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## Theory and Practice

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# Abbreviations

| | |
|---|---|
| ADI | Acceptable daily intake |
| BRC | British Retail Consortium |
| BSE | Bovine spongiform encephalopathy |
| DNA | Deoxyribonucleic acid |
| EFSA | European Food Safety Authority |
| EU | European Union |
| EVOH | Ethylene vinyl alcohol |
| ExTra | Extended Traceability |
| FAO | Food and Agriculture Organization of the United Nations |
| FBO | Food business operator |
| FCM | Food contact material |
| FEICA | Association of the European Adhesive and Sealant Industry |
| FIC | The Food Information for Consumers |
| GMP | Good Manufacturing Practices |
| GSFA | Codex General Standard of Food Additives |
| GSPP | Global Standard for Packaging and Packaging Materials |
| HPP | High-pressure technology |
| ICT | Information and communications technology |
| IFS | International Featured Standard |
| INS | International Numbering System |
| LAB | Lactic acid bacteria |
| LDPE | Low-density polyethylene |
| MAP | Modified atmosphere packaging |
| MZR-BAR | Mozzarella cheese: bar-shaped version |
| NOAEL | No-observed-adverse-effect level |
| OL | Off-Line |
| OML | Overall migration limit |
| PA | Polyamide |
| PAL-BAR | Processed cheese: bar-shaped version |

| | |
|---|---|
| PBO | Packaging business operator |
| PDO | Protected designation of origin |
| PE | Polyethylene |
| PEF | Pulsed electric fields |
| PET | Polyethylene terephthalate |
| PGI | Protected geographical indication |
| PP | Polypropylene |
| PRA-CLP | Analogue cheese: cylindrical shape |
| PVDC | Polyvinylidene chloride |
| RASFF | Rapid Alert System for Food and Feed |
| RFID | Radio frequency identification |
| SCF | Scientific Committee on Food |
| SDU-BAPS | Semi-hard cheese: white, smoked, wax-coated, and sectioned versions |
| SML | Specific migration limit |
| UHT | Ultra-high temperature |
| Y | Experimental cheesemaking yield |

# Part I
# Food Traceability and Raw Materials for Cheese Productions

# Chapter 1
# Food Traceability System in Europe: Basic and Regulatory Requirements

**Abstract** The role of food traceability systems is critical because of required high standards for foods and beverages. With relation to the industry of cheeses, traceability tools have to take into account the existing regulatory framework, and the European Union has provided a significant contribution in this ambit concerning cheese products and dedicated food-contact materials for cheeses. The aim of this chapter is to provide a detailed overview of the current European regulatory framework. The approach to the European food legislation, regulated on multiple levels, seems to be very intricate because of the enormous amount of technical and very detailed provisions. This legislation can be analysed on two different levels. The first level concerns powers for public authorities and consequently the power of implementing and enforcing food law (information and risk communication, scientific risk assessment and emergency measures). The second one regards the requirements for food business operators. These requirements can be grouped into three different sub-categories: legislation concerning the product, legislation concerning the process (including withdrawal and recall procedures) and legislation with relation to the presentation of food products (labelling, publicity, risk communication). The last point is essential for the final consumer. The above-mentioned requirements, listed in the Regulation (CE) No 178/2002 (the backbone of the whole food security discipline in the EU), are critically discussed with concern to different topics: protection of consumers' health, alerts at the European level, labelling requirements and traceability.

**Keywords** European Food Safety Authority · European Union
Food business operator · Information flow · Labelling · Risk communication
Traceability



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## 1.1 Food Traceability System in Europe: An Introduction

The development of European food law dates back to the nineteenth century. Before the mid-1980s, any safety food issue did not seem to represent a significant political concern since community provisions were principally targeted to the creation of an internal market for the exchange of food products.

Food safety and traceability were underestimated by the European Community until when most of Member States have started to experience emergencies concerning foodstuffs for human use and feed (e.g. bovine spongiform encephalopathy (BSE) better known as the 'mad cow disease', *Escherichia coli*, *Salmonella* spp., dioxin residues) (Beck et al. 2005; Chammem et al. 2018; Knowles et al. 2007; Malisch and Kotz 2014; Pennings et al. 2002).

Moreover, it was difficult to identify a coherent body of rules regulating the production and the marketing movement before these emergencies. Many of the European Community—not yet European Union (EU)—food provisions, transposed into domestic laws, were very generic, not well harmonised and not always properly achieved by all Member States.

The above-mentioned crisis impacted negatively the consumers' confidence, with consequences on consumption patterns and also on purchasing behaviour (Ahluwalia et al. 2000) as well as a negative impact on the food business operators (FBO).

Nevertheless, as already said, the damage to consumer confidence and to the food industry shows that existing laws were inadequate in dealing with this kind of problem. The issue concerning the relationship between food regulation and human health became a priority for the EU that started to think in terms of 'informed consumer' policy. For all European citizens, this approach generally means to guarantee the access to safe food, by monitoring every single stage of the food production process, especially when it deals with products imported from a non-EU Country (Jezsó 2015; Skogstad 2006).

The EU is a single market in which products can be sold freely in. The most important advantage for the final EU consumers corresponds to the huge choice of food products they can find at lower prices thanks to the high competition's standard set. On the other hand, the basis of any food quality or security standards must be stated at the European level. Indeed, there would be no free trade if every food product should be controlled in each country according to different criteria. The presence of heterogeneous measures would authorise FBO to benefit from an unfair competitive advantage.

The approach to the European food legislation, regulated on multiple levels, seems to be very intricate because of the enormous amount of technical and very detailed provisions. This legislation can be analysed at two different levels.

The first level concerns powers for public authorities and consequently the power of implementing and enforcing food law (information and risk communication, scientific risk assessment and emergency measures).

The second one regards the requirements for FBO. These requirements can be grouped into three different sub-categories: legislation on the product (product standards, food safety limits), legislation on the process (production and trade traceability, withdrawal and recall) and legislation on the presentation of food products (labelling, publicity, risk communication). The last point is essential for the final consumer.

The above-mentioned requirements are listed in the Regulation (CE) No 178/2002 which definitely represents the backbone of the whole food security discipline in the EU (European Parliament and Council 2002; Pisanello 2014). It should be noted that, even if the interests of EU consumers are the main objective of food law, EU legislation does not offer any specific rights or remedies to consumers except for the general consumer protection law through the product liability legislation. Other obligations of public authorities (both at the EU and at the Member State level) are secondary to the obligations of FBO. Indeed, the EU legislation applies to all food operators (manufacturers and processors) which work along the food chain, following the well-known 'from farm to fork' principle (Van der Vorst 2006).

Since it is an act of general scope, the above-mentioned regulation suits to all legal entities belonging to the European Union and not only to the Member States, but also to individuals and legal persons based in each European Country. These subjects are farmers, agri-food businesses or everyone which operate in the sector.

Historically, the first concrete step leading to the adoption of the Regulation considered the publication of the Green Paper on the 'general principles of food law', in 1997, through which the EU Commission intended to verify the adequacy of food safety legislation with consumer's protection needs (Commission of the European Communities 1997).

The next step was the publication of the White Paper on Food Safety in 2000 (European Commission 2000). The White Paper was adopted with the aim of achieving the guidelines outlined in the Commission's Green Paper on Food Law (Commission of the European Communities 1997). The White Paper also emphasised the need to move the focus from the original intent to develop a common market in the direction of guaranteeing high levels of consumer food safety.

In particular, it was stated the need to trace all the steps of the product chain, '*from farm to table*', and to reinforce the legislator's action by extending these provisions both to food and to animal feed intended to become foodstuffs for human consumption by giving to the European Commission the management of food risk. It also outlined the need to create a special body, a new European Food Authority thought as a scientific point of reference for the whole Union (European Commission 2000).

These preparatory works were concluded with the adoption the European food law cornerstone, the already mentioned Regulation (EC) No 178/2002, which is a result of the co-decision procedure of the European Parliament and the Council. It lays down the general principles and requirements of food law enacting procedures in matters of food safety, binding for all Member States, and it establishes the European Food Safety Authority (European Parliament and Council 2002).

The choice to rely on a measure with the nature of Regulation (and not Directive) is fully coherent with the need of introducing general security requirements which can bind each Member State to the same rules, avoiding the risk of heterogeneous legislation in a sector that directly involves consumers health.

It was intended to unify the rules of the market and set the limits to its exercise, guaranteeing the protection of food health and, as an additional effect, by removing obstacles to European trade.

If, in fact, the European Commission had opted for a directive rather than a regulation, Member States would have bound to reach the objectives specified, but they would have also autonomy in the ways to achieve those results, with the consequent risk of different regulatory approaches.

Before analysing the safety provisions, it is fundamental to understand the meaning of some terms. For example, the definition of food is crucial to determining the scope of any food safety rule; as highlighted in article 2, food is defined as *any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be ingested by humans. 'Food' includes …any substance, including water, intentionally incorporated into the food during its manufacture, preparation or treatment.* (…) (European Parliament and Council 2002).

The definition of food is also based on the one described in the Codex Alimentarius. This clarification is useful to underline another regulation principle: '*where international standards exist or their completion is imminent, they shall be taken into consideration in the development or adaptation of food law, except where such standards or relevant parts would be an ineffective or inappropriate means for the fulfilment of the legitimate objectives of food law or where there is a scientific justification, or where they would result in a different level of protection from the one determined as appropriate in the Community*' (article 5, European Parliament and Council 2002).

This definition refers to everything can be ingested. Unlike the definition of feed contained in the same Regulation (Article 3, paragraph 4), the nutritional purpose seems to be not a relevant requirement for the inclusion of a substance in that category. For this reason, the authority has stated that drugs and medicines, even if can be ingested, are excluded from the above-mentioned definition and follow different disciplines. However, the nutritional purpose could indirectly be obtained. Articles 9 and 44 of the subsequent (EU) Reg. No 1169/2011 make compulsory the presence of nutritional information in labels or packaging materials (European Commission 2011a).

The provision does not solve the problem of the different definitions laid by the Member States. In this case, the Court of Justice used to apply the mutual recognition criterion, which attributes evenness to national rules on the production of foodstuffs in intra-community trade. It could be also followed the principle of supremacy of community law that prevails over similar provision contained in any national law.

About the subjective profile, the food operator is defined by Article 3, paragraphs 3 and 6, as '*the natural or legal person responsible for ensuring compliance with the provisions of the legislation in the food business or feed under its control*' (European

Parliament and Council 2002). In detail, producers and distributors are obliged to introduce safe products in any stages of production, processing, transport, storage and distribution. The safety obligations, in Articles 14–20 of the (EC) Regulation No 178 of 2002, apply within the limits of subject activities and according to their control capacity.

Concerning EU food safety requirements and risk analysis, the 'zero risk' does not exist, but with extensive food security strategies, the EU tries to limit it by adopting modern food and hygiene standards based on the most advanced scientific data.

In detail, art. 6 paragraph 1 provides that 'food law is based on risk analysis'. This definition means a science-based decision procedure subdivided in three interconnected phases: the risk assessment phase, the risk management procedure, and the risk communication stage (European Parliament and Council 2002).

Talking once again about the risk, Article 14 of Reg. No 178/2002 states that foodstuff at risk cannot be placed on the market. In particular, the concept of 'risky food' is provided by the Regulation in Article 14, paragraphs 4 and 5 under the categories of '*food harmful to health*' and '*unsuitable for human consumption*'. Moreover, food safety requirement is evaluated under normal conditions of use at each stage of production, processing, and distribution and according to information provided on the label or the other ones relating to the harmful effects of food.

To ensure the science basis of risk analysis, the General Food Law has instituted the European Food Safety Authority (EFSA). EFSA is not an authority in the legal sense of the word; in fact, it has not the competence to make decisions (European Parliament and Council 2002). It is a consultant organism of EU institutions, especially the European Commission, on all scientific aspects related to the production, processing and marketing of foods and feed.

Before deciding if a product for human or animal nutrition is safe or authorising the use of a particular ingredient, the EU analyses different scientific opinions. Consequently, the risk assessment is carried out through a scientific-based procedure that assesses the exposure to risk. This check is carried out by the European Food Safety Authority (European Parliament and Council 2002), which collects reports from national authorities, consumers, food businesses and the academic community (Article 3, paragraph 13). Then, the European Commission manages the risk following the 'precautionary principle' (Article 7). The use of that principle according to Article 3 implies an assessment of any possible risk associated with a particular product and the consequent adoption of the most appropriate measures to eliminate it.

Some scientific decisions may involve restrictive measures (e.g. measures that limit the access of products to the market) or measures that, on the contrary, reduce restrictions (e.g. granting the access). In the first case, science has to identify hazards and risks and, consequently, the burden of proof is usually on the authorities; in the second case, it is asked to exclude the hazard and the burden of proof, or at least the burden to provide scientific data, bears on businesses that want to place a product on the market.

Lastly, there is the risk communication phase consisting in the exchange of information and opinions about the detected risks among consumers, food companies and the other interested stakeholders.

In order to notify in real time the direct or indirect risks to health, the EU established the Community 'Rapid Alert System for Food and Feed' (RASFF) as a fast communication tool which ensures a complete and quick flow of 'alerts' (Parisi et al. 2016; Leuschner et al. 2013; Zhang et al. 2012).

The community alert system—based on Council Directive 92/59/EEC, transposed by Legislative Decree No. Regulation (EC) No 115/1995 on general product safety and Regulation (EC) No 178/2002—is a network involving the European Commission, EFSA and the Member States.

If a member of the network has any information relating to the existence of a direct or indirect risk to human health deriving from food or feed, it must immediately notify it to the Commission. The data exchanged support the preparation of effective measures to contain consumer's risk, with rapid intervention such as the withdrawal from the market or the recall from the consumers.

However, the primary responsibility for ensuring that foodstuff satisfies the requirements of food law bears upon food business operators (Article 17, paragraph 1). If the Operators believe that their food or feed is unsafe, they shall immediately inform the competent authorities. In fact, the intention of the legislator was to make the national food safety authorities the primary contact point for exchanging information about any food incident. When one of them decides to adopt measures to restrict the introduction on the market or to set the withdrawal, it shall notify, via the Rapid Alert System, to the Commission.

The Commission assesses the information received, and it categorises the notification under one of these three categories (European Commission 2009; Parisi et al. 2016):

(1) Alert notification, which is sent when a dangerous food or feed 'is already on the market and when immediate actions are required'.
(2) Information notifications concerning a food or feed introduced into the market for which has been identified a risk, but that product has not reached member's market yet or it is no longer present on it or because of the nature of the risk, it seems not necessary to adopt immediate action.
(3) Border rejection concerning food and feed that have been examined and rejected at the EU borders because of the identification of a health risk. Notifications are sent to all border inspection posts in order to increase controls and to ensure that the rejected product is not reintroduced inside the community through another border point.

Moreover, if a food or feed could constitute a serious risk to human health, animal health or the environment, and it cannot be contained by the traditional measures taken by the Member States, the Commission shall suspend the placing on the market laying down special conditions for the product in question or adopting any other appropriate temporary measure.

Instead, if the Commission, after receiving information from a Member State, does not establish the procedure for the adoption of emergency measures at Union level, Member State itself can adopt interim protective measures (Article 54). This measure can be maintained until a Union decision has been adopted.

As already said, in order to prevent any risk, EU decides to coordinate the interests of food producers and consumers through a detailed control of each phase of production, transformation and distribution of products. Food and feed operators must ensure proper systems and procedures to identify the companies to which they have provided their products. This aim is achieved through the traceability tool, defined in Article 3 paragraph 15 of the Regulation No 178/2002, as '*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*'.

With relation to traceability and correlated legislations concerning the protection of food consumers, the European framework is the Regulation (EC) No 178/2002. This Regulation (and subsequent amendments and implementation documents) corresponds to the legal basis for many requirements in the EU, including traceability and other useful instruments such as the 'Rapid Alert System for Food and Feed' (European Commission 2004, 2006, 2008, 2011b; European Parliament and Council 2002, 2003a, 2009, 2014). In addition, three specific regulations concern the traceability of food of animal origin, sprouts and seeds intended for the production of sprouts and genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms (European Commission 2011b, 2013; European Parliament and Council 2003b).

The general provision states that businesses must be able to trace their inputs and outputs one step back and one step forward. It has to be noticed that the term traceability is often used improperly. In fact, it can be considered in two different but complementary meanings: tracking and tracing.

The first term concerns the process that follows products from the top to the end of the supply chain, and it makes sure that every single stage is matched with proper traces or information. In this case, the main problem is to determine which Operators and what information should leave a track. Tracing, on the contrary, is the reverse process that allows collecting the information previously released and the primary difficult consists in highlighting the most suitable technical tool to collect these traces. These two processes are strongly interconnected and based on the one that, in the absence of specific references, could be generally called traceability.

The onus to reconstruct the entire evolution from these information bears on the authorities, but companies (producers, processors, or importers) must ensure that they can find every food or feed by tracing the chain from the consumer to the producer. More in detail, the identification of a product and its traceability are set up to go back to the characteristics of any product (constituent parts, lot, processes adopted), to rebuild its technical-commercial history (ownership passages, change of destination), or also to recall a product if there is a risk to human health and the environment.

Therefore, foods placed on the market must be identified through documentation or specific information. Some information is mandatory, but additional information concerning, for example, the composition or the method of production may be individually recorded, in order to characterise the product by reporting such information on the label. Determining what information should be traced is one of the most delicate aspects of the whole process, and the comparison term is usually the consumer's behaviour (Mania et al. 2017).

Generally, the information flow needs to be up to date, archived and quickly available. To collect them, the company (especially the small ones) could decide to use manual documentation which allows reducing costs, but it brings the obvious limit of a high risk of inaccuracy or storage problems. Otherwise, the Operator could adopt advanced technologies, more simple with a speed access to any information but expensive because of the initial investment.

