, correction or removal of risk factors throughout the food chain in order to deliver only safe and quality products to consumers.

The paper aims to outline the main food traceability conceptual approaches and to highlight traceability key-elements and objectives in order to emphasize the significance of a traceability system for the food chain.

Key words: *traceability, traceability system, food chain*

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Traceability – concepts and objectives

The notion of "*traceability*" first originated in different fields related to health, space and arming activities, but it has also extended to industrial sectors, including the food industry sector.

In the past decades, the need for information regarding animal health and food quality and safety has significantly increased for governments, regulators, businesses and consumers, as a result of several crises. Encountered issues underlined the need to develop instruments that could guarantee reliable information throughout the food chain and could enhance food safety.

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Concepts - As a concept, traceability developed in the context of the quality system preoccupations. Although it can be traced back to the 90s, interest in food traceability has intensified, especially in the last two decades, due to the various food crises that severely affected many countries, especially the European ones.

The first international definition of traceability was given in ISO 8402 standard in 1987 (also assumed later in ISO 8402:1994 edition of the standard) as "*the ability to retrieve history, use or location of an entity by means of recorded identifications*". The entity may designate: an activity, a process, a product, an organization or a person.

Subsequently, the concept of traceability was introduced in ISO 9000 series of standards on quality assurance systems as a key element of any quality management product.

Thus, ISO 9000:2005 defines traceability as the "*ability to trace the history, application or location of that which is under consideration", adding that "when considering product, traceability can relate to the origin of materials and parts; the processing history, and the distribution and location*".

The US Food and Drug Administration (FDA) proposes the following definition: "*the ability to identify by means of paper or electronic records a food product and its producer, from where and when it came, and to where and when it was sent*" [5].

At European level, recommendations of good practices prefer the definition set according to EU General Food Law (Regulation [EC] No. 178/2002, Article 3: "*'traceability' means the ability to trace and follow a food, feed, food-producing animal or substance intended to be, or expected to be, incorporated into a food or feed, through all stages of production, processing and distribution.*" [3]

This regulation has promoted the concept "*from farm to fork*", or in other words knowledge of the food chain from primary producer (farmer) up to the consumer, to help identify the cause of an event of major non-compliance related to product safety and to limit the expansion of negative consequences.

According to the Codex Alimentarius Commission (CAC 60-2006) [4], traceability or product tracing means "*the ability to follow the movement route of a food product through specified stage(s) of production, processing and distribution*". Traceability allows thereby the tracking of a product, following its path from raw materials until exposure for selling, including their path to the final consumer.

In Romania, the definition of traceability is found in Law no. 150/2004 [2], indicating the possibility to identify and follow the entire course of all stages of production, processing and distribution of food, feed, animal intended for food production, or a substance which is, or that can be incorporated into food or feed for animals.

As a related concept, according to ISO 22005 standard [7], traceability system means all data and operations able to maintain the desired information about a product and its components during a segment or the whole chain of production and use.

The term "traceability" is often used in close correlation with the concept of "product tracing": while "traceability" is considered a passive process, "product tracing" is an active process [5]. All these approaches are similar, containing elements of common reference. Thus, traceability implies using identification and record systems, and also a system of communication between operators.

Objectives of traceability - The main purpose of traceability development is to increase security and safety throughout the food chain and to establish an acceptable model for raw material supply, food production, marketing and consumption. Traceability systems are likely to detect raw materials or products, identifying them downstream and upstream of the production chain, regardless of the time and place of the technological flow [10].

Food traceability allows total control over the products by individual and group identification (lot or batch), representing a tool for achieving the following *objectives*:

1) to contribute to foodstuff safety, managing risks related to food safety and animal health issues, allowing, if necessary, withdrawal of nonconforming batches and product recall. This means to [5]:

   - identify outbreak or hazard sources;
   - manage safety alerts;
   - withdraw contaminated or dangerous products.

2) to provide reliable information to product users, to guarantee products' authenticity and to ensure consumers that certain production practices have been followed. This means that traceability can be used to [5]:

   - ensure fair practices in trade;
   - protect consumers from fraud;
   - safeguard producers from unfair competition.

3) to improve overall product quality and processes; traceability is an instrument to identify sources of non-compliance and to enhance product flows and stock management.

In order to achieve traceability objectives, the organization must define in particular:

- information to be obtained from suppliers of raw materials, auxiliary materials, packaging, etc.;
- means of identification of supplied products which allow the return of an inadequate lot.

