MODEL OF FOOD TRACEABILITY PROCESS IN THE CONTEXT OF WAREHOUSE MANAGEMENT

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INTRODUCTION

The purpose of the study is to develop a good traceability management model with a special consideration for the stage of their storage in the supply chain. The added value of the model design is to draw attention to the type of product which are goods requiring storage at a controlled temperature and to a specific part of the food supply chain which is storage. Goods requiring storage at a controlled temperature are items of particular sensitivity [6] and the quality of frozen foods is dependent upon the strength or weakness of each link in the supply chain [10].

Improvement of the speed and accuracy of food movement and origin tracing in the supply chain reduces the risk of launching food dangerous for health. Currently, in the world, unfortunately, we are also facing food security threats, which do not result from accident or mistake, but from intentional and deliberate actions, which are referred to as food crime. Croall in his study [4], the phenomenon of food crime, treats as the area of research the so-called green criminology. Newly emerging food hazards are understood as those hazards that have been scientifically identified for the first time and which may cause unexpected, new, unpredictable health effects [13].

In addition to the introduction and summary, the structure of the study includes, firstly, a presentation of the theoretical background related to the issue of the article, i.e. traceability in the supply chain, using a literature review and ISO standards. Then the research methodology was presented, with particular emphasis on the description of the conditions characterizing

the three magazines on which the model design was based. Another element of the study is a graphic representation of a food traceability management model in the context of its storage. The last key part of the article is the discussion related to the presented model and conclusions.

1. THEORETICAL BACKGROUND

The process of food movement and origin tracing is known as traceability. The literature related to food safety presents different approaches to the term „*traceability*". It appeared originally over twenty years ago, in 1996, in ISO 8402 which pertains to quality management and quality assurance. According to the definition given in the standard, traceability stands for the ability to trace a unit's history, application or location through an analysis of records enabling its identification [9]. The paper by T. Moe of 1998 entitled „*Perspectives on traceability in food manufacture*" contains the most extensive definition which describes traceability as an ability to trace a product batch or its history throughout the whole supply chain or its part, from picking through to transport, storage, processing, distribution and sales or internally – within a single step in the chain, e.g. production [11]. According to L.A. Rabade and J.A. Alfaro, traceability involves recording and tracing processes and materials used in production [12]. Identification is an indispensable element of traceability, which conditions its success in reference to product history tracing. F. Schwagele defines traceability through the prism of identification and states that identification enables data acquisition from the previous stage of the supply chain and allows providing information for the next stage [14]. A definition of traceability can be found in the first international standard ISO 22005 of 2007, which refers to food safety management in the context of tracing its history. The following definition is included in the standard: „*traceability stands for a possibility to trace the flow (movement) of feed or food through specific stage(s) of production, processing and distribution; movement can apply to the origin of materials (raw materials), history of processing and distribution of feed or food*" [8]. Traceability systems should create an opportunity to document a product history and/or locating a product in the food chain. They enable tracing of non-conformities and – if such a need arises – a product can be withdrawn from distribution and from the customer. Movement of goods

can be related to the material origin, process history or food distribution, while for any organisation in the supply chain it is recommended to apply it to at least to one step forward and one step backward. Identification of products facilitates their traceability. Traceability helps to identify the exact processes of the stream of goods executed on the suppliers and recipients' market on condition that all participants follow the same rules and regulations, e.g. based on GS1 standards and requirements of the European Union. Basic GS1 standards include:

- identification of trade items – GTIN – Global Trade Item Number (GTIN-8, GTIN-12, GTIN-13, GTIN-14); unique code of a trade article (former EAN);
- SSCC – Serial Shipping Container Code; its structure is similar to the structure of GTIN; it is preceded by an application identifier;
- GLN – Global Location Number;
- Application Identifiers (Polish abbreviation: IZ); marking which specifies in a unique way the kind and format of the information which follows;
- description of standards (bar codes, EPC, eCom[7] electronic messages etc.).