To ensure traceability, it is not enough for a company to know what are their suppliers and customers; it is also fundament to record the link between lots and logistic units during the transformation. In fact, only the correct bond allows tracing back the connection between incoming goods and what was produced or sold (and vice versa). In fact, in case of emergency, these information must enable the authorities to identify the origin of the problem in order to eliminate the cause removing affected products from the market. Every business operator must be responsible for the links between its suppliers and its customers. The absence of a ring along the chain and the impossibility of making a link upstream and downstream create a traceability loss (Mania et al. 2017).

One of the critical issues of this process is the problem concerning the identification and the composition of each batch. Since chain traceability refers to each product unit identifiable, the management of process production must be done by means of lot identification, in order to identify at any time the companies that have contributed to the collection of raw material or the production of semi-finished products. The term batch identifies a set of products that have undergone the same process and which have homogeneous characteristics (all the materials that contribute to compose a batch must have the same characteristics). The lot size is usually determined by the nature of the production processes, but the number of information traced also influences it. Definitely, the more the number of information grows, the more the system becomes complex.

Lastly, this communication process, which is the heart of the chain traceability system, ensures the interoperability of the system (Mania et al. 2017). To ensure the regular flow of information, each Operator in the supply chain has to communicate the batch identification's information to the next Operator in order to enable him to apply again the principles of traceability (communication language and methods should be standardised to reduce any resource waste connected to the adoption of individual solutions).

Traceability could also have a double nature. As already said, it could be an internal process realised by each partners on its products, and it is made possible in a series of internal procedures that allow tracing back to the origin of the materials, their use and the related destination. It could also be a supply chain process or a cross-company process, resulting from the combination of each internal traceability procedure with an efficient stream of communication. In any case, the realisation of internal traceability systems constitutes a prerequisite without which there cannot be chain links. Surely, it is an efficient help when speaking of food safety assurance, including also the need to demonstrate durability values for food products (Fiorino and Parisi 2016; Parisi 2002, 2012).

Traceability can also be an important marketing tool because it improves the image of the company and enhances the identity of the territory on which it operates. Companies can take a competitive advantage on the global market by increasing the perceived value of the product. In fact, companies attest that their product has no secrets behind its creation, and they assume a formal admission of liability. These two messages contribute to reinforce the relationship between customer and producer. In addition, the realisation of traceability systems is a fundamental tool to control processes, the streamline flows, to improve logistics efficiency and to reduce costs (Mania et al. 2017).

It has often been attributed to the traceability tool a role that it only partially covers. Traceability should not be confused with communication to the final consumer of information that characterises a product.

The aim of traceability is just the identification of the companies that participate in the production of each unit and therefore assume the connected responsibility. Communicating a method of production, the geographical origin or the composition of a product does not mean properly leave a trace. These elements in fact regard the labelling process used to transfer information about the product to consumers.

Even at a regulatory level, traceability and labelling concepts have often overlapped, because of the obligation to show some relevant information in order to promote the information transparency.

The obligation to highlight some information introduces the need to transfer interesting data along the supply chain through a linear approach, which makes it essential to have solid internal traceability systems as well as an effective system of communication.

In order to make uniform the rules in terms of communication in all member states, it has been introduced the Regulation No 1169/2011 on the provision of food information to consumers. The Regulation sets out the requirements that producers are obliged to follow in providing consumers with information that is simple and easy to understand (Article 7, paragraph 1).

Labelling refers to '*any words, particulars, trade marks, brand name, pictorial matter or symbol relating to a food and placed on any packaging, document, notice, label, ring or collar accompanying or referring to such food*' (Regulation 1169/2011, Article 2, paragraph 2 i). Thus, the label on food contains all the information both appropriate and necessary to know the origin and any characteristic of each product.

Also, Article 9 of the Regulation states clearly that each food has to be identified by means of 12 different information, including:

(a) The exact definition (name) of the product

(b) The used ingredients for this production (the amount of certain ingredients or ingredient classes can be requested)
(c) The declared amount in terms of weight or volumetric capacity
(d) The expiration date or 'use-by' date
(e) The identification of the FBO responsible for mandatory information concerning the food product. It has to be clarified that this FBO is responsible if the food is on the market with the FBO brand, or if this FBO acts as an importer, or manufacturer, or packager or simply a selling agent established within the EU.

Moreover, in addition to compulsory information, the same Regulation allows Operators to place voluntary information on the label. However, it is necessary that such information should be specific and not ambiguous or confused. These further measures, introduced with the aim of protecting the interest of consumers, are also a useful tool to stimulate competitiveness in the food sectors.

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# Chapter 2
# Raw Materials in the Cheesemaking Field and Related Input Data in the Traceability

**Abstract** The liberalisation of the European Union food market and the globalisation have increased the need of safety guarantees in the area of food safety. Consumers demand enhanced safety and hygiene assurance. Transparency, product quality and safety along the dairy supply chain could be reached by the application of specific standards and proper mechanisms such as traceability tools. The role of traceability is critical in supply chain management. With peculiar reference to the milk and dairy sector, Europe has a leading position in this area. The essential segments of each dairy supply chain can be easily identified, including dairy farms, dairy processing companies, wholesalers, retailers and the final consumers. With relation to the traceability of cheese products only, a joint work of the interested food business operators is implicit. In some situations, the system may have a 'chain leader' coordinating the whole food supply chain; alternatively, different food business operators may cooperate without a leading subject. It has to be noted that information technology-assisted software may be helpful in the management of similar systems. In addition, the authenticity of raw materials may be assessed at the analytical level. Finally, the role of some national institutions should be considered when speaking of traceability: the Italian example (mandatory declaration of milk origin on cheese labels) is discussed.

**Keywords** Cheese · European Union · Food business operator · Information flow Milk · Supply chain · Traceability

## 2.1 Raw Materials in the Cheesemaking Field—The Milk

As previously stated, the liberalisation of the European Union (EU) market and the globalisation have increased the need of safety guarantees in the area of food safety. Consumers, due to the growing fear of disease, demand safety and hygiene, especially in the most delicate food sectors.

With relation to traceability and correlated legislations concerning the protection of food consumers, the European framework is the Regulation (EC) No 178/2002.



I. Mania et al., *Traceability in the Dairy Industry in Europe*,
https://doi.org/10.1007/978-3-030-00446-0_2

This Regulation (and subsequent amendments and implementation documents) corresponds to the legal basis for many requirements in the EU, including traceability and other useful instruments such as the 'Rapid Alert System for Food and Feed' (European Commission 2004, 2006a, b, 2008, 2011; European Parliament and Council 2002, 2003a, 2009, 2014). In addition, three specific regulations concern the traceability of food of animal origin, sprouts and seeds intended for the production of sprouts, and genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms (European Commission 2011, 2013; European Parliament and Council 2003b).

Transparency, product quality and safety along the dairy supply chain could be reached by the application of specific standards and proper mechanisms such as the traceability tool. Traceability ensures a whole flow of information among the food operators and a continuous data exchanging (Bechini et al. 2008; Dabbene et al. 2014; GS1 2016; Manzini and Accorsi 2013; Pant et al. 2015; Pisanello 2014).

In fact, traceability seems to be a fundamental issue in supply chain management, especially in case of high perishable foodstuff, which is subject to rapid deterioration such as milk and dairy products. Moreover, an effective food traceability system not only allows the management of safety risks but also guarantees the integrity of products (Mania et al. 2017). This 'integrity' depends on the process production, and it is achieved when a product obtains all the researched requirements with specific procedures (Espiñeira and Santaclara 2016). The importance of food safety risks (Knowles et al. 2007; Jezsó 2015; Parisi 2012; Zaccheo et al. 2017) is critical when speaking of correct traceability.

With peculiar reference to the milk and dairy sector, it should be emphasised as a starting point that the EU has a fundamental role in the world market. Since Europe has a leading position in exporting many dairy products, milk production represents a considerable part of the value of EU agricultural output. The most part of milk production is used to create cheese and butter, and the remaining part is destined to the production of foods including cream, milk powder and other derivatives, with the addition of milk for human consumption (Anonymous 2016; Jansik et al. 2014).

Even if the European dairy farming presents a specific structure which changes from one to another Member State, the essential segments of each dairy supply chain can be easily identified.

Starting from the definition of the 'from farm to fork' approach (Sect. 1.1), the dairy supply chain would include dairy farms, dairy processing companies, wholesalers, retailers and—of course—the final consumers. However, this basic chain concept could be extended: it looks like much more complex than the above-designed structure (Fig. 2.1).

Dairy production chain, in fact, is composed of separated steps: the chain starts with animal feed production, and then there is the raw milk production stage at the farm and the connected processing either in the dairy company or at the farm itself.

Usually, the majority of dairy products within the EU are sold at a retail level, depending mainly on the size of farms and the dairy herds which influence sales and milk circulation.

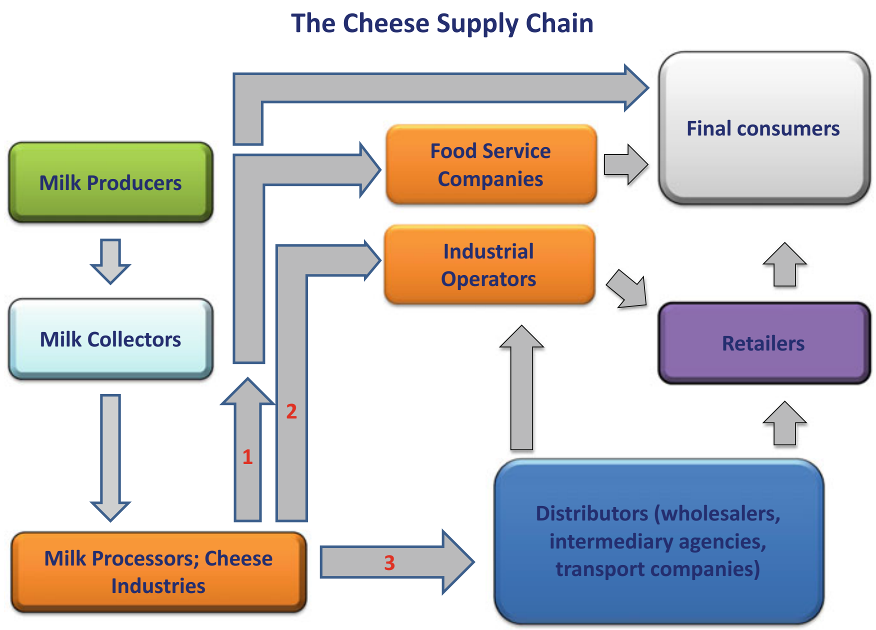


**Fig. 2.1** Milk and dairy supply chain include dairy farms, dairy processing companies, wholesalers, retailers and the final consumers. Usually, the majority of dairy products within the EU are sold at a retail level (options 2 and 3). However, most farmers sell their milk to outsourcing dairy companies for further processing or through the help of farmer-owned cooperatives, while small farmers directly process a minor part of milk

Most farmers sell their milk to dairy companies for further processing. This is the traditional way for milk entering in the food chain as a raw material. On the other side, farmers can decide to process themselves milk or sell it directly to the final consumers. The processing transformation or the selling phase usually takes place with the help of farmer-owned cooperatives. In some Member States, the majority of processing phases is in the hands of private companies.

Moreover, specialised companies provide many services in order to make smoother or cleaner the performance of the production chain (e.g. milk collection, transportation or trading companies). There is a tendency concerning food processing companies in general (and dairy manufacturers in particular) to outsource a great number of activities such as logistics and the accounting ones to external companies.

Milk could also arrive from extra-European countries around the world, from small-scale producers to large dairy farms. In this case, general health rules are observed when speaking of trade or introduction into the European Union of milk and milk products for human consumption, in accordance with the Council Directive 2002/99/EC. This Directive forms the legal basis for all animal health rules governing the production, processing, distribution and introduction of products of animal origin for human consumption (European Union Council 2002).

Provision establishes that the same requirements adopted for the introduction of milk and milk products are considered in all Member States with the aim of avoiding and preventing the introduction of products able to spread diseases potentially hazardous for livestock or humans in the EU area. These rules also apply to each product that is temporarily on the EU territory (European Commission 2006b; European Union Council 2002).

The most part of the used milk in Europe is produced by cows with a little proportion by goat and buffalo. Therefore, it is obvious that milk composition varies from an animal species to another. Moreover, since milk is a natural raw material, related quality is influenced by different variables (Claeys et al. 2014; Hocquette and Gigli 2005). Milk features are:

(1) Fat matter (approximately 4% of the original milk content)
(2) Proteins (3.2% of the original milk content), with the prevailing presence of caseins
(3) Other solid substances, including lactose and other carbohydrates (5.3% of the original milk content)
(4) Water (87.5%).

Since it can be used both as a raw material and converted through different processes into a variety of dairy products, it seems clear that the starting point of the dairy supply chain is the milk itself.

## 2.2 From Milk to Cheese—Cheesemaking and Traceability

Cheese is the final product obtained from raw whole, partially skimmed or skimmed milk, which is soured with lactic acid bacteria (LAB). Consequently, the only allowed ingredients for cheese production are milk, rennet and salt, although different exceptions exist depending on cheese typologies and marketing definitions (Papademas and Bintsis 2017).

In detail, cheese is the product derived from the enzymatic transformation of milk with the use of rennet and the fermentation achieved by LAB. After the thickening or coagulation of the milk, the produced mass is reduced to small pieces with cutting tools, and then it is separated into curds—the solid components of the milk—and whey. At this stage of the production process, it has to be decided if a soft cheese, a cut cheese or a hard cheese will be made. The cheese curd is put into forms and pressed depending on the final cheese type. Subsequently, the cheese is salted and finally subjected to a period of ripening/seasoning (is needed). This description is extremely simplified, and it does not take into account the many different types and sub-categories of cheeses made from milk. The interested reader is invited to consult the more specific literature on this argument (McSweeney 2007; Parisi 2002, 2003, 2006; Parisi et al. 2006, 2009).

The above-mentioned ingredients allow producing a huge variety of cheeses with different sensory characteristics, exterior appearance and textural appearance. From the perspective of the final consumers, each kind of foodstuff—and the dairy ones in particular—can also be defined by means of some attributes (sensory, health and process features) which depend on both external and internal factors.

These attributes could be intrinsic to the raw material such as the quality deterioration caused by thermal variations or different fat compositions; other reasons can be a different way of feeding animals and genetic variations. Even the seasonality, i.e. the production in lean seasons, can influence the inner features of milk.

The extrinsic product features refer to the history of milk and breed as vaccination, processing and handling procedures, or storing method used along the production chain.

These attributes influence the chemical composition of any kind of cheese, especially in terms of fat and protein content, which at the end depends both on the characteristic of the starting milk and on a number of other different factors including microbial flora, processing procedures and seasoning.

Each food business operator (FBO) who works along the dairy supply chain has its own perspectives on the attributes of dairy products and related processes; these different visions, caused by the importance attributed to any production element, could create a discrepancy in managing processes among Operator's tools.

However, despite the special characteristics of dairy products and processes, FBO must guarantee data recording and information flow related to traceability (Sect. 1.2). In fact, as already mentioned, the dairy supply chain includes many stages from the production to the delivery, each of which is linked to the other, that is the antecedent and subsequent ring of the chain. Thus, the safety of dairy products depends upon the entire supply chain as the product quality at every stage depends upon product and process quality at any (previous or intermediary) stages.

## 2.3 Traceability and Cheese—Different Technical Strategies

It is important to underline that compulsory traceability, established by the Regulation (EC) No 178/2002, sets out limited procedures mainly aimed at identifying FBO (both suppliers and customers/manufacturers and producers of food services also) working in the different steps of the chain in accordance with the '*one step backward and one step forward*' principle. Therefore, as the information is not linked to individual products, it does not allow reconstructing the history of a product along the chain (European Parliament and Council 2002).

Therefore, in addition to the compulsory provision, different voluntary traceability systems referring to private standards were born from the need to accurately trace the path of a food product along the chain. In voluntary systems, the information does not concern only the economic operators involved in the chain; they are associated with the product, tracing its story. In order to realise this target, it is necessary to carry out an effective logistic management between raw materials and discontinuous product streams, and to provide specific procedures for assigning a series of information to each batch. This system should include separate management of each batch and the associated information in the connection both among the agents of each chain creating a sort of intercompany traceability and among the business processes (i.e. intra-industrial traceability) (Mania et al. 2017).

As just said, the traceability system must be able to trace both lots and processes. In other words, data related to traceability must include the indication of the batch and the related activity as key elements in order to allow lot tracking and tracing (Sect. 1.2).

Traceability systems must be able to trace both lots and processes. Data related to traceability must include the indication of the batch and the related activity as key elements in order to allow lot tracking and tracing. Each lot or raw material, either supplied directly from nature or provided by a food operator, can be directly transformed into another lot without additional codification, or it can be provided to another food operator with a different codification. Consequently, the flow of information has to take into account the correctness of data related to the initial lots/batches of raw materials and the identification data of subsequent lots/batches related to intermediates and finished products, as displayed in Fig. 2.2 (Cimino et al. 2005).

As a result, if someone acquires a lot from a provider, he must create, through a new lot, an association between these two steps (in this way, it can be assured the origin and characteristics of that product). These actions are needed to guarantee a correct flow of information and to implement the tracing and tracking process.

The creation of a new lot is also required even when a lot transformation occurs. In fact, a half-processed product can undergo a division (i.e. a lot is split into many numbers of lots), an integration (many lots are integrated into a unique lot, i.e. mixing) or an alteration which consists in a transformation through different processes such as heating, freezing or drying.

It has to be noticed that consumers are the last actors of the supply chain: at this step, there is no need to create any lot because this purchase is intended for private consumption and has not to be traced.