Traceability allows pursuing a product's route by following a product from raw materials to marketing exposure, including its way to the final consumer and thus completing the flow of food through documented identification and tracking, according to the concept "from farm to fork" and reversely, "from plate to source". Regarded as a supply chain process, traceability can be conducted in two distinct *directions*:

- following forward or downward traceability (*tracking*); this is the ability to locate a product based on specific criteria, at any of its locations in the supply chain. This term

defines the present monitoring step, the current position of any given product. Tracking provides real-time data and current information on the status and location of a product;

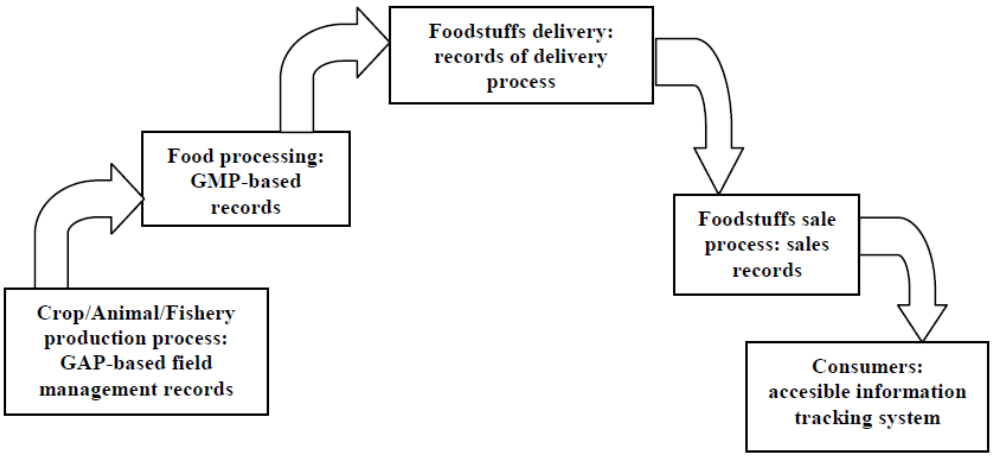
- following backward or upward traceability (*tracing*); this is the ability to identify the origin and characteristics of a product based on criteria established uniformly for all points of the distribution chain. This term defines subsequent visualization of steps taken by recording "tracks". In this approach, traceability becomes the "big picture" that reflects the past.

Types, elements and mechanisms of traceability

Food traceability can be achieved by recording information upstream and downstream related to the physical flow deployed in the production process (see Figure 1).

Traceability systems are able to provide records, according to the nature of the product, production and processing practices, customer specifications, regulatory requirements. In some cases, laboratory tests may serve as support systems for checking traceability.

Figure 1. Main components of a Food Traceability System



Source: adaptation from [8]
Note: GMP - Good Manufacturing Practice; GAP - Good Agricultural Practices

The following subtypes can be distinguished:

1) internal traceability, represented by the information that allows product tracking within an organization; internal traceability occurs when traceability partners receive one or more materials and ingredients that are subject to internal processing (within the organization). The development of an advanced internal traceability system can be stimulated by developing and implementing effective data storage, production process control and quality assurance.
2) external traceability, represented by the information received or provided by the other members of the food chain on a particular product;

3) traceability of the food chain, i.e. traceability of the chain links, with a focus on information accompanying the product from one end to the other in its chain, so that traceability should be extended for any product at all stages of production, processing and distribution.

Traceability *components* can be summarized as follows:

- Provider's traceability - includes all records and documents according to which the source of all raw materials, ingredients and additives can be proven;
- Process traceability - represented by records made during the technological process, which provides the possibility of identifying all raw materials, ingredients, additives etc. used to obtain a certain product and operations that they have suffered during the technological flow.
- Client's traceability that ensures the identification of all customers of the product.

Traceability represents, on the one hand, the ability to restore the food chain from harvesting, transportation, storage, processing, distribution and marketing (external traceability) and on the other hand, the ability to trace the history of the product at any stage in the chain (internal traceability).

There are *six basic elements* of traceability which form an integrated agri-food chain traceability [11]:

Product Traceability - determines the physical location of a product at any level in the food chain, in order to facilitate logistics management, product recall and dissemination of information to consumers and other stakeholders.

Process Traceability - defines the type and sequence of activities affecting product during growing and post-harvest operations.

Genetic traceability - determines the genetic structure of the product, including information about the origin of genetically modified organisms (GMOs) or materials derived from GMOs.