The use of traceability for food is required pursuant to the following regulations of the Commission of the European Union:

- 178/2002 No. 1935/2004 (general food law) on products and goods intended for contact with food;
- 852/2004 of 29 April 2004 on hygiene of food products;
- 1224/2009 concerning fishery products; the requirements of the regulation became effective as of 1 January 2013 (details of fishery products traceability have been laid down, including batch identification number, fisherman's label and fishing vessel name, alpha-3 FAO code for each species, date of catch (production), quantity of each species and suppliers' data);
- 931/2011 of 19 September 2011 on the requirements concerning tracing possibilities laid down by (EC) regulation No. 178/2002 of the European Parliament and the Council in reference to food of animal origin.

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[7] GeCom is a collection of standard electronic messages which help the company send business data electronically between trade partners quickly, effectively and accurately in a form of standard Electronic Data Interchange (EDI) messages or XML documents

When developing a traceability system in the food chain it is necessary to identify specific objectives. The objectives may include the following:

- supporting food safety objectives,
- fulfilling the client's specifications,
- identification of the product history or origin,
- facilitating product withdrawal from distribution and/or distribution and from consumer,
- identification of organisations responsible in the feed and food chain,
- facilitating review of detailed product information,
- communicating information to relevant stakeholders and consumers,
- meeting all local, regional, domestic and international regulations or policy rules, if applicable,
- improving effectiveness, productivity and profitability of an organisation.

Many literature sources perceive warehouse management as a key logistic process, especially when it applies to a food sector. The complex process of warehousing includes the following four subprocesses:

- acceptance of goods,
- storage,
- picking,
- release of goods.

Each of the subprocesses is characterised by a number of actions, which can also become processes, depending on their complexity level. From the point of view of the subject matter of the study, traceability mainly applies to goods acceptance and release processes.

2. RESEARCH METHODOLOGY AND MODEL BUILDING CONDITIONS

Three high bay warehouses were the subjects of the analysis carried out to develop a model of food traceability in warehouse management. The goods stored in the warehouses included:

- deep frozen products – storage temperature: 18°C,
- ice-cream – storage temperature: 22°C,
- fruit, vegetables, mushrooms, bakery products – storage temperature: 18°C.

The warehouses for analysis were selected based on their similarity within the following variables: warehouse size, processes executed and foodstuffs stored. The research tools used in the analysis included: observation, documentation review and discussions with the staff. While presenting an analytical description of the studied entities, the authors observed ethical aspects and did not present specific names of the entities subject to analysis. Moreover, the possibility of comparing the analysed entities was eliminated by using standardised descriptions. Warehouse processes in the analysed entities are executed according to the following requirements:

- described in the GMP (Good Manufacturing Practice) and GHP (Good Hygiene Practice),
- OHS and environmental protection standards,
- effective regulations of law and clients' requirements (e.g. HDI[8], quality certificates).

The selection of suppliers, ordering of goods and commissioning services necessary for correct flow of logistic processes in warehouses is strictly specified by procedures which appointed persons are responsible for. Estimation of the needs of future clients (customers), bearing in mind food quality, food safety, OHS and taking care of the environment are the starting points of the process of goods and services (products) supplier selection. Potential suppliers of goods are subject to a detailed review (qualification) before the collaboration starts. The qualification includes:

- evaluation of previous cooperation and the qualitative and quantitative results achieved;
- investigation of views and opinions using a survey questionnaire which contains problems related to the management system and ways of controlling goods and services;
- internal audit at the supplier's for the purpose of evaluation and continuous review of strategic and operating objectives, reporting and compliance;
- clients' comments, proposals.

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8   HDI- Trade Identification Document which is used for food trading; it contains the following data: detailed description of the food; food volume or quantity; name and address of an entity operating on the food market which sent the food; sender's (owner's) name and address, if it is different than the entity operating on the food market which sent the food; name and address of the entity operating on the food market which the food was sent to; name and address of the customer (owner), if it is different than the entity operating on the food market which the food is sent to; reference which identifies the series, batch or shipment; delivery date

The suppliers' qualification is based on:

- quality evaluation which includes:
  – holding of a valid ISO 9001 Quality Management System;
  – identification and validity of certificates, approvals and mark according to the Polish Standard(s), references and other documents;
- analysis and evaluation of previous cooperation with the supplier, with a consideration for:
  – number of complaints,
  – flexibility,
  – prices,
  – payment conditions,
  – guarantee and references.