A voluntary traceability system causes changes in vertical chain organisation, and consequently, it modifies coordination mechanisms among FBO. In order to implement voluntary traceability systems, it is necessary to centralise and standardise the management of information (Fig. 2.3). This work implies that a company should assume the role of ‘chain leader’ by performing the coordination of activities among the other actors involved in the system. The functions of the leading company include the choice of the pillars of traceability standard, the responsibility for the adequate way to run the system, also with regard to the certification procedure, the flow of product information, the selection of companies participating in the system and the establishment of controls for all the involved FBO. Another approach, mainly observed at present, considers all FBO at the same level. Each FBO may choose its own traceability system and work alone in the food chain. Naturally, this situation is based on a (little) number of involved FBO without a chain leader, and the reliability of the system is dependent on the reliability of each single and independent FBO.

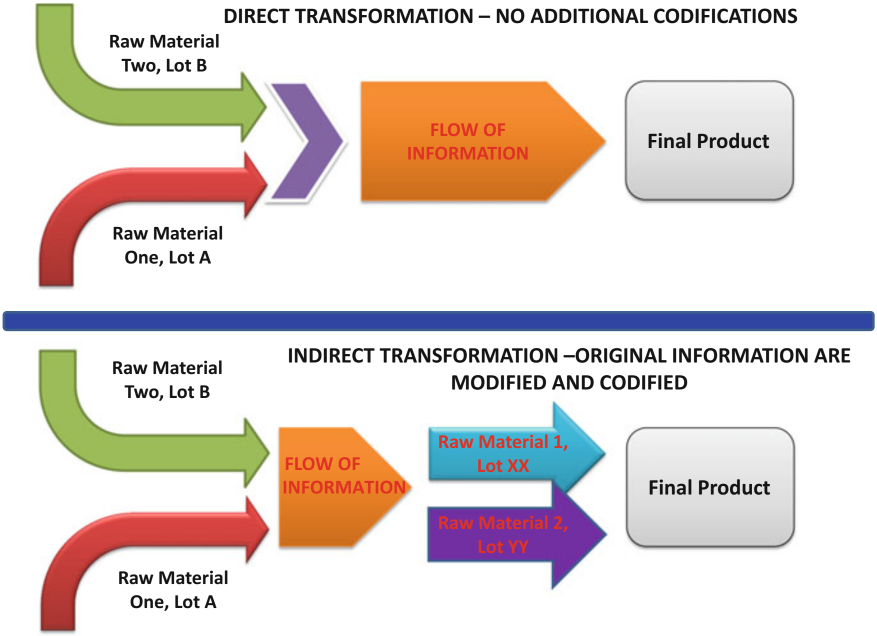


**Fig. 2.2** Traceability systems must be able to trace both lots and processes. Data related to traceability must include the indication of the batch and the related activity as key elements in order to allow lot tracking and tracing. Each lot or raw material, either supplied directly from nature or provided by a food operator, can be directly transformed into another lot without additional codification, or it can be provided to another food operator with a different codification. Therefore, the flow of information has to take into account the correctness of data related to the initial lots/batches of raw materials and the identification data of subsequent lots/batches related to intermediates and finished products. This point is extremely important because of the possible codification of entering information with internal data of interest for purchasing FBO, while the new codification would be useless for raw material suppliers and the final customers and consumers

It becomes obviously fundamental that each partner participating in the traceability system must introduce changes in the production processes to make it possible the link information among lots of products or raw materials (van der Meulen 2013). In addition, every FBO must adopt the information management procedures established by the system, making investments and supporting the necessary costs. This behaviour strengthens the bilateral dependency among the Operators participating in the system and, especially, the connection with the leading company.

Talking again about the link between dairy product compositions and tracing procedures, since cheese is made of a different component, the problem is to identify and take a trace of each element, which contributes to its production. A proper traceability system should follow the history of a product from its origin until it is used, considering all transformation and commercialisation steps.

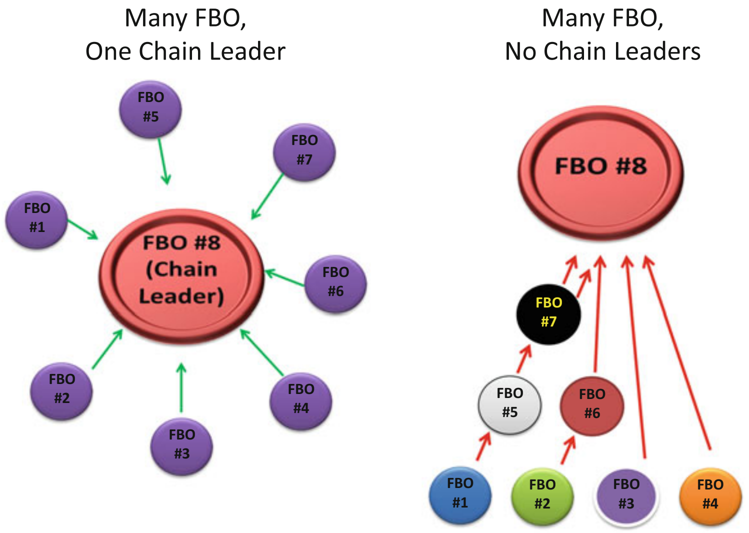


**Fig. 2.3** A voluntary traceability system causes changes in vertical chain organisations. A good approach would imply that a company should assume the role of 'chain leader' by performing the coordination of activities among the other actors involved in the system. This behaviour strengthens the bilateral connection with the leading company. The second approach, mainly observed at present, considers all FBO at the same level in spite of their position in the pyramid. Each FBO may choose its own traceability system and work alone in the food chain. Naturally, this situation is based on a (little) number of involved FBO without a chain leader, and the reliability of the system is dependent on the reliability of each single and independent FBO

Thus, a traceability system should provide, first of all, the information related to the origin of milk in order to know where, when, what kind of milk, from which animals and by whom a particular cheese was produced and sold and also to facilitate the recall of cheeses in a specific lot if a problem should be detected. Due to the economic relevance of the risks related to this category of products, the development of techniques, which can evaluate the quality of milk-derived foods and the presence of any kind of fraud, is currently an issue of primary importance (Popping et al. 2018; Parisi 2018).

The tracking process of milk as a raw material, like any other liquid material, shows several critical issues connected to the need for storing in tanks and progressively merged during the production process. Many parameters, from the data and the hour of delivery to the monitoring of the temperature, need to be recorded with the aim of tracing any change during the transport process and improving reliability in milk analysis.

Since molecular techniques can trace breed origin, the use of these procedures to characterise and trace dairy products is gaining positive feedbacks. This approach is surely a suitable procedure in products, which derive from single animals, since deoxyribonucleic acid (DNA) fingerprinting is unique in each individual. In this case, a coherent 'farm to fork' traceability system can be organised collecting samples and verifying the DNA identity between these samples and the ones collected along the production chain. The application of molecular tools allows, moreover, detecting frauds and the adulteration of dairy products (e.g. the use of undeclared cow's milk or the omission of the use of other milk species).

With regard to the characterisation of milk origin and quality, the application of DNA barcoding seems to be helpful (Galimberti et al. 2013). However, in order to obtain a clear description of any dairy product inner characteristics, it is necessary to apply a multi-level molecular approach. In fact, DNA barcoding procedures are useful when providing a detailed composition of raw milk, while other approaches seem to be more effective in order to study the origin of processed milk products. Molecular identification and traceability systems were developed to work on raw materials.

As a matter of fact, physical and chemical treatments such as heating, boiling or the addition of food preservatives contribute to alter the DNA structure. This reason demonstrates that the application of DNA-based identification techniques on processed products can be useless considering the level of DNA degradation and the coexistent presence of different genomes belonging to various organisms.

Furthermore, the molecular tracing of milk-derived products and cheese identification may be difficult enough because raw milk is collected from different sources and frequently handled before processing. Milk from several animals is first pooled and then processed; consequently, each animal contributes its own DNA to the pool. DNA contribution to cheeses of single animals and the connected variability may make most of the above-mentioned strategies inapplicable to milk or cheese traceability.

Among the most innovative technologies available, radio frequency identification (RFID) has been considered the most suitable method in the dairy sector so far.

RFID tags can be included in conformed food-contact materials. Consequently, foodstuff can remain undamaged during various processes, and features of the final product remain unaltered. Thanks to the tag, in fact, the products become 'smart' new information adding at every stage of the process that constantly integrate the management systems, allowing to update collected data in real time. The tag, suitably designed for this use, contains all the useful data for traceability. Usually, in order to allow the traceability of cheese products, a casein disc is placed on the above-mentioned tag to protect it during each stage, in particular for seasoned cheese (salting and mechanical brushing steps are repeated during maturing). The content of the tag can be also constantly updated using portable terminals. In this way, it is possible not only to read entered data but also to write new information by updating data at every stage of the production and distribution process. Each single information related to each product can be verified at any time, both inside the production plant, during the production process, and outside (when the finished product is sold to the final customer).

In addition, besides to certify information guaranteeing consumers the origin and authenticity of their products, technologies safeguard food chains from a different kind of counterfeiting.

This model of traceability tool plays a fundamental role along the supply chain ensuring safety and quality. Similar procedures are necessary because milk is a very delicate product, as a matter of fact. As a result, safety hazards can be notable affecting milk derivatives along each stage of the supply chain. The management of these processes and the complete control of the materials flow allow to automatically track the product, to locate the source and to deal with the batches, in particular when speaking of production dates and shelf life for each raw material, semi-finished or finished product.

Most of the possible risks are usually detected at the first production step: generally, they concern the ingestion of contaminated feed, environmental factors or the inadequacy in storing the raw material. Other hazards can depend on the use of veterinary antibiotic prescribed to prevent animal diseases (Commission of the European Communities (2009). As explained in the European Directive 2001/82/EC, in order to avoid the presence of drug residues in animal products, a withdrawal period has been prescribed before the milk can be sold to consumers or the interested Operators.

A way to reduce and partially prevent some kind of contamination by eliminating micro-organisms is the use of good farming practices—voluntary solutions—adopted with the aim of promoting high health and safety standard conditions.

## 2.4 Traceability, Milk Products and Different National Approaches—The Italian Situation

The quality of products is not only the result of a good production process: the origin and the use of raw materials should be carefully controlled. For the food industry, this is even more important because the knowledge of each component has an important influence on the final consumer's health.

In this way, the qualitative characteristics of products can be highlighted and made available to the final consumer in order to establish a sort of customer guarantee agreement.

It is interesting to note how Italy, a country where quality and creativity are a fundamental part of its patrimony, especially in the food sector, tries to defend its products and to ensure complete information to food consumers.

An example can highlight the importance of the matter. The Italian Inter-ministry Decree on 9 December 2016 (Ministero dello Sviluppo Economico and Ministero delle Politiche Agricole, Alimentari e Forestali 2017a) has been adopted in order to implement the EU Regulation (EU) No 1169/2011 on the provision of food information to consumers, concerning the indication of the origin of milk on the label. This decision has had a notable influence not only with relation to milk as a raw material but also with concern to milk derivatives.

With relation to Italy, the indication of origin is prescribed for all types of fresh, ultra-high temperature (UHT) and sterilised milk (cow, buffalo, goat, donkey and other animals) and on pre-packaged dairy products labels. These rules apply only to

'Made in Italy' products, and they are valid only for sale on the Italian market. As a result, the Inter-ministry Decree on 9 December 2016 (Ministero dello Sviluppo Economico and Ministero delle Politiche Agricole, Alimentari e Forestali 2017a) does not apply to cheeses imported from abroad and cheese with non-Italian destination, in accordance with common rules that do not provide for this obligation. Organic foods, 'protected designation of origin' (PDO) and 'protected geographical indication' (PGI) products are also excluded as they undergone a specific system of traceability and certification.

The labels must indicate the origin of the milking country and the milk of the transformation country. If these operations are carried out in a single Nation, the term 'milk origin' could be used followed by the name of the country. If the collection and the other processing phases are carried out in different countries, it should use the expression 'milk mixture of EU countries' (or 'non-EU countries') or 'milk processed in EU countries' (or 'non-EU milk'). The information must be labelled with indelible characters in order to make them visible and easily readable. This information must not be hidden, obscured, limited or separated by other written or graphic indications. In the absence of visual-specific requirements, Operators are free to choose where to place the writings (Ministero dello Sviluppo Economico and Ministero delle Politiche Agricole, Alimentari e Forestali 2017b).

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# Chapter 3
# The ExTra Tool—A Practical Example of Extended Food Traceability for Cheese Productions

**Abstract** At present, the problem of traceability in food industries is one of the most important and emerging factors with a notable influence on the management of food business operators. In fact, the mandatory requisite of traceability, both from raw materials to final products and vice versa, is mentioned in many legislative documents and in the most important voluntary food certification standards. The situation is continually evolving, and the most part of food and beverage sectors are trying to find different solutions. Traceability is one of the main pillars of the modern food safety strategy worldwide. The sector of milk and dairy productions can show an extremely variegated situation because of the many possible intermediate and final products associated with the original raw material: milk. The flow of input information has to be analysed, raw material per raw material; the same thing is true when speaking of output information concerning final products and by-products (sometimes defined 'off-line' products). One or more processing food business operators can be involved in the global process; the role of water has to be considered. The aim of this chapter is to describe in practice the complex operations—named jointly 'traceability'—related to a peculiar sub-area of milk-based products: cow's milk cheese by means of a software product—the ExTra tool—with reference to two simulated productions: Mozzarella cheese and a general semi-hard cheese.

**Keywords** Input information · European Union · Off-line · Output information Cheese · Milk · Traceability

## 3.1 Traceability in Cheese Industries—A Practical Introduction

At present, the problem of traceability in food industries is one of the most important and emerging factors with a notable influence on the management of food business operators (FBO). In fact, the mandatory requisite of traceability, both from raw materials to final products and vice versa, is mentioned in many legislative documents and in the most important voluntary food certification standards such as Global



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Standard for Food Safety (by the British Retail Consortium, UK) and the International Featured Standard (IFS) Food (Bitzios et al. 2017; Jin et al. 2017; Nicolae et al. 2017; Stilo et al. 2009; Telesetsky 2017).

Relations between food traceability and safety concerns are one of the most important problems at the international level (Allata et al. 2017; Chen 2017; King et al. 2017; Lewis et al. 2016); however, new emergencies have been progressively observed worldwide, and related legislation has considered non-food safety questions. Some of the new emerging problems concern food frauds (also named 'economically motivated adulteration') and authenticity issues, or the undeclared presence of allowed additives with some specific food allergenic reaction. Currently, the attention of national and international authorities working with food and beverage controls is focused on these topics, and the list is virtually infinite because of new and 'traditional' foods with different features, including herbal preparations and novel foods in general (Kok 2017; Lacorn et al. 2018; Moyer et al. 2017; Pisanello and Caruso 2018; Silvis et al. 2017).

In relation to traceability and correlated legislation concerning the protection of food consumers, the European framework is the Regulation (EC) No 178/2002. This Regulation (and subsequent amendments and implementation documents) corresponds to the legal basis for many requirements in the EU, including traceability and other useful instruments such as the 'Rapid Alert System for Food and Feed' (European Commission 2004, 2006, 2008, 2011a; European Parliament and Council 2002, 2003a, 2009, 2014). In addition, three specific regulations concern the traceability of food of animal origin, sprouts and seeds intended for the production of sprouts, and genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms (European Commission 2011a, 2013; European Parliament and Council 2003b).

The situation is continually evolving, and the most part of food and beverage sectors are trying to find different solutions. In general, traceability should have the following requisites (Olsen and Borit 2018):

(1) Food or beverage units should be clearly identified.
(2) Secondly, these units may be put together or separated when speaking of their number and association into a complex number of different commodities with various products, sizes, weights and so on. The transformation of raw materials towards the final product(s) determines a complication in the traceability.
(3) Finally, food or beverage units should be recorded with reference to important data. The simple record of unit numbers is only the most evident of related data.

In addition, different FBO can use dissimilar systems performing (or giving the evidence of) these operations. Manual records were diffused enough in the recent past with reference to paper-based systems. The current panorama shows the evolution of information and communications technology (ICT) integrated approaches, the use of dedicated nanosensors, the application of radio frequency identification (RFID) on packages or the diffusion of 'smart' packages (Allain et al. 2018; Bibi et al. 2017; Ferrero et al. 2018; Parisi 2009, 2012, 2013).

As discussed in Sect. 2.1, traceability should be considered as the evidence of a whole flow of information among the food operators with a continuous data exchanging. In this way, transparency, product quality, food safety and finally 'food supply integrity' along the food supply chain could be easily guaranteed. In detail, it should be considered that a good definition of 'food supply integrity' should concern the capability of FBO to demonstrate their compliance '*with respect to food safety and quality in communication to stakeholders such as consumers and government bodies*' (Beulens et al. 2005). In addition, the traceability requisite is particularly important and requested when speaking of high perishable foodstuff subject to rapid deterioration (such as cheeses). In other words, traceability can be used to demonstrate the performance of food products not only in relation to food safety, food frauds and so on, but also when speaking of expiration or use-by dates (and the correctness and reliability of analytical reports carried on expired products) (Parisi 2002a, b, 2004).

On these bases, it may be inferred that traceability is one of the main pillars of the modern food safety strategy worldwide. In addition, because of the complexity of different food sectors and sub-sectors, it has to be highlighted that foods and beverages cannot be managed in the same way when speaking of processed meats, eggs, seafood products, cheeses and so on. In other words, each food or beverage typology has its own specificity and related traceability tools because declared objectives may be different (Golan et al. 2004). As a result, the matter is new enough and should be discussed critically firstly on a general level and secondly sector by sector.

The sector of milk and dairy productions can show an extremely variegated situation because of the many possible intermediate and final products associated with the original raw material (McSweeney 2007a): milk. Actually, different milk types are available depending on the animal origin (cow, cattle, etc.). Therefore, the simple definition of 'milk' is not sufficient at all; moreover, recent adulteration episodes and the need of authenticity require that the origin of the used milk be clearly and unambiguously stated on labels. Finally, thermal treatments or safety treatments carried out on raw materials constitute a peculiar identification for used ingredients; the same thing has to be affirmed when speaking of milk (McSweeney 2007a).