Inputs traceability - determines the type and origin of inputs such as fertilizers, irrigation water, livestock, feed, additives;

Disease and pest traceability - traces the epidemiology of pests and biotic hazards such as bacteria, viruses and other pathogens that may contaminate food and other products derived from agricultural raw materials.

Traceability of measurements - connects individual measurement results within a continuous calibration circuit to accepted reference standards. To achieve this, test and measurement equipment and measurement standards are calibrated using a reference standard whose calibration is certified as traceable to a national or international standard.

The process of ensuring traceability takes place in four *stages* [15]:

1. identification of lots of products that have been subject to the same processes of production and / or processing;
2. recording information on the production process (on electronic or paper support);
3. establishing links between information; each economic operator in the chain - agriculture, manufacturing, distributor, point of sale - must be able to provide documented evidence of the link between batches, suppliers and customers;
4. communication - every economic operator in the chain communicates the identification elements of the lot to enable the continuous implementation of the traceability principles.

The basic characteristics of traceability systems (e.g. identification, information and connection between them) are common to all systems, regardless of the type of product, production and control system applied.

In practice, traceability systems consist of record keeping procedures that show the path of a product unit, a group of products or ingredients from a supplier, through all intermediate steps along the food chain to the final consumer and *helps to*:

- identify units / batches of all ingredients and products;
- provide information about when and how products were sent and processed;
- configure a system that correlates the data.

Simple records, hand-written or printed labels are today quickly replaced by automated identification (e.g. bar codes and radio frequency tags). In this way, the amount of information that can be identified and provided by such systems has increased significantly.

Traceability in the food chain - establishing the information link between different entities - cannot be achieved without an integration based on a vertical approach of information. In this respect, careful planning is required from the early stages of development, taking into account *three essential elements* to the success of any traceability system:

1) compatibility;
2) standardized information;
3) defining the resources that shall be subject to traceability and the traced unity.

All over the world, there are many approaches for unique identification of food [14] using different types of identifiers, hardware and software solutions. Several *means of product identification* are presented below:

- Bar codes (including 2D): originally applied only to products in order to identify them in the marketing chain, have been used for several years for traceability purposes related to raw materials processing [12, 13].
- Radio frequency identification (using RFID technologies):
    - transmitters transmit energy in the form of radio waves through an antenna, so that when waves meet the label, it emits a radio signal that can be picked up by the transmitter and decoded to reveal the contained information;

- electronic tags can be attached to boxes, racks, machines and are used to carry traceability information in a format that can be read remotely;
- edible markers - to be applied directly on/in food, the marking should consist of an edible substance, generally recognized or scientifically proven to be safe for human consumption.

· Individual identification systems:

- DNA tests and iris scanning can be performed on animals at any stage of life;
- optical signatures can be encoded on plastics during manufacturing and can be read anywhere on the package under fluorescent lighting;
- chemical volatile signatures.

Despite the diversity of traceability technical solutions commercially available, there are several *constraints and problems* that drive forward the search for optimal traceability concept that could work globally:

· multi-ingredient foods may include materials from different food chains and countries, importers may have to rely on the traceability systems of other countries up to the point of import [14];
· bulk supply may consist of a heterogeneous mixture of lots, and product lots are not uniform themselves;
· high reliance on business operators capability to maintain adequate records and internal traceability;
· slowness when utilizing traceability for outbreak investigations [14];
· food business operators involved are using different ordering systems;
· difficulties in transmitting information;
· technical issues due to specific characteristics of product, operation and sector [1].

The importance of traceability systems

Traceability schemes must satisfy the need to follow legislative requirements, also contributing to the improvement of the control process and manufacturing practices (GMP). The need for documented traceability systems for the food chain has never been stronger than in the period that began in the 1980s, as issues posed by the dioxin crisis in Belgium, BSE in UK, the current debate on GMOs, and horse meat adulteration scandal in Europe in 2013 highlight concerns about lack of foodstuffs traceability.

Initially, the loss of consumer confidence in beef in the UK due to the BSE crisis has exacerbated this need, especially in the context of the export ban. This problem has focused heavily on the lack of adequate traceability system that governmental authorities should have provided for beef. While BSE was fundamentally a food safety issue, it is now widely accepted that the debate on GMOs is a consumer choice, strongly related to transparency and ethics regarding labeling. In this context, traceability is an essential aspect in order to meet labeling requirements according to EU legislation and to justify labeling of "GMO free" foodstuffs.