Acceptance of a delivery in the analysed warehouses, where food requiring temperature control is kept, requires performing various tasks which include the following:

- establishing the date of a vehicle's arrival from suppliers or producers (e.g. according to delivery note, fixed delivery cycle);
- delivery identification, directing to the unloading dock and reloading zone;
- checking compliance with the delivery (order) documents for the goods kind and quality;
- control of data concerning the manufacturer, production date, expiry date and timely delivery of the goods;
- checking the requirements for the means of transport, which apply to:
  – measurement of temperature in the semi-trailer/vehicle loading space;
  – cleanliness of the loading space (including tightness, presence of foreign odours, presence of pests or traces of their presence);
  – holding valid documents: a sanitary logbook with an entry confirming that the means of transport was cleaned and a certificate of medical examination issued for the driver;
- evaluation of a delivery batch, which includes:
  – checking the temperature of the goods;
  – condition of collective packaging (e.g. tightness, surface quality, colour, closure, dampness, shape and volume);

- checking the delivery documents, which include:
  - quality certificates;
  - Trade Identification Document (HDI);
  - warehouse documents related to the movement of goods with temperature control (containing relevant information, including in particular the temperature of frozen goods);
  - other;
- checking the pallets fitness for accepting a delivery, by giving answers to the following questions:
  - was the delivered kind of pallet according to the order or arrangements made?
  - does the condition of a single-use pallet raise any quality concerns?
  - does the condition of a euro-pallet meet the requirements laid down in the current euro pallet (EUR) specifications?

During the goods acceptance, goods are unloaded/reloaded under conditions and within the time which do not pose the risk of their damage, thermal shock or breaking the refrigeration chain/thawing. Unloading/reloading is performed as smoothly as possible. After the delivery has been accepted, the goods are immediately placed in the warehouse facility, according to the requirements, not forgetting that the temperature in the reloading zone should be kept as low as possible.

Actions/subprocesses which are performed within warehouse management of the analysed entities include first and foremost:

- temperature measurement,
- traceability,
- testing products of animal origin (usually outsourced e.g. to veterinary hygiene institutions),
- ensuring safety in case of emergency.

Goods stored in the analysed warehouses hold labels which enable goods identification. The following information can be found on the label (example – Figure 1):

- product name,
- expiry date,

- SSCC carrier number,
- delivery date,
- product code,
- batch number,
- bar codes,
- storage area number,
- quantity (number of collective packaging items on the pallet), product weight.

Figure 1. Sample GS1 logistic label
Source: study based on [16].

The use of standards and data on the labels in the analysed warehouses ensures that all traced goods or loads can be recognised owing to the use of the same identifiers, all locations are identified with a GLN number along the whole supply chain, the data concerning products and their physical flow are collected and shared according to the rules agreed upon by the trade partners.

For temperature control warehouses, temperature measurement and control are among very important operations (due to the specificity of the goods stored). Temperature is usually measured upon delivery (unloading), storing and co-packing of goods. The measurements usually apply to the

indoor environment (premises/rooms), food, semi-trailers/ vehicle loading space. The temperature in the warehouse facility is measured by means of:

- electronic system of sensors, which are located at the ceiling (it is a measurement and control tool important for the HACCP system);
- wall-mounted thermometer located at the height of ca. 1.5 m (it is an indicator for the warehouse staff).

The temperature of the food stored is measured with an electronic thermometer, remembering that the following operations have to be performed:

- select the goods for tests - at least 3 pallets with products from on batch/ delivery during unloading and loading;
- selected pallets with goods should be located as close to the source of heat as possible or their appearance could suggest incorrect temperature of the goods (pallets with goods which are the closest to the source of heat are usually the ones which are located near the semi-trailer/ vehicle door, near the dock or damaged insulation panel);
- place the thermometer probe (needle) between collective packaging items, or between individual containers, if necessary (the thermometer probe shall be put between the packaging items to the depth recommended by the instrument manufacturer (usually ca. 25-50 mm);
- the thermometer probe should adhere tight to the goods packaging (so as not to measure the air temperature; when the measurement is done during loading/unloading, the goods should stay in the semi-trailer/ vehicle loading space, and the loading dock door should be closed);
- wait for the audio (and optical) signal emitted by the thermometer, which informs that the measurement has been completed (the temperature is stable);
- read the temperature of the goods from the display and record the highest indicated temperature of the goods in the required document (e.g. delivery note).