The aim of this chapter is to describe in practice the complex operations—named jointly 'traceability'—related to a peculiar sub-area of milk-based products: cow's milk cheese. A peculiar case study is described here in this ambit and in Chaps. 4, 7 and 10, with concern to different products and materials.

## 3.2 Traceability in Cheese Productions—The Flow of Input Information

With reference to cheeses and their production (used ingredients and manufacturing procedures), the following product types should be mentioned at least (Sect. 6.1):

(1) 'Normal' cheese products, obtained from milk, enzymes or enzymatic preparations (animal rennet, chymosin, vegetable rennet, other microbial-origin milk

coagulants), selected lactic acid bacteria (named ‘starters’) and food-grade salt (mineral origin, also named ‘mine’/‘rock’ salt or sea salt depending on production sites). The addition of certain food additives such as citric acid or potassium sorbate may be allowed in the European Union (EU) and in other countries/economic areas depending on existing laws (European Commission 2011b; Eymery and Pangborn 1988; GSFA 2017).

(2) Cheese substitutes, obtained with milk-based ingredients in addition to milk-derived cheeses:

    (2.1) Dairy cheese products where cheeses, dairy fat and proteins (casein, caseinates, milk fat, butter oil, etc.) are used as main component in
    (2.2) Partial dairy cheeses produced using only a part of milk product(s) (cheeses, casein, caseinates, etc.). In this kind of cheese, some dairy components are partially replaced; in detail, milk fats are mainly substituted by vegetable oils, and this replacement is justified by functional benefits or just because it may simply be cheaper
    (2.3) ‘Non-dairy’ cheeses produced through components other than milk and cheeses, i.e. vegetable proteins (soya protein, vegetable oil, soya oil, etc.). In non-dairy cheese products, both the protein and the fat contents come from a vegetable source.

This chapter is explicitly dedicated to entering raw materials (input data) information for the production of normal cheeses (Fig. 3.1). Consequently, the entering information in a traceability (tracking and tracing) system has to concern (Barbieri et al. 2014; Barone et al. 2017; Delgado et al. 2016; Laganà et al. 2017; Mania et al. 2016; Steinka and Parisi 2006):

(a) The used milk(s)
(b) The used coagulant agent(s)
(c) The used culture (selected lactic acid bacteria or ‘starters’)
(d) The used salt
(e) The used food-grade additives, on condition that their use is needed and allowed.

In addition, the role of water should be mentioned (Sect. 3.4) in spite of the general absence of this ‘solvent’ medium in the list of ingredients.

### *3.2.1 Milk for Cheese Productions*

In general, milk used in the cheese industry is produced from four major mammal species: cow, goat, sheep and buffalo (McSweeney 2007a). By the cheesemaker viewpoint, the main problems are dependent on irregular fat/protein ratio values, low protein amounts (note the main constituent of milk protein is defined as ‘casein’, although many casein species can be grouped under this name) and the possible deficiency of calcium ions in the original milk. Anyway, the production of bovine milk is reported to exceed 80% of the global milk production (the remaining part is

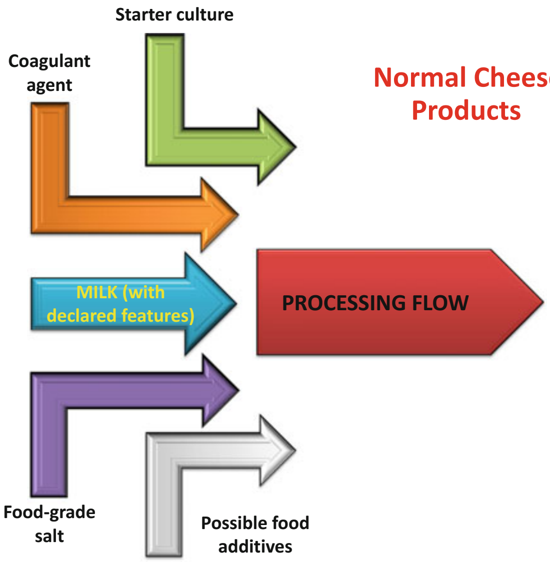


**Fig. 3.1** With reference to 'normal' cheese products, the entering information in a traceability (tracking and tracing) system has to concern: **a** the used milk(s), with declared features where possible (thermal treatments; definitions concerning organic productions, declaration of origin, statements for peculiar processing methods, Kosher or Halal certifications, etc.); **b** the used coagulant agent(s); **c** the used 'starter' culture; **d** the used salt (e.g. rock or mine salt; sea salt); and **e** the used food-grade additives, on condition that their use is needed and allowed

composed of goat, sheep and buffalo milk, depending on the more abundant presence of related mammal species in certain world regions) (Kelly 2007).

In general, cow's milk cheeses are the most abundant products in this ambit; consequently, the main goal of this book—the description of a reliable traceability in the cheese production and the complete cheese supply chain—has concerned a practical experience carried out in a cheese production plant working with different ingredients. With relation to 'pure' cheeses (obtained by milk, coagulant agents, starter lactic acid bacteria, salt and possible/allowed food-grade additives), only cow's milk has been considered.

### *3.2.2 Coagulant Enzymes for Cheese Productions*

The second term in the list of ingredients for normal cheese is generally defined as 'rennet'. However, many possible rennet typologies are nowadays available on the market, and the most used of them are mentioned in the following list:

(a) Animal rennet
(b) Vegetable rennet

(c) Microbial (also named microbiological) rennet.

Actually, milk may be coagulated with the expulsion of water and several substances by means of different thermal and pH conditions. The addition of 'rennet'—chemically, a single proteinase enzyme, or a mixture of different proteinases—is not strictly needed when speaking of milk coagulation; the simple use of organic acids may be also useful because pH for coagulation should be 4.6 at least. However, the most useful and acceptable way for the production of edible cheeses is the use of classic or 'modern' rennet.

Animal rennet is generally represented and declared as (McSweeney 2007b):

(1) Calf rennet. This product is a brine extract correspondent to the mixture of chymosin (types A, B and C) and pepsin.
(2) Lamb and/or kid rennet. These products are obtained from sheep or goats.
(3) Rennet paste. This product is roughly similar to calf rennet, but it also contains a lipase enzyme. Actually, the use of rennet paste is reported when speaking of peculiar Greek and Italian cheeses.

With relation to vegetable rennet, the most used varieties are reported in the Iberian Peninsula, and they are often linked to traditional productions (Aworh and Muller 1987; Cavalli et al. 2008; McSweeney 2007b; Roseiro et al. 2003; Silva and Malcata 2000).

Finally, microbial or microbiological rennet (proteinases) can be produced by selected micro-organisms such as *Mucor miehei*; their importance is strictly related to the non-animal origin and notable proteolytic activity (microbial proteinases are thermally resistant) (Prins and Nielsen 1970; Seker et al. 1999; Da Silveira et al. 2005).

### 3.2.3 *Lactic Acid Bacteria for Cheese Productions*

Animal milk naturally contains a certain proportion of lactic acid bacteria (LAB) in the global microflora, with other micro-organisms (spreading and degradative bacteria, pathogen agents). After thermal treatments, only a little amount of these life forms survives, and residual LAB is normally defined 'non-starter' LAB.

However, the presence and amount of LAB in cheeses are extremely remarkable because of the direct addition of starter LAB as a fermentation aid in the initial cheesemaking steps, because milk needs to be acidified. As an example, ultra-filtered milk may be initially pre-fermented with selected LAB in the early stages of some cheddar production (Banks 2007a). In other situations, acidified milk is obtained by original (non-starter) LAB or by means of cultured whey solutions (by-products from the cheese production of the last 24 h). At present, the controlled acidification by means of selected starter LAB (lactobacilli and streptococci above all; pure or mixed culture) in determined amounts is preferred (McSweeney 2007c). With reference to LAB activity, microbial spreading by degradative or pathogen agents may be inhibited because of low pH values; on the other time, the possible use of antibiotics can inhibit LAB fermentation, with comprehensible risks in the subsequent cheesemaking steps (Sheenan 2007a). Other interferences may be observed if high salt amounts are present in milk (non-starter LAB are more resistant) (Sheenan 2007b).

The difference between cheeses produced from raw (untreated) milk and products obtained from pasteurised milk is the different ratios between starter LAB (added to milk as an important technological aid) and non-starter LAB (more abundant in untreated milk). These differences may be altered because of environmental contamination or cross-contamination episodes between different productions from raw and treated milk at the same time (McSweeney 2007d). For these reasons, the traceability can act as a powerful control tool.

LAB utilise lactose for their fermentation; consequently, the higher the lactose amount in milk, the higher the fermentation yield. In general, buffalo milk contains more lactose than other milk, while goat milk contains less lactose; cows and sheep produce milk with intermediate lactose contents (McSweeney 2007a).

### *3.2.4 Salt for Cheese Productions*

Sodium chloride is usually added during cheese productions with the aim of lowering water activity (and consequently inhibiting microbial spreading) (Beresford 2007) and enhancing whey expulsion at the curdling step (Banks 2007b), but the additional step may vary depending on the finished product. Food-grade sodium chloride (mineral origin, normally defined ‘mine’/‘rock’ salt or sea salt depending on production sites) can be added in the intermediate mass, during stretching (in *pasta filata* cheeses such as Mozzarella cheese), or in brine solutions (dry-salted cheeses, semi-hard cheeses) (Guinee 2007; Sheenan Sheenan 2007a, b). In the last situation, the amount of dissolved salt has to be regularly monitored and maintained in the brine solution.

### *3.2.5 Minor Ingredients for Normal Cheese Productions—Three Examples*

With reference to normal cheeses, other ingredients may be used with different scopes.

#### 3.2.5.1 Calcium Chloride

Calcium chloride is usually added with the aim of enhancing rennet coagulation and curd yields (Banks 2007c; Parisi et al. 2006, 2009), because the production of curds is obtained by means of caseins precipitation (fat matter is inglobated in the new agglomerations) and whey expulsion (with minor water-dissolved substances). Calcium acts as bonding element between different casein chains; high contents may be detrimental because caseins remain strictly associated (bad coagulation), while low contents mean that curdling may be difficult (a few interactions only between casein agglomerates may be observed). Consequently, the ‘right’ amount of bonding calcium ions has to be provided.

#### 3.2.5.2 Organic Acids

Organic (citric, acetic, phosphoric, lactic, etc.) acids may be added to milk or intermediate cheeses in different production steps with following scopes (Alichanidis 2007; Farkye 2007):

(a) To raise acidity values in the milk
(b) To lower pH values in the final product
(c) To adjust brine solutions (pH values should be acidic).

With reference to some traditional cheese, fruit juices or similar mixtures may be also used (Farkye 2007).

#### 3.2.5.3 Preservation Agents

In certain situations, the use of preservatives in normal cheeses may be tolerated and allowed, provided that maximum doses are respected. The most important and used of these substances are nisin, potassium and calcium sorbates and propionates, sorbic acid. Generally, the aim is to extend shelf-life periods by means of the inhibition of moulds (and the delay of visible mycelia on cheese surfaces). However, the regulatory is continually evolving: as a simple example, sorbic acid (E 200) and potassium sorbate (E 202) are fully approved in the European Union, but calcium sorbate (E 203) was banned in foods on 12 August 2018 (European Commission 2018).

## 3.3 Traceability in Cheese Productions—The Flow of Output Information

Traceability input data correspond, with relation to normal cheeses only, to five or six main groups (Sect. 3.2). This number may appear little enough; however, the management of similar data may become difficult when speaking of different raw materials for each mentioned category entering into a single production (the final cheese is identified with: name of product; brand; weight; aspect; lot; shelf life; list of ingredients; and specific claims, if any).

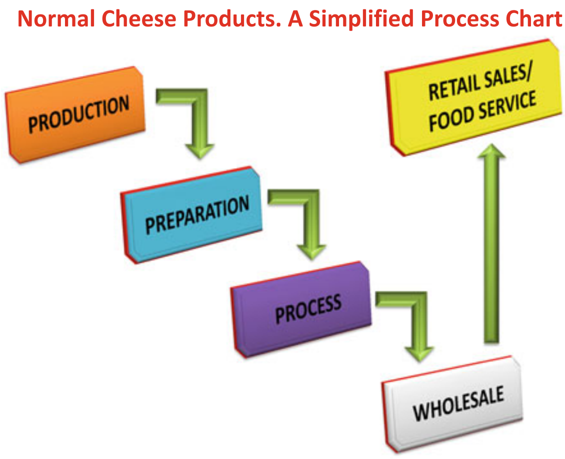


**Fig. 3.2** The information flow needs to be updated, archived and quickly available, along the whole food chain. This chain may be described by means of a simplified block chain: production, preparation, process, wholesale and retail sales/food service

From a regulatory viewpoint, the traceability is defined (Sect. 1.1) in Art. 3 paragraph 15 of Regulation 178/2002, as '*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*' (European Parliament and Council 2002). In practice, traceability may be defined also with different but complementary meanings, tracking and tracing (Food Marketing Research and Information Center 2008):

(1) Tracking (also defined 'tracing forward') concerns the process which follows products from the top (raw materials) to the end (final products) of the supply chain.
(2) Tracing (also defined 'tracking back') concerns the process, which follows the information previously released in the upstream flow.

Foods placed on the market must be identified by means or specific information, including also additional (non-mandatory) documentation, where possible. The information flow needs to be updated, archived and quickly available, along the whole food chain that is composed of five main 'blocks': production, preparation, process, wholesale and retail sales/food service (Food Marketing Research and Information Center 2008). A more complete and general process may be shown in Fig. 3.2 (Zhang 2015).

Consequently, a specific item—a normal cheese, in our situation—should be traced by means of the following information at least:

(a) Common or widely accepted name of product
(b) Commercial brand of the product
(c) Identification of the cheese producer
(d) Identification of raw materials entering the process (with identification of related producers)
(e) Weight of the product (with different measure units, when possible)

(f) General and visual aspect of the product (shape, external and clearly non-edible closures such as metallic rings)
(g) Lot/batch of the product with lot size in terms of units number, with additional information concerning the possibility of sub-lots (and related lot sizes)
(h) Data of production (and also data concerning date of initial production, intermediate seasoning/ageing periods, until the final date of packaging and additional treatments such as freezing)
(i) Declared shelf life with storage conditions
(j) Declared list of ingredients
(k) Specific claims concerning the products (e.g. organic cheese, declaration of origin, declaration of specific production processes, peculiar products certifications, use of different milk in the same product, use of peculiar and traditional ingredients)
(l) Data concerning by-products or discarded pieces (production output).

This list may be not complete because of the complexity of different products involving more than a single production process. Should a cheese be manufactured from a specific milk into a single factory, until packaging/storage/delivery to external consumers, the problem would be easy enough when speaking of traceability data. On the other side, should some process(es) be shared between different processors, several data would be also shared with increasing complexity (Fig. 3.3). A cheese production may be subdivided into various steps concerning different FBO for processed cheeses and for normal cheeses in spite of the lower process complexity (Fig. 3.4).

The problem of output data can be also challenging. In general, a well-designed process should (a) start from a defined number of involved raw materials and (b) end with a specific product. On the contrary, the problem of food productions is often complicated by the number of possible by-products and discarded products without a well-defined identity because of one or more of the following factors:

(1) Different chemical and/or microbiological qualities (including also food safety concerns) in comparison with the normal product exiting from the same process. It should be noted that food safety problems depend often on the temporary exit of these by-products from the process. An example can be shown here: a determined mass of cheese intermediate is not workable, and it cannot be packaged because of abnormal texture (no food safety problems). However, the mass is temporarily removed from production lines, stored in chillers and destined to reworking (use in the process as an internal additive) in the same process with a defined deadline: 30 min from the exit. Should the deadline be not respected, the reworking material might increase the microbial number of certain bacteria (in spite of refrigerated storage) with a visible difference between the normal product before by-product exit and the normal product after this interruption. Moreover, the exit from the process and refrigerated storage can be the cause of additional texture problems
(2) Different sensorial features in comparison with the normal product exiting from the same process

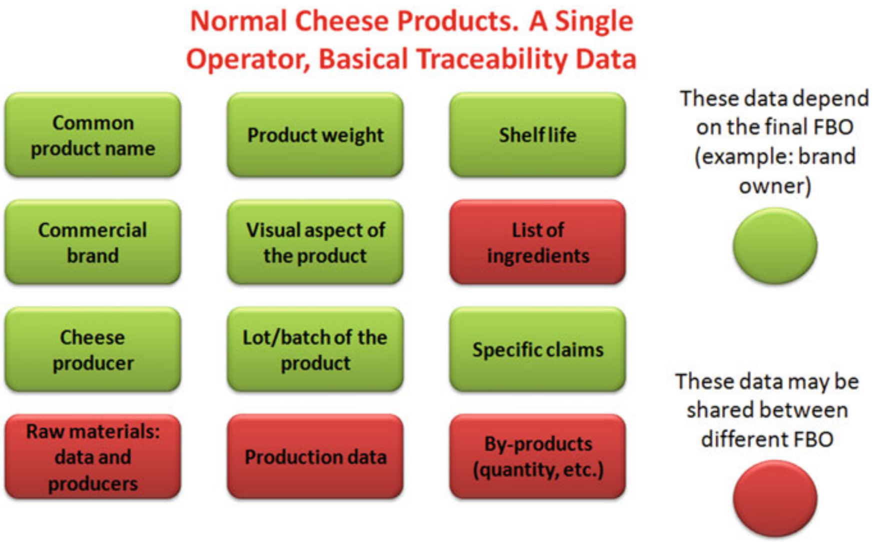


**Fig. 3.3** A specific item—a normal cheese, in our situation—should be traced by means of different information. It should be considered that cheese manufactured from a specific milk into a single factory, until packaging/storage/delivery to external consumers, can be relatively easy when speaking of traceability data. On the other side, should some process(es) be shared between different processors, several data (displayed in the picture with a different colour) would be also shared with increasing complexity

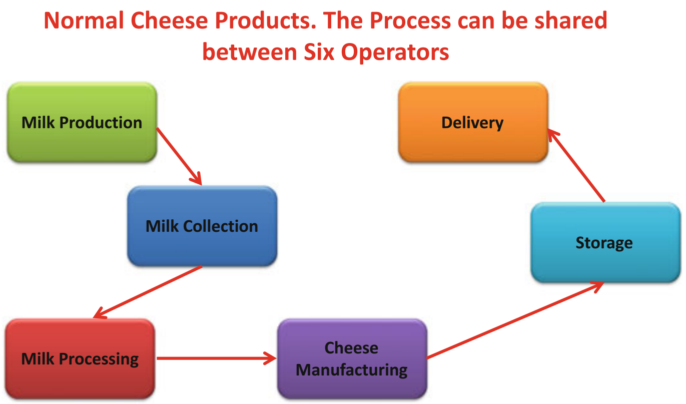


**Fig. 3.4** A cheese production may be subdivided into various steps concerning different FBO for processed cheeses and for normal cheeses in spite of the lower process complexity. As a simple example, a cheese may be produced by means of six different Operators sharing the complete production process

(3) Unacceptable or different size(s) if compared with the usual shape and size of the normal product
(4) Other minor reasons correlated implying the interruption of the continuous process.