Considering how these recent issues affect the food industry, globalization of supply and production, some *key aspects* of traceability systems could be identified:

- compliance with national and international traceability requirements;
- development of schemes for agricultural production for conventional or organic foods, able to meet market demands and health or other requirements.
- ingredients definition and control using complete specifications (including the ability to avoid negative requirements such as allergens);
- improved process control and GMP using complete specifications and standards and minimizing losses; implementation of traceability systems in production may cause changes related to process control systems.
- improved consumer perception by raising transparency, confidence and fidelity.

A traceability system provides useful information for *both* the entire supply chain *and* the end consumer.

For the *food industry*, traceability gained significant importance because some records are ethically and legally essential for producers, distributors and consumers (e.g. consumer information, pricing, optimal processing etc.).

Regarding the food industry and processing sectors of agricultural and livestock products, traceability systems are part of the ability:

- to meet legislative requirements;
- to take immediate collective action by withdrawing products from the market and maintaining the company's reputation (in the case of quality and food safety related incidents);
- to minimize the size and costs of withdrawn lots;
- to minimize the spread of any animal contagious diseases;
- to protect food chain from the effects of emerging diseases in animals;
- to provide products that maintain and increase consumer confidence;
- to provide differentiated products on the market.

For the *retail distributor*, traceability provides information on:

- what is the origin of food and when was it processed;
- which *organizations were involved in the food processing and distribution*

For wholesale distributor, traceability provides information on:

- when to expect the new lots of products at the maximum distribution capacity;
- what are the changes in the requirements of transport, storage etc.

Similar requirements apply to all levels of the food chain: processing, marketing, restaurants, catering etc.

Traceability systems are of special interest also for *governments*, as part of the system that:

- protects public health through food withdrawal when necessary;
- helps prevent fraud when tests can not be used for authentication (e.g. organic food);

- controls zoonotic diseases;
- enables human and animal health control in emergencies (e.g. soil contamination, raw materials contamination);
- facilitates epizootic and enzootic control of livestock diseases through early identification of sources of diseases and dangerous contacts;
- monitors/controls the livestock number related award of subsidies.

Traceability systems are also useful to *consumers* because they help them to avoid specific products and food ingredients that may cause allergies, food intolerances, or those that do not meet a particular lifestyle, enabling the choice between different kinds of food. Moreover, in case of necessity, traceability ensures food safety by helping consumers to recognize the product, and to buy only safe foodstuff that meet their needs.

Conclusions

Traceability is part of the reactive control system for risk management. A traceability system provides answers to the following *questions*:

1) when? where? which type? how much was produced? by whom? who participated and in what production phase of the product?
2) when? where? how much? by whom was it deposited? how long did that product remain in stock?
3) when? where? by whom? to whom? what is the delivered quantity?

Traceability, as it is designed and used in food production practices, is a key element of transparency. The traceability associated with an information flow is a physical process, which consists in tracing food in space and time. Traceability is a simple concept from a cognitive perspective, but it evinces complex features in terms of practical implementation. Traceability is integrated into the quality system.

Traceability is advantageous in the following *ways*:

- Animal health protection - protection of animal health burden is mainly farmers' responsibility, as their interest is to keep animals in a very good state of health in order to avoid economic loss;
- Poultry and animal disease control – as traceability serves to immediately trace the source on the one hand, and on the other hand, to check all links in the processing chain, which excludes transferring animal diseases to humans;
- Protection of human safety - is favored by the traceability system for multiple reasons: exclusion from slaughtering of diseased or animals suspected of infectious and contagious diseases for public consumption; selling meat products and by-products derived from such animals;
- Fraud control – traceability, along with regular records audits can prevent fraud on the products origin, on the species of organisms used to obtain a product and allows verifying the truthfulness of statements about raw materials or products;
- Facilitating withdrawal - traceability allows the determination of control measures to

prevent or reduce an identified hazard, in the event that an incident that endangered the safety of consumers has occurred;

- Promoting the brand - leading to the establishment of trust in consumer loyalty regarding the goods/services provided by the manufacturer, ensuring the originality of goods and/or services for which the mark has been created;
- Developing food contaminants monitoring programs - traceability facilitates the identification of key products in a food chain where product sampling is necessary to monitor the concentration of chemical, microbiological and biological contaminants;
- Risk assessment from exposure to food - can be easily demonstrated by correlating information from traceability records of the system.

Careful planning is essential for ensuring traceability throughout the food chain, taking into consideration the need to create consensus among the food operators and to gain consumers trust, which involves compliance with the set standards. Introducing the system through the food chain and establishing effective connections among all the sub-systems requires both a consistent approach of the food traceability system implemented by each food operator and a common understanding regarding food traceability among all food business operators.

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