The temperature in the semi-trailer/vehicle loading space is measured automatically, at least every 15 minutes. To that end temperature recorders (thermographs) are mounted – they can be fixed (placed at the ceiling or in the upper part of the cargo compartment) or portable (placed on the last product pallet – at the loading door between the collective packaging, e.g.
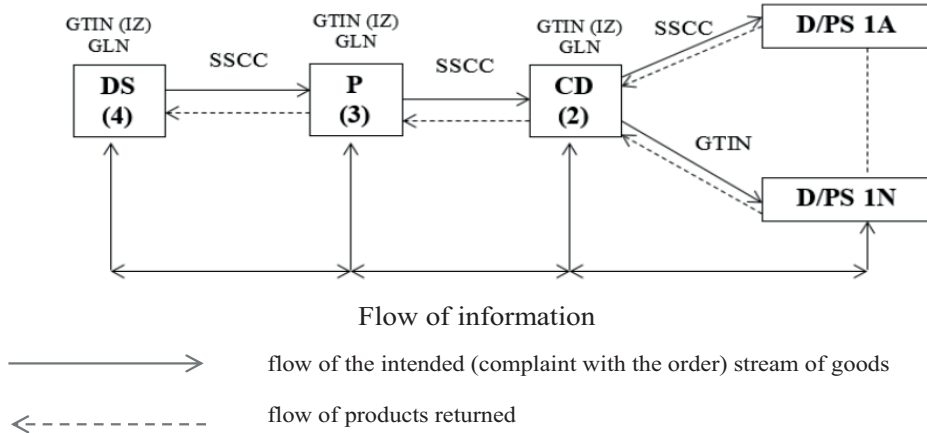
cardboard box and stretch film wrap). It is recommended that the driver should always be able to present to the recipient a valid, authorised printout from the temperature recorder of the given semi-trailer/vehicle. One should remember that when the temperature is measured all measurement devices should hold relevant calibration certificates, which confirm the device's metrological condition and fitness for use.

The presented temperature measurement plays a very important role in the process of products traceability, especially when a need arises to withdraw non-compliant goods or if the recipient makes any claims. It is then possible to refer to reliable records of temperature measurements and monitoring of the stored goods temperature. This protects senior management of the warehouse in case of any process negligence allegations. The process of goods traceability in the analysed warehouses is additionally supported by Qguar computer systems, scanners and Voice Picking system, which enable warehouse management and warehouse operations control. Additionally, they facilitate controlling the products expiry dates, product batches and goods management based on quality statuses.

Considering the above-mentioned conditions functioning in the analyzed entities, it was proposed based on these examples – the model of traceability of goods requiring controlled temperature. The limitation of the proposed model may be too small a sample of case studies on which the design is based and the lack of a reference model / comparison in the dedicated area analysis.

3. RESULTS – MODEL DESIGN

Having taken into account the conclusions from the analysis carried out for warehouses which require temperature control and following a review of literature and standards concerning traceability, the authors developed a traceability model which includes the storage component. The model is presented in Figure 2.

Flow of information

⟶ flow of the intended (complaint with the order) stream of goods

⟵ - - - - - - - - - flow of products returned

DS – raw of products returned,

P – producer,

CD – distribution centre,

D/PS – retailer/sales outlet,

1A…………1N – quantity.

Figure 2. Flow chart of the traceability system model

Source: original project.

Basic components of the model include:

- retailers – sales outlets (1A…1N),
- distribution centre, warehouse (2),
- producer (3),
- raw materials delivery (4),
- suppliers (transport companies) who supply raw materials and products to entities included in the model flow chart,
- information system which ensures the flow of information between the supply chain cells.