Another notable problem concerning cheeses is related to the amount of the food 'solvent': water. Basically, cheese is a solid solution containing fats, carbohydrates and minor components trapped into a more or less rigid and amorphous protein network—hydrophilic casein chains—where nitrogen-based proteins are linked together with water by means of many hydrogen bonds (Parisi et al. 2009). Because of the hydrophilic behaviour of caseins, a certain increase of water in the initial mass exiting from curdling processes should be expected. However:

(a) Certain cheeses are produced with a few production processes only, with the declared aim of increasing the final weight (no ageing). Water is absorbed notably, depending on the casein chains and related decomposition on the one side, and the amount of calcium ions forming metallic bonds between caseins on the other side. For this reason, the sum of entering raw materials may be lower in comparison with the final products (in terms of weight) if water is not considered as 'entering raw material'.
(b) Other cheeses are aged. As a result, the lost weight is mainly a function of water lost in the ageing process (casein chains are generally demolished, with reduced hydric absorption). For this reason, the sum of entering raw materials may be notably higher in comparison with the final products in terms of weight.

Consequently, cheese productions should take into account the role of entering water in some of the involved steps and the subtraction of by-products and water from the total weight of products.

As an example, a simulated situation concerning a cheese type such as Mozzarella cheese (a traditional Italian cheese with only a few production steps) can be shown and discussed as follows. Two different and simplified traceability pathways are discussed here depending on the number of FBO involved in processing steps.

### *3.3.1 Traceability Pathways in Cheese Productions—One Processor*

Basically, the production of Mozzarella cheese—a traditional and widely recognised soft cheese (Parisi 2003, 2009)—requires a few production steps only. Consequently, small farms are able to produce their own Mozzarella cheeses without subsidiary companies and external help.

Briefly, the production flow (Fig. 3.5) for this cheese from cow or goat milk may be summarised as follows (Paz et al. 2017; Rodrigues et al. 2014):

(1) Raw milk collection
(2) Standardisation of different milk

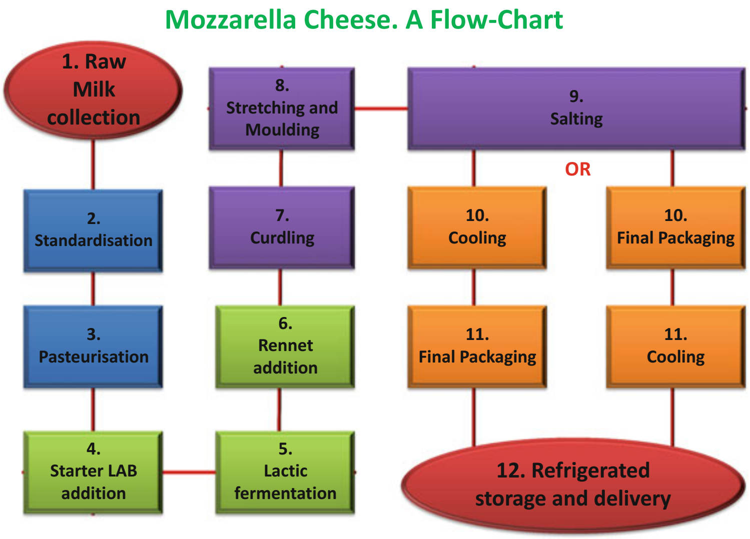


**Fig. 3.5** The production flow for Mozzarella cheese from cow or goat milk may be summarised in 12 steps, from the initial raw milk collection (milk production is omitted here) until the refrigerated storage and delivery to customers. Actually, some step may be slightly different depending on the desired product

(3) Pasteurisation (calcium chloride may be added before this step)
(4) Starter LAB addition
(5) Lactic fermentation
(6) Rennet addition
(7) Curdling (with pH decrease and expulsion of whey)
(8) Stretching and moulding
(9) Salting
(10) Cooling in refrigerated water
(11) Final packaging
(12) Refrigerated storage and delivery to customers.

Actually, some step may be slightly different depending on the desired product.

The entire production (Fig. 3.5) can be easily carried out in small farms. As a result:

(a) Depending on the prompt availability of collected milk and adequate collecting silos, steps 1 and 2 are realised in the beginning of the working day.
(b) Usual pasteurisation (72 °C/15 s), correspondent to step 3, is carried out as soon as possible.
(c) Subsequent 4, 5 and 6 steps—starter LAB addition, lactic fermentation, rennet addition—are critical for the good performance of the whole process. The critical step is no. 7 (curdling).

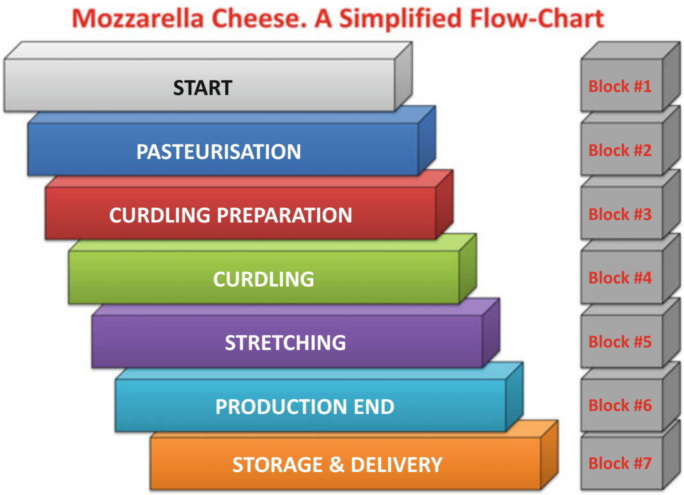


**Fig. 3.6** The flow chart of the process for Mozzarella cheeses may be simplified by means of practical working blocks. The first of these blocks, 'start', joins steps 1 and 2 (Fig. 3.5); the second block concerns only pasteurisation (step 3), while the third block joins steps 4–6. Step 7 is identical to the fourth block, while 'stretching' concerns steps 8 and 9. The 'production end' joins steps 10 and 11, without differences between the two alternative pathways (Fig. 3.5). Finally, 'storage and delivery' is identical to step 12.

(d) After curdling (step 7), the paste has to be stretched in hot water (variable times and temperatures—step 8). The result is a *pasta filata* ('stretched' in Italian language) mass. The resulting cheese paste has to be moulded (step 8) and salted (this addition might be made also before stretching—step 9).
(e) Finally, the cheese has to be (i) cooled by means of water immersion (step 10) and subsequently packaged (step 11), or (ii) firstly packaged into thermosealed containers and subsequently cooled (alternative pathway).
(f) The final step corresponds to storage and delivery in refrigerated conditions at least (step 12).

The above-mentioned summary of the process may be useful because several steps are 'grouped' into seven practical working blocks (Fig. 3.6):

- 'Start': Raw milk collection (step 1) and standardisation of different milk (step 2)
- 'Pasteurisation' (step 3)
- 'Curdling preparation': Starter LAB addition (step 4), lactic fermentation (step 5), rennet addition (step 6)
- 'Curdling' (step 7)
- 'Stretching': Stretching and moulding (step 8), salting (step 9)
- 'Production end': Cooling in refrigerated water (step 10); packaging (step 11) or vice versa (alternative pathway)
- 'Storage and delivery' (step 12).

The subdivision of the processing flow chart may be more comprehensible in this way; at the same time, it should be highlighted that each working block may correspond to a single operation unit located into a small farm or into a specialised company. In other terms, the production of similar cheeses could concern one or five different FBO with processor functions (Sect. 3.3.2).

Should the production be carried out by a single processor, the temporal subdivision of different steps would have a negligible importance because the cheese can be produced on the same day, provided that (a) the amount of desired Mozzarella cheese is low enough in small farms, and (b) there is a good availability of collected milk and water. With relation to milk, it should be considered that an average yield in similar productions from cow milk is 10%: in other words, 1,000 l of collected milk may generally give 100 kg of Mozzarella cheeses. It has to be noted that this yield is extremely variable depending on various factors, including also the possible addition of calcium chloride (Parisi 2012).

### *3.3.2 Traceability Pathways in Cheese Productions— Many Processors*

With relation to Mozzarella cheese productions (Sect. 3.3.1), the entire production (Fig. 3.5) can be easily carried out in small farms. On the other hand, the proposed subdivision of the processing flow chart into seven ‘operation units’ (Fig. 3.6) may be useful because each ‘working block’ can be located into a small farm or into a specialised company. In other terms, the production of similar cheeses could concern one or five different FBO with processor functions. Each working block—start; pasteurisation; curdling preparation; curdling; stretching; production end; storage and delivery—can be theoretically carried out separately. However, practical and logistic considerations require that the subdivision of the process is carried out in the following way (Fig. 3.7):

(A) Start
(B) Pasteurisation
(C) Curdling preparation + curdling
(D) Stretching + production end
(E) Storage + delivery.

Should different processors carry out the production, the temporal subdivision of different steps would have an important impact:

(a) The cheese cannot be produced on the same day, although several exceptions are possible, provided that different FBO processors are located in the same geographical area. In general, the opposite situation is observed nowadays.
(b) Each working block takes a certain time, and additional periods have to be expected between a sub-process and the subsequent step (Fig. 3.7) because of logistic operations and delivery between two different processors.

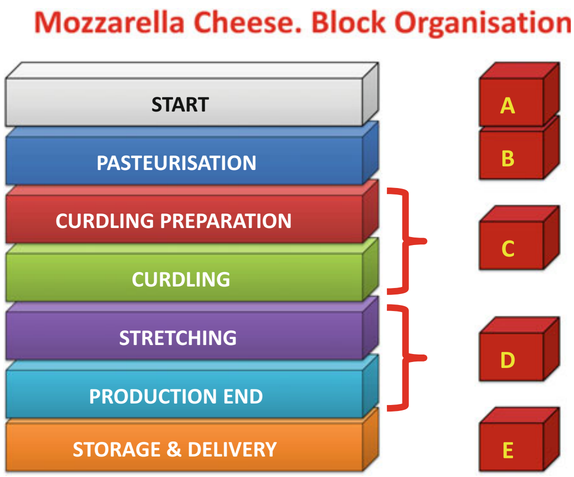


**Fig. 3.7** The proposed subdivision of the Mozzarella cheese flow chart into seven 'operation units' (Fig. 3.6) may be useful because each 'working block' can be located into a small farm or into a specialised company. In other terms, the production of similar cheeses could concern one or five different FBO with processor functions. Should more than one FBO be involved, working blocks would be coupled and managed with the aim of simplifying the process. Practical and logistic considerations require that the subdivision of the process is further grouped in five main 'blocks'

(c) Finally, each processor can perform its own operations in a different way if compared with the idea or technological solutions operated by other FBO. Consequently, the final Mozzarella cheese should be the result of different working blocks carried out in a different way (and possibly with dissimilar scopes).

## 3.4 Traceability in Cheese Productions—Curds and the Role of Water

The production of modern cheeses in an industrial and globalised system and the concomitant scarcity of the main raw material in certain countries have progressively increased the importance of milk processors and transporters. In addition, and with relation to the production of cheeses on a large scale, the use of pre-packaged curds is a constant parameter should be considered carefully. These curds are produced as explained in Sect. 3.3.1; however, the production of curds is stopped as shown in Sect. 3.3.2 by a FBO, and the produced item is packaged and sold to one or more FBO, generally responsible for the production of the final cheese(s). As a result, the subdivision of the process is carried out in the following way (Fig. 3.8):

(A) Start, by the first FBO (the milk collector)
(B) Pasteurisation, by the first or the second FBO (if different from the first FBO)

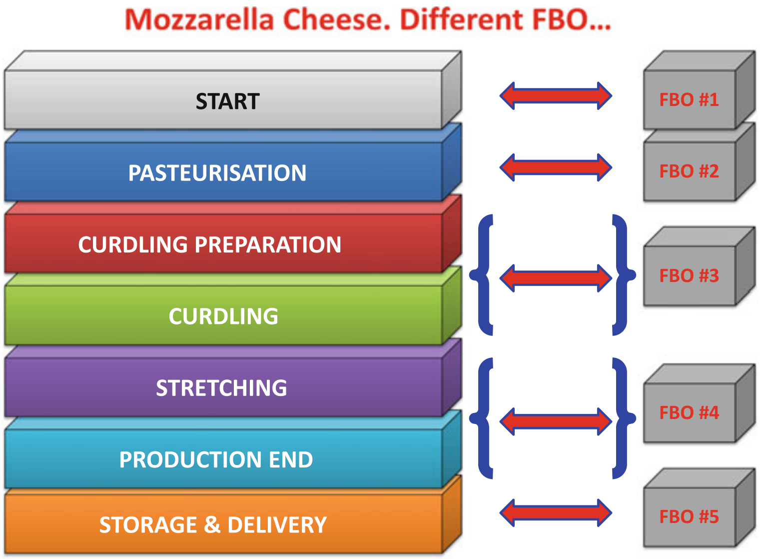


**Fig. 3.8** Should Mozzarella cheese (Figs. 3.6 and 3.7) be obtained by external and pre-packaged curds, the subdivision of the process would be probably carried out in the following way: A start, by the first FBO (the milk collector); B pasteurisation, by the first or the second FBO (if different from the first FBO); C curdling preparation and curdling, by the second or third FBO (if different from the second FBO); D stretching + production end; and E storage + delivery. Practical and logistic considerations require that the subdivision of the process is carried out by a maximum FBO number (five processors)

(C) Curdling preparation + curdling
(D) Stretching + production end
(E) Storage + delivery.

Should the production be carried out in this way, the producer of the final cheese would use a curd produced by another FBO. Consequently, the traceability system has to take this possibility into count. This chapter aims to demonstrate a practical application of this system by a cheese industry where milk is not used; on the contrary, cow's milk curds are used for the production of Mozzarella cheeses and semi-hard cheeses (Parisi 2003).

Another problem concerning traceability in foods is the role of added or incorporated water. On the one hand, food traceability should take into account all food 'inputs' including raw materials, additives, other compounds and packaging materials and objects. This requirement includes all possible input data entering the production flow. On the other side, and with the specific exclusion of '*meat, meat preparations, unprocessed fishery products and unprocessed bivalve molluscs*', it is allowed that added water may be omitted from the ingredient list on condition that '*it does not exceed 5 by weight of the finished product*', in accordance with Reg. No 1169/2011, Annex VII, part A, point 1 (European Commission 2011c). Anyway, the quantity of added water should be calculated by means of the following formula, although an important error is introduced here (Sect. 3.5):

$$[\text{Added water}] = \left[\text{Finished product}\right] - \left[\text{Sum of all ingredients excluding added water}\right] \quad (3.1)$$

Consequently, added water incorporated in one or more than one of the involved procedures shown in Fig. 3.8 should be also traced, although the origin of this water is practically coincident with the interested FBO in the related production step. Anyway, the problem of the traceability of added water(s) is not simple because of two main reflections:

(1) Cheeses are produced with the aim of obtaining a good ‘cheesemaking yield’ (Parisi et al. 2006, 2009). As a consequence, should pre-packaged curds be used, the process should show a definite and clear yield: this difference should be the apparent increase of weights after water addition. On the other side, water may be not mentioned in the list of ingredients. As a clear result, the sum of declared raw materials (without added water) may give ‘100’ parts (or kilograms), while the resulting products (including by-products) may give ‘110’ parts (or kilograms). This difference may be not always comprehensible by all FBO and interested stakeholders. It has to be noted that water incorporation depends strongly on the chemical–physical state of the used curd(s) (Parisi et al. 2006, 2009): different (‘matured’ or ‘non-matured’) curds may give very different hydric absorptions.

(2) Secondly, cheeses obtained by means of the ‘normal way’ (no use of pre-packaged curds) cannot show the incorporation of added water until the first working block (Fig. 3.8) because of the obvious nature of used raw materials and intermediates (aqueous liquid solutions). Water incorporation can only be demonstrable in the third ‘curdling’ block.

(3) Moreover, chemical–physical and microbiological transformations concerning cheese intermediates imply tacitly that:

(3.1) A small water amount is continually expelled from the product (this phenomenon might be considered as a delayed syneresis) (Parisi 2006; Parisi et al. 2006). This expulsion continues in all possible environments with variable results depending on storage temperatures, and it could be observed in packaged units also (expelled water cannot be re-incorporated a second time).

(3.2) Microbial spreading and the continuous activity of LAB can produce different molecules, with the addition of water by hydrolysis. This water can be expelled from the cheese, and the final products can show lower weights than expected (depending on thermal conditions and the microbial ecology).

(3.3) Anyway, it has to be considered that many cheeses may be seasoned (aged) for a variable number of days. As a result, in-progress intermediate cheeses are forced to reduce their weight, depending on environmental conditions and possible superficial treatments. The importance of this phenomenon has to be considered because the sum of raw materials and added waters should not determine the equal amount of finished products.

It has to be also highlighted that the production of a cheese product 'generates' the final product itself and '*n*' possible by-products; consequently, Eq. 3.1 should be amended, as shown and discussed in Sect. 3.5.

## 3.5 Traceability in Cheese Productions—The Importance of 'Off-line' By-Products

As discussed in Sect. 3.4, the 'mass balance' between entering raw materials and other ingredients on the one side and the final result(s) in terms of end products on the other side should take into account the importance of added water, even if this water is not really declared in the product label (this situation may cause many misunderstandings). In addition, it has to be considered that the production of a cheese product 'generates' the final product itself and '*n*' possible by-products. With reference to a single processing step generating one intermediate cheese, these materials, also defined 'Off-Line' (OL) products, should correspond to the difference between:

(a) The total amount of produced intermediates in a specific process and
(b) The amount of final products that can be sold because of their marketability or compliance with current regulatory laws, as shown in Eq. 3.2:

$$[\mathrm{OL}] = [\text{Sum of products}] - [\text{Marketable products}] \tag{3.2}$$

As a consequence, Eq. 3.1 should be amended as shown in Eq. 3.3:

$$\begin{aligned}[\text{Added water}] = {} & [\text{marketable products}] + [\mathrm{OL}] \\ & - [\text{Sum of all ingredients excluding added water}]\end{aligned} \tag{3.3}$$

Equation 3.3 corresponds to an acceptable estimation of the processing balance mass. It should be noted that this equation does not take into account water losses, as explained in Sect. 3.4. Should this amendment be introduced, Eq. 3.4 (derived from Eqs. 3.2 and 3.3) would explain the process very well:

$$\begin{aligned}& [\text{Sum of all ingredients excluding added water}] + [\text{Added water}] \\ & \quad = [\text{Marketable products}] + [\mathrm{OL}] + [\text{Lost water}]\end{aligned} \tag{3.4}$$

Another possible strategy might be used instead of Eq. 3.4. In other terms, it should be implicit that each process has a conversion rate or yield, and this 'performance' could be determined experimentally. Consequently:

(1) It might be assumed that the sum of all raw materials with the exclusion of water (intended as a pure solvent in the process) generates a determined mass of end products and OL materials at the end of the process.
(2) Water incorporation (dependent mainly on curds) may be omitted from the equation on condition that water losses are omitted at the same time.
(3) As a final result, the balance mass of this process would be determined according to the new Eq. 3.5.

$$\begin{aligned}&\left[\text{Sum of all ingredients excluding added water}\right]\\&\quad=\left\{\left[\text{Marketable products}\right]+[\text{OL}]\right\}\times \text{Y}\end{aligned}\tag{3.5}$$

where Y corresponds to an experimental cheesemaking yield (Y) specific for the process: it should implicitly compensate for the absence of both added water and lost water at the same time (Fig. 3.9). Although this explanation may be satisfactory in certain situations, it should be considered that Y depends on many possible parameters including environmental temperatures, thermal cycles, microbial ecology, type of added ingredients. As a consequence, the use of similar approaches might be questioned in certain ambits. Anyway, traceability requires all possible food inputs are considered; as a result, the first strategy (Eq. 3.4) would be preferred. In this book, the following case studies are considered taking into account the first approach.

## 3.6 Traceability in a Cheese Industry—The ExTra Tool

At present, food traceability approaches in the cheese sector are both manual (paper documentation) and ICT-based systems. Anyway, the basic requirements of these systems are:

- The identification of foods, with brand and producer data
- The identification of customers, with a description of food products supplied to these subjects
- Dates of production and shelf-life periods
- Dates of transaction or transportation documents (invoice documents are clearly used in this ambit)
- Amount of used raw materials for a specific food, with a description of suppliers and producers
- Amount of sold food products
- Other data (e.g. OL amounts; definition of weight loss or lost water).

In addition, food industries can use a hybrid system combining physical documents and related (manual) recording with ICT solutions.

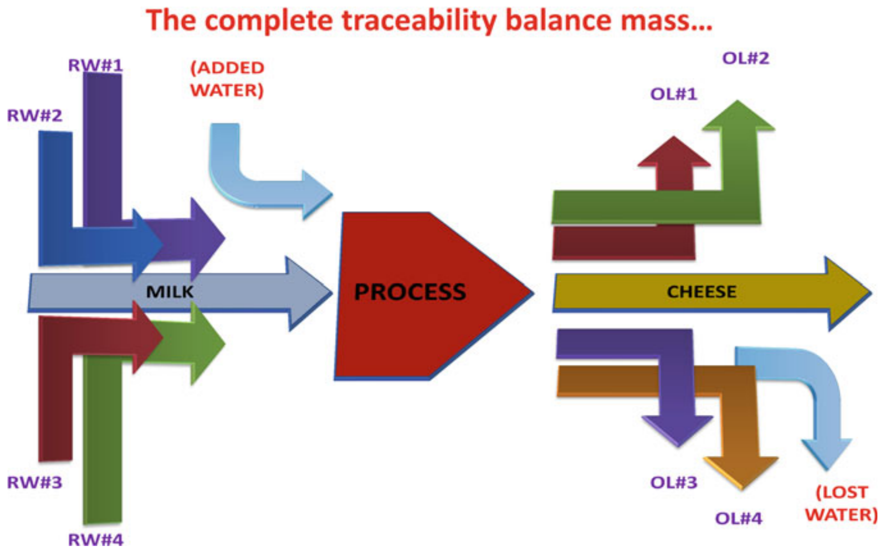


**Fig. 3.9** Traceability requires all possible food inputs that are considered; as a result, the best strategy is to count all possible input and output data in a process, including also added water and lost water (Eq. 3.4). Another strategy might consider all input and output data (left of the picture: milk and raw materials #1, 2, …; right of the picture: final cheese + Off-line (OL) by-products #1, 2, …) without added and lost water (in brackets); a corrective factor or yield (Y) would be used. It should compensate for the absence of both added water and lost water at the same time. However, this approach is not always accepted. Consequently, the first approach—represented in the picture—is used in this book

### *3.6.1 The ExTra Tool—An Overview*

This chapter would describe a practical part of a traceability system into a cheese industry, Gambino Industrie Alimentari Spa (Sicily, Italy), as performed by Dr. Ignazio Mania from 02 May 2016 to 29 July 2016, in the ambit of a dedicated training under Dr. Salvatore Parisi's supervision. Traceability is quite a complex argument: for this reason, the discussed arguments in this book are related exclusively to processing operations without other non-technological topics.

The above-mentioned company—specialised in the production of Mozzarella cheeses, semi-hard cheeses and dairy products and preparations (processed and analogue cheeses)—has implemented a multi-electronic sheet software created by Salvatore Parisi in 2007. This software has been called 'Extended Traceability' (ExTra): the basic aim of this product is to give evidence of all raw materials and other ingredients used in the production of related cheeses.

In brief, the ExTra software—subsequently defined 'ExTra tool' only—is able to join all information related to different productions for a single day by means of (Fig. 3.10):

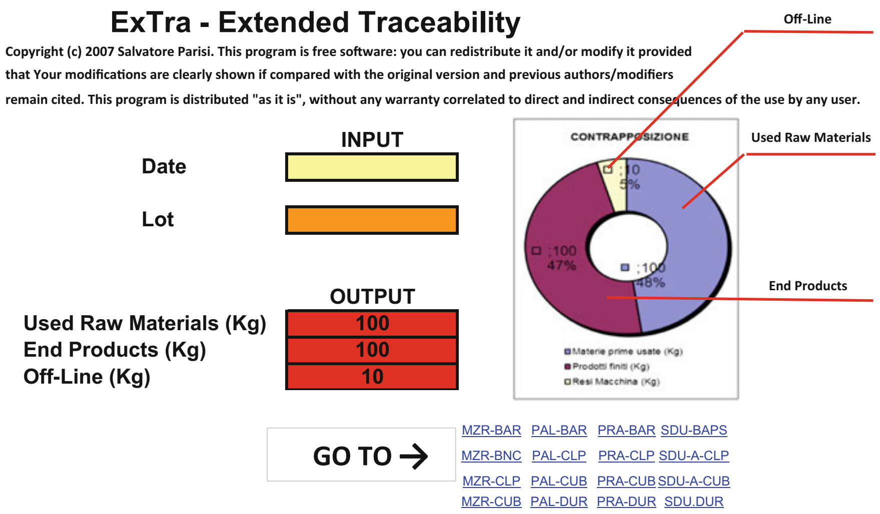


**Fig. 3.10** A cheese industry, Gambino Industrie Alimentari Spa (Sicily, Italy), specialised in the production of Mozzarella cheeses, semi-hard cheeses and dairy products and preparations (processed and analogue cheeses), has implemented a multi-electronic sheet software created by Salvatore Parisi in 2007. This software has been called 'Extended Traceability' (ExTra): the basic aim of this product is to give evidence of all raw materials and other ingredients used in the production of related cheeses. Dr. Ignazio Mania has performed a dedicated training under Dr. Salvatore Parisi's supervision from 02 May 2016 to 29 July 2016. These experiences have been partially described here and in Chaps. 4, 7 and 10. All simulated situations are not real (for training purposes only)

(a) The description of different product formulations
(b) The overview of the global amount of used raw materials for the production day
(c) The description of the total quantity of obtained end products or (marketable cheeses) for the production day
(d) The overview of the global amount of obtained OL (non-marketable foods) for the production day.

Figure 3.10 shows the overview page of ExTra tool, where the following data are available:

(1) Basic input data. The production date is defined also by means of the lot code (the xxx-th day of the year)
(2) Basic output data concerning used raw materials (this description includes all ingredients and added water), marketable foods (end products) and OL
(3) The 'balance' graph showing the situation correspondent to raw materials on the one side (left part) and output data on the other side (end products and OL)
(4) Finally, 16 different links correlating the first overview page to individual cheese formulations.

The use of ExTra tool cannot be possible without the existence of additional data: real documents and other information related to raw materials and obtained products. In fact, the real aim of ExTra is to give evidence of the production for a specific product such as one of the 16 given cheese formulations, provided that other information is supplied (brand, weight, shape, etc.).

## *3.6.2 The ExTra Tool—One Single Product, One Single Sheet*

Figure 3.10 shows the overview page of ExTra tool, where 16 different links correlating the page to individual cheese formulations are displayed. With relation to this book, a simplified version of ExTra is shown, and the following formulations are practically discussed in this chapter:

(1) MZR-BAR
(2) SDU-BAPS.

The first of these acronyms is for 'Mozzarella cheese: bar-shaped version', while the second acronym means 'semi-hard cheese: white, smoked, wax-coated and sectioned versions'.

Data related to these products concern two different products in this simplified case study:

(a) A normal Mozzarella cheese related to MZR-BAR formulation
(b) A semi-hard cheese, white version (no superficial treatments, 5 ageing days), related to SDU-BAPS formulation.

Each link is related to a single electronic sheet showing the formulation, identification data for the final product and output data as discussed in Sect. 3.3.

### 3.6.2.1 Mozzarella Cheese—ExTra File

Figure 3.11 shows the link page related to MZR-BAR formulation. This sheet contains the following information:

(a) The name of formulation acronym (MZR-BAR is displayed on the top left of the picture)
(b) A link to the overview page ('START') grouping all information related to all formulation sheets
(c) The lot of the final product
(d) The production date of the final product
(e) Brand, weight and other interesting data concerning the final product (expiration date, etc.)
(f) Input data to be supplied: ordered amount of the final product
(g) Used raw materials (total sum in kilograms)
(h) Final products (total sum in kilograms)

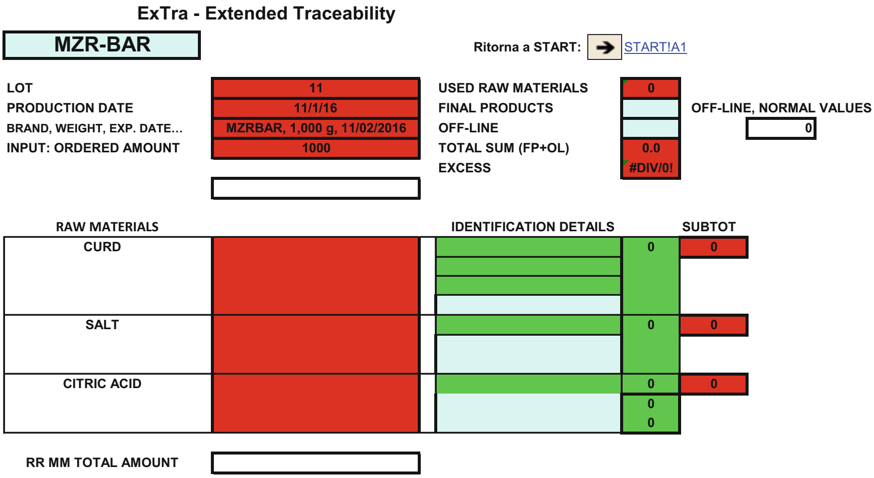


**Fig. 3.11** This picture shows the link page related to MZR-BAR formulation. This sheet contains different information. The Operator inserts the following input: lot of the production (011); production date (11 January 2016); brand, weight, etc. (MZRBAR, 1,000 g, 11 February 2016); and input, ordered amount: 1,000 kg. On these bases, the ExTra tool can calculate the formulation for this product as shown in Fig. 3.12. The shown formula has been created for this simulation only; it is not real (for training purposes only)

(i) Off-line (OL) or 'reworking products' (in kilograms). An additional information (Off-line, normal values) can be forecasted on the basis of previous statistical analyses concerning the same production)
(j) Total sum (all ingredients excluding added water)
(k) Excess (an exceeding percentage amount of production dependent on the difference between the total sum and the amount of final products)
(l) Detail of used raw materials: curd, salt and a general additive for acidity correction, citric acid. Details are shown on the right of this image, with relation to: name of the producer, arrival, amount, lot/batch information and used amount of the specific raw material
(m) Raw materials' total amount (sum of all declared raw materials): this number may be not equal to 'used raw materials' (total sum in kilograms) because the last number refers to really used raw materials, and the first number is only a prediction.

Basically, the work on ExTra files is summarised as follows. The Operator inserts the following input (Fig. 3.11):

(1) Lot of the production (in our simulated case study, it is 011)
(2) Production date (in our simulated case study, it is 11 January 2016)
(3) Brand, weight, etc. (in our situation: MZRBAR, 1,000 g, 11 February 2016)
(4) Input, ordered amount: 1,000 kg.

On these bases, the ExTra tool can calculate the formulation for this product as shown in Fig. 3.12. The formula—created for this simulation only, it is not real—is

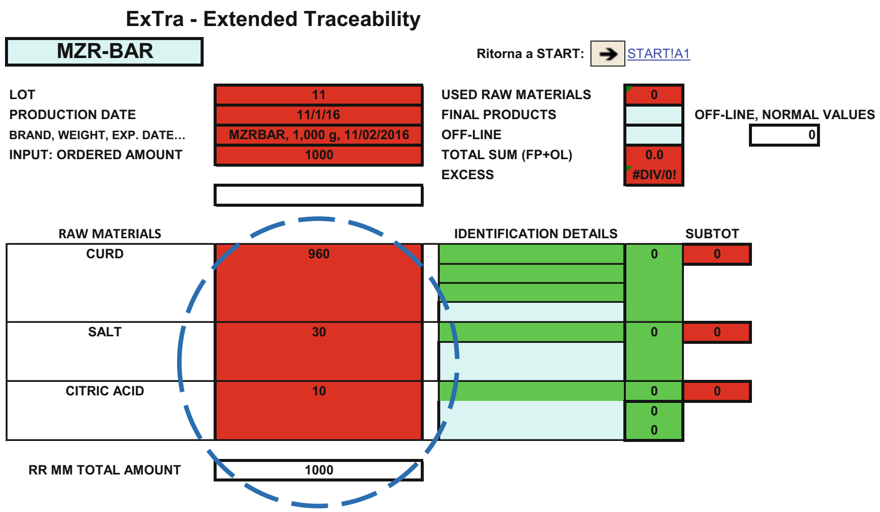


**Fig. 3.12** The ExTra tool (Fig. 3.11) can calculate the formulation for this product (blue circle). Each raw material has to be identified with the name of the supplier, arrival date and lot numbers; subsequently, the used amount of raw material per line has to be inserted (blue circle in the image), and the total sum of raw materials is calculated and expressed as 'used raw materials' (purple circle on the top right of the picture). The shown formula has been created for this simulation only; it is not real (for training purposes only)

recorded in the ExTra tool and calculated on the basis of ordered amount (input data). In our case study, 1,000 kg (ordered Mozzarella cheese) implies that:

(a) Cow's milk curd has to be approximately 96% of the ordered amount (960 kg).
(b) Food-grade salt has to be approximately 3% of the ordered amount (30 kg).
(c) The considered additive, citric acid, has to be approximately 1% of the ordered amount (10 kg).

After this operation, the Operator inserts also data related to single raw materials. In the simulation, one single curd is inserted, and the same thing for salt and citric acid, in the following way:

(a) Each raw material has to be identified with name of the supplier, arrival date and lot numbers at least (the identification is more correct when speaking of data for single pallet units).
(b) Subsequently, the used amount of raw material per line has to be inserted (blue circle in the image).
(c) The total sum of raw materials is calculated and expressed as 'used raw materials' (purple circle on the top right of the picture).

It should be noted that the formulation has been completely respected in this situation; however, theoretical formulations are not really coincident with used raw materials. In general, a limited percentage tolerance is allowed, raw material per raw material, when ordering practically ingredients for food productions.