4. DISCUSSION AND CONCLUSIONS

If the supply chain model operates smoothly, the flow of the stream of goods proceeds according to the orders placed by retailers/ sales outlets (1A…1N) to the distribution centre/ warehouse (2), distribution centre/ warehouse to the producer (3), and the producer to the raw material supplier (4). If any problems with the products quality arise, previously developed procedures are activated, which enable taking actions to eliminate the disturbance. The notion of risk is related to the notion of disturbance [1]. „Risk" is among common terms and definitions of ISO standards pertaining to management systems. It means the impact of uncertainty which can cause positive or negative deviations from the expectations. The risk is often expressed as a combination of the event consequences and the related likelihood of its occurrence [15].

Owing to the standards employed and relevant IT solutions, if a defective product is delivered to the recipient, the following actions are taken:

1) retailer – sales outlet (1A): identifies the defective product name, its number (GTIN), supplier (GLN), factory production number (IZ 10) and then communicates the information to the product distributor (2) and secures all products from the identified batch to prevent their further sales;

2) distribution centre, warehouse (2): identifies all products (GTIN) from the defective production batch (IZ 10), then informs the product batch supplier about the problem (GLN), informs the recipients (GLN) about the effective product batch (SSCC, IZ 10) and similarly to the retailer secures the defective product batch to prevent its further distribution;

3) producer (3): identifies raw materials related to the identified non-conformities and identifies their supplier (GLN), then communicates the problem to the supplier, secures the batches of products which have not been sent yet, manufactured from the identified raw materials to prevent their further sale and informs the recipients (GLN) who the defective product batches were sent to (SSCC, IZ 10) about the problem;

4) supplier of raw materials (4): analyses the reason for the problem – finds and confirms the cause, informs all recipients (GLN) about the core of the problem and quotes the raw material batch number (IZ 10), identifies all goods sent from these delivery batches (SSCC) and secures other raw materials from the batches to prevent their further use;

5) producer (3) – based on historical data: the producer finds defective product batches, manufactured in the past, identifies SSCC numbers of boxes and pallets which contain the product batches to be withdrawn from the market, identifies recipients of defective products (GLN) and informs them about the products which have to be returned (SSCC, GTIN, IZ 10);

6) distribution centre, warehouse – based on additional data from the producer (3): identifies the boxes and pallets (GTIN, SSCC) which have to be returned, removes and returns the defective products from the distribution centre area (GTIN, SSCC), and communicates to the retailers and sales outlets (1A…1N) the SSCC and/or GTIN numbers and the numbers of the dispatched item batches that shall be removed;

7) retailer – sales outlet (1A….1N): retailers identify defective products (knowing GTIN and IZ 10 batch number) and return them to the supplier – distribution centre (2).

The flow of information, which should be smooth, is a very important element of the model. Disturbances in the information flow during traceability can directly contribute to its extended duration, which may lead to severe negative results related to the impact on the consumers' life and health in the case of operations related to withdrawal of non-compliant products (especially for sensitive goods, such as products that have to be stored at controlled temperatures). Much depends on what level of maturity in the supply chain [3] is represented by the organization that would be the recipient of the model.

The designed model was presented in the context of food products requiring storage at a controlled temperature, although it could also be implemented in relation to other products requiring storage under these conditions, such as cosmetics or medicines. However, food is a good with respect to which every process carried out against it should be given special care, because any negligence may adversely affect the health or life of the consumer. Quite new issues are becoming very important here, which may constitute another area of research in the supply chain, which is the culture of food safety. The food safety culture is considered to be the threshold condition for ensuring the safety of the product offered to the consumer [2], however, in many cases it is almost completely ignored and is not appreciated or understood by both top management and management

middle level [5]. Maybe it would be worth in the extended version of the presented model – take into account the aspect of culture of food safety.

SUMMARY

The main purpose of the study was to present a draft model of goods traceability with a special consideration for the stage of their storing in the supply chain. In pursue of the study purpose, an analysis was carried out based on case studies from temperature control warehouses. Traceability of food products is a difficult and complex issue. There are many studies on the subject matter but a wide variety of the process models is the main problem in a local and international scale, which makes standardised approach to traceability in organisations difficult. The problem can be treated as a starting point for further research and analyses pertaining to traceability.

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