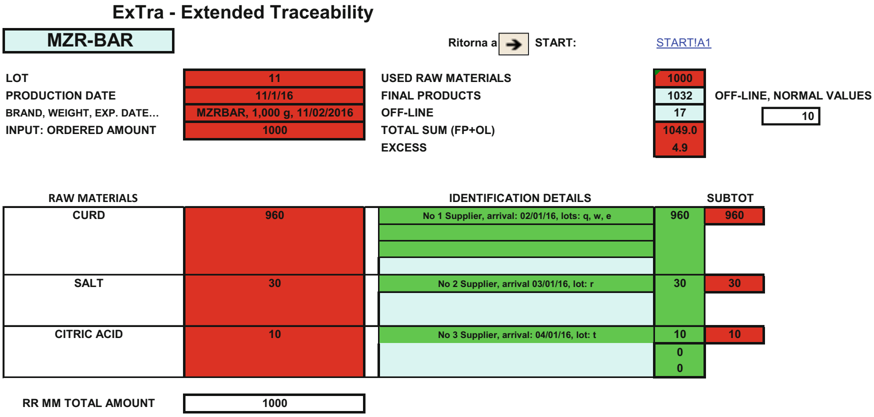


**Fig. 3.13** At the end of the production cycle (one step only, starting from pre-packaged curd with the addition of food-grade salt, citric acid and water as 'solvent'), the Operator writes the amount of final products and the OL quantity. In this simulated case study, the produced Mozzarella cheese is equal to 1,002 kg, while OL is correspondent to 17 kg only. In addition, the 'Excess' parameter is calculated automatically: 4.9% because of the difference between the total sum of production (1,019 kg) and final (marketable) products (1,002 kg). The shown formula has been created for this simulation only; it is not real (for training purposes only)

At the end of the production cycle (one step only, starting from pre-packaged curd with the addition of food-grade salt, citric acid and water as 'solvent'), the Operator writes the amount of final products and the OL quantity (Fig. 3.13). In this simulated case study, the produced Mozzarella cheese is equal to 1,032 kg, while OL is correspondent to 17 kg (the minimum value should be 10 kg). In addition, the 'Excess' parameter is calculated automatically: 4.9% because of the difference between the total sum of production (1,049 kg) and final (marketable) products (1,032 kg).

It has to be considered that OL includes the following by-product categories:

(a) Intermediate masses which cannot be packaged because of abnormal shapes
(b) Intermediate cheeses which have been packaged but with some failure (opened or broken packages, incorrect or defective ink printing with concern to lot, expiration dates, etc.)
(c) Intermediate masses, which have been not packaged because of the production end or because of temporary line stops.

Because of their nature, they may be reworked (reused) in the same process or in another similar process, in the same day or in another subsequent day, on condition that safety and legal requirements are respected. In addition, the most advisable solution for similar 'reworking' materials should be the addition in imitation cheeses because of their nature and medium–low hydric absorption (Parisi et al. 2006, 2009).

As mentioned in Sect. 3.4, water absorption should be always mentioned even if the amount of added water is lower than 5% (with these conditions, this 'ingredient' can be omitted from the list of ingredients). With concern to this simulated situation, the water amount may be easily calculated. In fact (Fig. 3.13):

(1) The global process has generated 1,032 kg of finished products and OL from 1,000 kg of raw materials (with the exclusion of water).
(2) The 'Excess' parameter states that the process has clearly produced more cheese than expected: the difference is 49 kg.
(3) Consequently, the production has globally allowed raw materials to absorb water in Excess (+4.9%).
(4) However, the 'Excess' value is not the real amount of added water in the process because this amount is related to finished products and OL at the same time. On the contrary, added water should be considered in the list of ingredients—and mathematically calculated—only on condition that the difference between final products and raw materials exceeds 5%.
(5) As a result, the global amount of added water by final cheeses only is (1,032 − 1,000) kg = 32 k or 3.2% if considered evaluating final products only.

This discussion is useful when water—always considered when speaking of traceability—has to be really considered and calculated. The 'Excess' parameter is the real indicator of the process; however, this number cannot be confused with added water.

It should be also highlighted that the above-discussed production (Fig. 3.13) is related to the use of one curd only, while many curds could be introduced in the same way. Consequently, the higher the number of different items, the more difficult the joint traceability for a single product.

Finally, the discussed case study has demonstrated—as usual—that Mozzarella cheese productions rely on measurable water absorption. However, this situation can be observed when speaking of matured curds only (Barone et al. 2017). Different curds can be unable to absorb water because of insufficient proteolysis on casein chains on the one side or enhanced casein demolition on the other side. As a result, certain productions may demonstrate the virtual absence of water absorption (Fig. 3.14) or weight losses (Fig. 3.15—water is not absorbed; on the contrary, inner water of curds is expelled during production). Figure 3.14 shows the simulation with final products equal to the sum of raw materials; actually, the process has a measurable performance, but the Excess parameter is too low (+1.7%).

Figure 3.15 shows the same simulation where final products are < raw materials. In this situation, water is not absorbed; on the other side, water linked to casein chains in the original curd is progressively expelled because of enhanced protein demolition (Barone et al. 2017). Consequently, added water is <0; however, it should be traced as an essential medium for the production. Anyway, the global process may still be able to absorb a minimum water amount; however, it has to be noted that OL composition is generally different from final products. In general, OL shows more

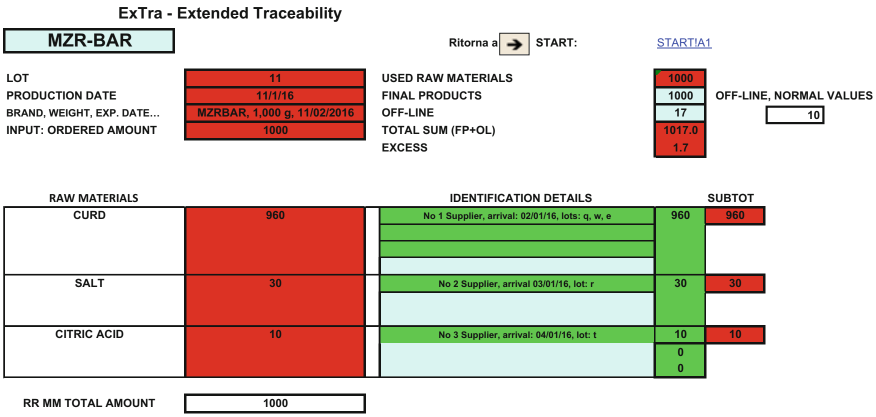


**Fig. 3.14** Certain productions may demonstrate the virtual absence of water absorption or weight losses. This simulation shows final products equal to the sum of raw materials; actually, the process has a measurable performance, but the Excess parameter is too low (+1.7%). The shown formula has been created for this simulation only; it is not real (for training purposes only)

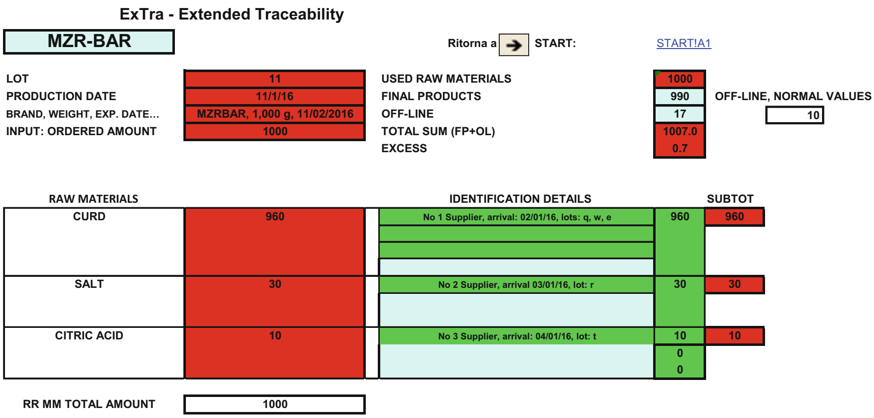


**Fig. 3.15** Certain productions may demonstrate weight losses (water is not absorbed; on the contrary, inner water of curds is expelled during production). Final products are < raw materials. In this situation, added water is <0; however, it should be traced as an essential medium for the production. The global process may still be able to absorb a minimum water amount (+0.7%); however, it has to be noted that OL composition is generally different from final products. In general, OL shows more moisture contents if compared with the final product, when speaking of Mozzarella cheeses. This phenomenon is substantially a partial water substitution. The shown formula has been created for this simulation only; it is not real (for training purposes only)

moisture contents if compared with the final product, when speaking of Mozzarella cheeses. For this reason, water should be always traced: expelled water is > absorbed water, but this phenomenon is substantially a partial water substitution (Fig. 3.16).

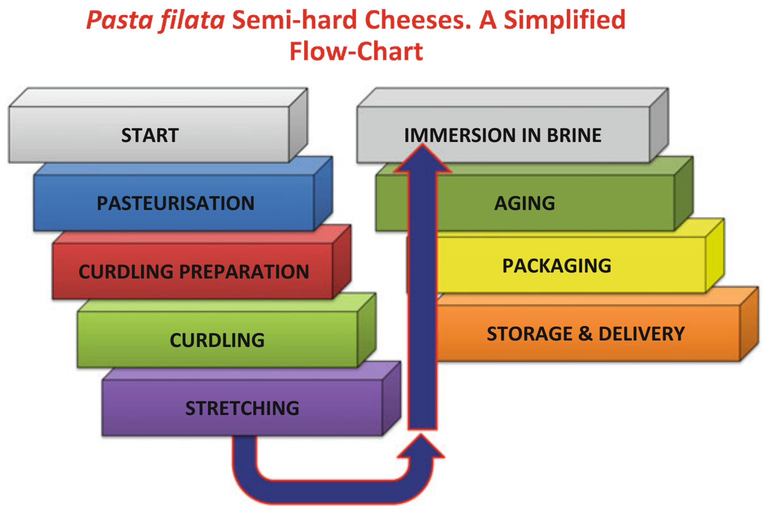


**Fig. 3.16** Semi-hard cheeses have some difference with concern to the general flow chart and the derived 'working blocks' (Fig. 3.6). Substantially, 'stretching' requires more time if compared with Mozzarella cheese. Moreover, three new working blocks—'immersion in brine solution', 'ageing' and 'packaging'—are required

#### 3.6.2.2 Semi-hard Cheese—ExTra File

The production of *pasta filata* semi-hard cheeses has some difference in comparison with Mozzarella cheeses, although the process is substantially similar in the first stages. In fact, Mozzarella cheese is produced and immediately packaged (Sect. 3.3.1); subsequently, final products are stored in refrigerating chillers (frozen products can also be observed in the current market).

On the other hand, *pasta filata* semi-hard cheeses have some difference with concern to the general flow chart and the derived 'working blocks' (Fig. 3.6).

- 'Start' (raw milk collection and standardisation of different milk. No differences.
- 'Pasteurisation'. No differences.
- 'Curdling preparation' (starter LAB addition, lactic fermentation, rennet addition). No differences.
- 'Curdling'. No differences.
- 'Stretching' (stretching and moulding; salting). Differences: the intermediate cheese can be stretched in a notably long time if compared with Mozzarella cheese.
- 'Immersion in brine solution' (new process). The cheese is not cooled in water after packaging, but immersed in brine solutions.
- 'Ageing (new process). The intermediate cheese is 'seasoned' (aged) for 1–5 days at temperatures ranging from 0 to 8 °C. This process determines a measurable weight loss because of water expulsion and enhanced proteolytic demolition.

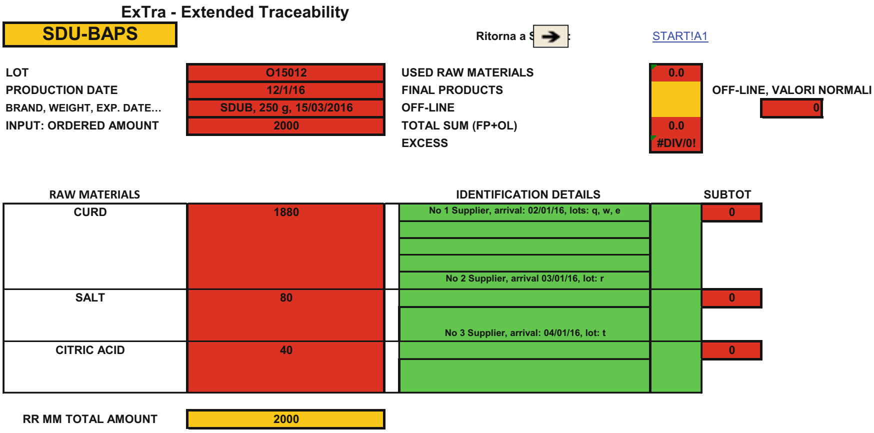


**Fig. 3.17** The ExTra tool shows the link page related to SDU-BAPS formulation. This sheet contains all input information. On the basis of input data, the ExTra tool can calculate the formulation for this product as shown in Fig. 3.17. The formula is recorded in the ExTra tool and calculated on the basis of ordered amount (input data). The shown formula has been created for this simulation only; it is not real (for training purposes only)

- 'Packaging' (new process). The aged product is packaged after 1–5 days. This process is different from the analogous process for Mozzarella cheese because it is carried out with products which do not need immersion in cold water.
- 'Storage and delivery': no differences.

With relation to the ExTra tool, Fig. 3.17 shows the link page related to SDU-BAPS formulation. This sheet contains the following information:

(a) The name of formulation acronym (SDU-BAPS is displayed on the top left of the picture)
(b) A link to the overview page ('START') grouping all information related to all formulation sheets
(c) The lot of the final product (XXXYYY). This time, the lot is composed of two sub-lots: the first three digits—XXX—correspond to the final date of packaging, while the second three digits—YYY—mean the initial date of production
(d) The initial production date of the final product (12 January 2016)
(e) Brand, weight and other interesting data concerning the final product (in our situation: SDUB, 250 g, 15 March 2016)
(f) Input data to be supplied: ordered amount of the final product (2,000 kg, in this simulation)
(g) Used raw materials (total sum in kilograms)
(h) Final products (total sum in kilograms)
(i) Off-line (OL) or 'reworking products' (in kilograms). An additional information (Off-line, normal values) can be forecasted on the basis of previous statistical analyses concerning the same production

(j) Total sum (all ingredients excluding added water)
(k) Excess (an exceeding percentage amount of production dependent on the difference between the total sum and the amount of final products)
(l) Detail of used raw materials: curd, salt and a general additive for acidity correction, citric acid. Details are shown on the right of this image, with relation to: name of the producer, arrival, amount, lot/batch information and used amount of the specific raw material
(m) Raw materials' total amount (sum of all declared raw materials; this number may be not equal to 'used raw materials' (total sum in kilograms) because the last number refers to really used raw materials, and the first number is only a prediction.

Because of input data, the ExTra tool can calculate the formulation for this product as shown in Fig. 3.17. Once more, the formula—created for this simulation only, it is not real—is recorded in the ExTra tool and calculated on the basis of ordered amount (input data). In our case study, 2,000 kg (ordered semi-hard cheese) implies that:

(a) Cow's milk curd has to be approximately 94.0% of the ordered amount (1,880 kg).
(b) Food-grade salt has to be approximately 4.0% of the ordered amount (80 kg).
(c) The considered additive, citric acid, has to be approximately 2.0% of the ordered amount (40 kg).

After this operation, the Operator inserts also data related to single raw materials (Fig. 3.17). In the simulation, one single curd is inserted and the same thing for salt and citric acid.

At the end of the process, after ageing and other steps until final packaging, the Operator writes the amount of final products and the OL quantity (Fig. 3.18). In this simulated case study, the produced semi-hard cheese is equal to 2,005 kg, while OL is correspondent to 20 kg (the minimum value should be 20 kg). In addition, the 'Excess' parameter is calculated automatically: +1.3% because of the difference between the total sum of production (2,025 kg) and final (marketable) products (2,005 kg).

Once more, OL includes the following by-product categories:

(1) Intermediate masses which cannot be packaged because of abnormal shapes
(2) Intermediate cheeses which have been packaged but with some failure (opened or broken packages, incorrect or defective ink printing with concern to lot, expiration dates, etc.)
(3) Intermediate masses, which have been not packaged because of the production end or because of temporary line stops.

Because of their nature, they may be reworked (reused) in the same process or in another similar process, in the same day or in another subsequent day, on condition that safety and legal requirements are respected. In addition, the most advisable solution for similar 'reworking' materials should be the addition in imitation cheeses because of their nature and medium–low hydric absorption (Parisi et al. 2006, 2009).

As mentioned in Sect. 3.4, water absorption should be always mentioned even if the amount of added water is lower than 5% (with these conditions, this 'ingredient'

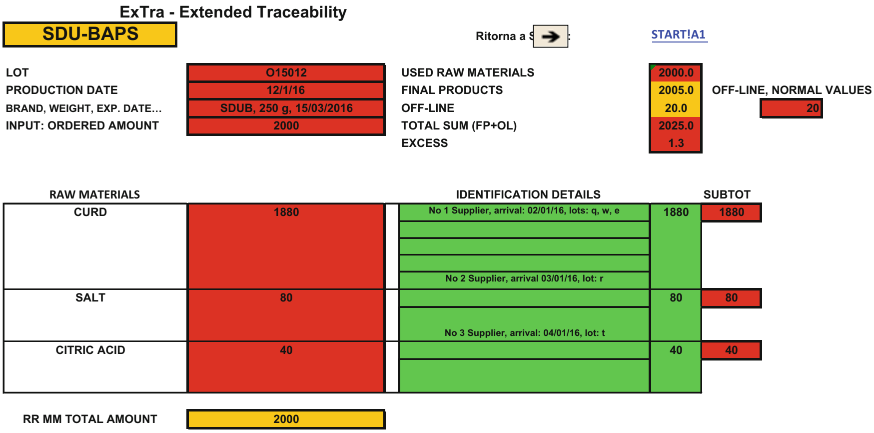


**Fig. 3.18** At the end of the process (Fig. 3.17), after ageing and other steps until final packaging, the Operator writes the amount of final products and the OL quantity. In this simulated case study, the produced semi-hard cheese is equal to 2,005 kg, while OL is correspondent to 20 kg (the minimum value should be 20 kg). In addition, the 'Excess' parameter is calculated automatically: +1.3% (low hydric absorption) because of the difference between the total sum of production (2,025 kg) and final (marketable) products (2,005 kg). The shown formula has been created for this simulation only; it is not real (for training purposes only)

can be omitted from the list of ingredients). With concern to this simulated situation (Fig. 3.18):

(1) The global process has generated 2,025 kg of finished products and OL from 2,000 kg of raw materials (with the exclusion of water).
(2) The 'Excess' parameter states that the process has clearly produced more cheese than expected: the difference is 20 kg, or +1.3%.
(3) The complete production has globally allowed raw materials to absorb water (+1.3%).
(4) However, the 'Excess' value is not the real amount of added water in the process because this amount is related to finished products and OL at the same time. On the contrary, added water should be considered in the list of ingredients—and mathematically calculated—only on condition that the difference between final products and raw materials exceeds 5%.
(5) As a result, the global amount of added water by final cheeses only is (2,005 − 2,000) kg = 5 kg or 0.3% if considered evaluating final products only.

In this situation, the global process has demonstrated low water absorption (Fig. 3.18) because a certain aqueous amount is lost during ageing at least. In addition, used curds could be not able to absorb water with consequent notable weight losses (Fig. 3.19). For example, the obtained amount of marketable semi-hard cheeses could arrive to 1,975 kg only, with an 'Excess' parameter equal to −0.3%. Consequently, the process would express a poor performance because there is no added water, but water expulsion (matured curds are mainly responsible for this result) (Barone et al.

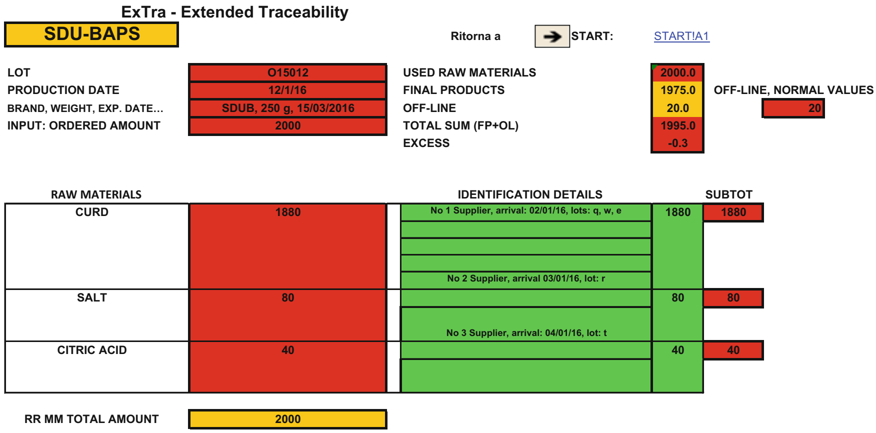


**Fig. 3.19** Semi-hard cheeses show normally low water absorption (Fig. 3.18) because a certain aqueous amount is lost during ageing at least. In addition, used curds could be not able to absorb water with consequent notable weight losses. For example, the obtained amount of marketable semi-hard cheeses could arrive to 1,975 kg only, with an 'Excess' parameter equal to −0.3%. Consequently, the process would express a poor performance because there is no added water, but water. This phenomenon is substantially a partial water substitution. The shown formula has been created for this simulation only; it is not real (for training purposes only)

2017). Once more, expelled water is > absorbed water, but this phenomenon is substantially a partial water substitution. For this reason, water has to be traced because of its undoubtable absorption by raw materials, even if a remarkable amount of the final aqueous quantity is removed.

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# Chapter 4
# The ExTra Tool—Practical Simulations in the Cheesemaking Industry When Using Cheeses, Butter and Rennet Caseins

**Abstract** At present, the problem of traceability in food industries is one of the most important and emerging factors with notable influence on the management of food business operators. The sector of cheese products is an interesting example. However, there are 'cheeses'—obtained from milk, salt, rennet and some minor additive(s)—on the one hand, and different products: 'processed cheeses' and 'analogue cheeses' or 'imitation cheeses' on the other side. The world of processed or melted cheeses is different enough from the sector of cheeses made from milk; however, new emergencies concerning food frauds and authenticity issues, or the undeclared presence of allowed additives with some specific food allergenic reaction, are observed in this ambit. In addition, the declared claims concerning 'low sugar contents', 'low cholesterol amounts', other health statements, etc., should be discussed in this area. The transformation of raw materials towards the final product(s) determines a complication in the traceability if compared to cheese obtained from milk (or curd). Moreover, durable products such as processed and analogue cheeses can remain on the market for extended period times, thus enhancing the temporal need of traceability data. The flow of input information has to be analysed, raw material per raw material; the same thing is true when speaking of output information concerning final products and by-products (sometimes defined as 'off-line' products). Generally, more than one processing food business operators are involved in the global process. The aim of this chapter is to describe in practice the complex operations—named jointly 'traceability'—in this ambit by means of a software product—the ExTra tool—with reference to two simulated productions: a processed cheese and a general imitation cheese.

**Keywords** Analogue cheese · Extended Traceability · Food business operator
Input information · Off-Line · Output information · Processed cheese

 
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## 4.1 Processed Cheeses and Traceability. A Practical Introduction

At present, the problem of traceability in food industries is one of the most important and emerging factors with notable influence on the management of food business operators (FBOs). As discussed in Sect. 3.1, the mandatory requisite of traceability, both from raw materials to final products and vice versa, is mentioned in many legislative and voluntary documents. In general, food certification standards such as Global Standard for Food Safety (by the British Retail Consortium, UK) and the International Featured Standard (IFS) Food (Bitzios et al. 2017; Jin et al. 2017; Nicolae et al. 2017; Stilo et al. 2009; Telesetsky 2017) are seriously taken into account.

The world of processed or melted cheeses is different enough from the sector of cheeses made from milk (Parisi 2002a, 2003); however, new emergencies concerning food frauds (also named 'economically motivated adulteration) and authenticity issues, or the undeclared presence of allowed additives with some specific food allergenic reaction, have been considered in this ambit. Currently, the attention of national and international authorities working with food and beverage controls is focused on these topics. The list is virtually infinite because of new and 'traditional' foods with different features, including herbal preparations and novel foods in general (Kok 2017; Lacorn et al. 2018; Moyer et al. 2017; Pisanello and Caruso 2018; Silvis et al. 2017), are available at present in the market. In addition, the declared claims concerning 'low sugar contents', 'low cholesterol amounts', other health statements and particular authenticity and origin declarations should be discussed in this area.

With relation to traceability and correlated legislations concerning the protection of food consumers, the European framework is the Regulation (EC) No 178/2002. This Regulation (and subsequent amendments and implementation documents) corresponds to the legal basis for many requirements in the EU, including traceability and other useful instruments such as the 'Rapid Alert System for Food and Feed' (European Commission 2004, 2006, 2008, 2011; European Parliament and Council 2002, 2003a, 2009, 2014). In addition, three specific regulations concern the traceability of food of animal origin, sprouts and seeds intended for the production of sprouts, and genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms (European Commission 2011, 2013; European Parliament and Council 2003b).

As discussed in Sect. 3.1, traceability should have the following requisites (Olsen and Borit 2018):

(1) Food or beverage units should be clearly identified.
(2) Secondly, these units may be put together or separated when speaking of their number and association into a complex number of different commodities with various products, sizes, weights and so on. The transformation of raw materials towards the final product(s) determines a complication in the traceability. Processed cheeses normally contain more ingredients than 'true' cheeses: as a

normal result, input raw material data and their interconnection with the final product and possible by-products may become harder than expected.
(3) Food or beverage units should be recorded with reference to important data. The simple record of unit numbers is only the most evident of related data.

In addition, different FBOs can use dissimilar traceability systems: paper-based documents, information and communications technology (ICT)-integrated approaches, the use of dedicated nanosensors, the application of radio frequency identification (RFID) on packages or the diffusion of 'smart' packages. The application of hybrid systems should be taken into account (Allain et al. 2018; Bibi et al. 2017; Ferrero et al. 2018; Parisi 2009, 2012, 2013).

The difference between 'normal' and processed (melted, analogue) cheeses may be also discussed in terms of enhanced durability expectations (Parisi 2002a, 2004): in general, cheese substitutes show higher durability than normal cheeses. The traceability requisite is particularly important when speaking of high perishable foodstuffs which are subject to rapid deterioration (such as cheeses). On the other side, durable cheeses can remain on the market for extended period times, thus enhancing the temporal need of traceability data (Parisi 2002a, b, 2004).

The sector of milk and dairy productions can show an extremely variegated situation because of the many possible intermediate and final products associated with the original raw material (McSweeney 2007a): milk. However, the sector of processed cheeses has different raw materials, including some extraneous ingredient (e.g. vegetable oils). Moreover, should cheeses be used in the formulation, input data would also take into account (McSweeney 2007b):

(a) Different typologies of ingredient cheeses (e.g. Mozzarella, Edamer, provolone, Parmesan)
(b) Different origins, because a product named 'Parmesan' may be produced in Italy and in other countries
(c) Different authenticity claims, if any
(d) Other different features concerning each ingredient with 'cheese' attribution (e.g. cow cheese, goat cheese).

Recent adulteration episodes and the need of authenticity require that the origin of the used milk is clearly and unambiguously stated on labels, even if cheeses are clearly obtained by cheeses and other ingredients (Aworh et al. 1987; Eymery and Pangborn 1988; Rodriguez et al. 2014).

The aim of this chapter is to describe in practice the complex operations—named jointly 'traceability'—related to a peculiar sub-area of milk-based products: processed cheeses (with cow's milk origin only).

## 4.2 Traceability in Processed Cheese Productions. The Flow of Input Information

With reference to processed cheeses and their production (used ingredients and manufacturing procedures), the following product types should be mentioned (Sect. 6.1):

(1) Dairy cheese products where cheeses, dairy fat and proteins (casein, caseinates, milk fat, butter oil, etc.) are used as main component in. It has to be considered that used cheese products are obtained at least from milk, enzymes or enzymatic preparations (animal rennet, chymosin, vegetable rennet, other microbial-origin milk coagulants), selected lactic acid bacteria (named 'starters') and food-grade salt (mineral origin, also named 'mine'/'rock' salt or sea salt depending on production sites). The addition of allowed food additives has to be mentioned also for labelling and traceability purposes.

(2) Partial dairy cheeses produced using only a part of milk product(s) (cheeses, casein, caseinates, etc.). In this kind of cheese, some dairy components are partially replaced; in detail, milk fats are mainly substituted by vegetable oils, and this replacement is justified by functional benefits or just because it may simply be cheaper. The use of cheeses as ingredients is important to qualify the product.

(3) 'Non-dairy' cheeses produced through components other than milk and cheeses, i.e. vegetable proteins (soya protein, vegetable oil, soya oil, etc.). In non-dairy cheese products, both the protein and the fat contents come from a vegetable source.

This chapter is explicitly dedicated to entering raw materials (input data) information for the production of processed cheeses and imitation cheese (Fig. 4.1). Consequently, the entering information in a traceability (tracking and tracing) system has to concern (Barbieri et al. 2014; Barone et al. 2017; Delgado et al. 2016; Laganà et al. 2017; Mania et al. 2016; Steinka and Parisi 2006):

(a) The used cheese(s), including in this step curds also (in spite of the clear difference between finished products and curdled materials)
(b) The used fat (butter)
(c) The used protein ingredient (casein, caseinates, total milk proteins, whey proteins only, etc.)
(d) The used food additives: melting agents, corrector acidity agents, compounds with other functions, on condition that their use is needed and allowed
(e) The used salt
(f) The used water.

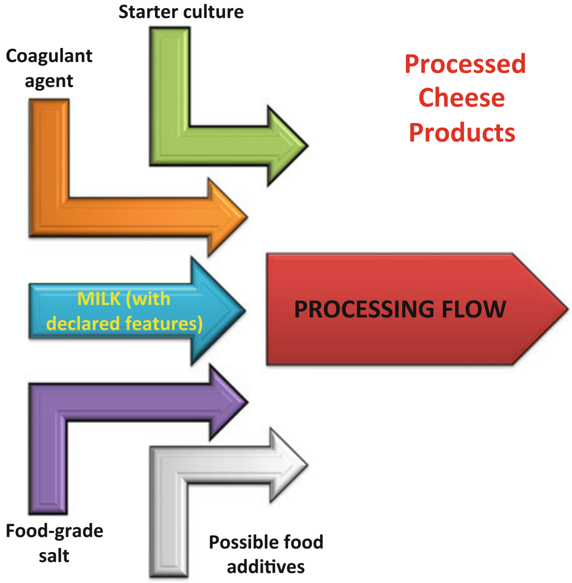


**Fig. 4.1** With reference to processed cheese products, the entering information in a traceability (tracking and tracing) system has to concern: **a** the used cheese(s), including in this step curds if available; **b** the used fat (butter); **c** the used protein ingredient (casein, caseinates, total milk proteins, whey proteins only, etc.); **d** the used food additives; **e** the used salt; **f** the used water

### *4.2.1 Cheese as Ingredient for Imitation Cheeses*

Cheeses can be used widely as food ingredients in many products, including new cheeses, because of the intrinsic nature of the original product (McSweeney 2007c; Parisi 2002a, 2003):

(a) The normal cheese is substantially a 'preserved milk condensate'.
(b) Consequently, the processed cheese is a 'preserved cheese' in a new form.

The use of cheeses in new cheese-like formulations is extremely important when speaking of countries or geographical areas where the access to fresh milk(s) is difficult. As discussed in Sect. 3.2.1, one of the most important information in the sector of cheeses is the animal origin (cow, goat, sheep and buffalo) (McSweeney 2007a). This information is mandatory when speaking of traceability. In addition (Guinee 2007a):

(1) The composition of cheeses has to be evaluated in comparison with other formula components. In general, 'old' (extremely proteolysed) cheeses life can be melted very well at high temperatures (75–90 °C). On the other side, relatively 'fresh' cheeses (shelf life lower than 60 days; proteolytic reactions have a low impact on the texture of the casein network, with high moisture, hydrolysis water and calcium) may be melted with some difficulty. In these conditions, the blending of ingredients has to be defined with a reasonable addition of emulsifying salts (trisodium citrate, sodium phosphates, etc.) and the consequent modification of blend pH to values >5.8 (in general, 'old' cheeses should have

pH between 5.0 and 5.3). As a result, abundant calcium ions—binding metallic cations between casein chains—are progressively sequestrated and replaced with sodium ions, and the resulting product has an acceptable texture.

(2) Certain products have peculiar texture, flavour and colour depending on the addition of selected additives. On the other hand, the addition of particular cheeses can add these qualities to the final product without the use of additives, depending on the formulation. Consequently, the mention of certain cheeses in the food preparation has to be carefully evaluated (Kelly 2007).

With relation to this chapter, the main goal—the description of a reliable traceability in the cheese production and the complete cheese supply chain—has concerned a practical experience carried out in a cheese production plant working with different ingredients. With relation to processed cheeses, only cow's milk cheeses have been considered. It has to be noted that Off-Line (OL) by-products should be chemically considered as low-water-absorption materials, similarly to cheeses for subsequent reworking (Sect. 3.5). These ingredients are unable to absorb notable aqueous amounts; for this reason, the addition or unproteolysed rennet casein (able to absorb water at the maximum level, depending on the low quantity of binding calcium ions) is needed.

### *4.2.2 Butter for Processed Cheese Productions*

The second term in the list of ingredients for normal cheese is generally defined as 'butter'. However, many possible 'butter' typologies are nowadays available on the market including anhydrous milk fat, butter oil, homogenised cream and whey butter (Guinee 2007a).

Anyway, the aim of butter (fat) addition is to raise the final fat content of the final product avoiding certain textural failures. As a simple example, the use of relatively 'fresh' (young) cheeses may determine undesired 'creaming' effects in the final imitation cheese because these ingredients are low-fat products. Should this be the situation, the addition of butter, butter oil or other fat matters would be needed. Alternatively, 'old' cheeses (normally high-fat products) would be added, but the access to these ingredients could be difficult and expensive in certain situations (Guinee 2007b).

### *4.2.3 Proteins for Melted Cheeses*

The protein structure of processed cheeses is determined by:

(a) The amount of 'true' cheeses used in the formula (consider these cheeses can be more or less proteolysed, with an enhanced amount of binding calcium ions in the first situation), and

(b) The quantity of added casein (rennet casein, or acid casein) or caseinates. The addition of milk proteins (80% of milk casein and 20% of lactoalbumins + lactoglobulins) is possible.

The protein network is needed in a cheese or cheese-like structure: the physicochemical stability is assured, with consequent good textural properties (Guinee 2007c). In addition, the whole system has to be able to hold back a notable amount of fat matters: consequently, proteins are needed, even if in a partially proteolysed situation. In fact, added rennet casein (practically unproteolysed chains) can be turned into a hydrated paracaseinate structure by means of the partial calcium removal on the one side, and the correct addition of water (if needed). It has to be noted that the hydric absorption of rennet casein can be notable. On the other hand, cheeses for melting may lose or be unable to absorb water, similarly to OL by-products (Sect. 3.5).

### 4.2.4 Food Additives and Salt for Cheese Productions

Sodium chloride is usually added during cheese productions with the aim of lowering water activity (and consequently inhibiting microbial spreading) (Beresford 2007). The same thing can be affirmed when speaking of processed cheeses. Food-grade sodium chloride (mineral origin, normally defined 'mine'/'rock' salt or sea salt depending on production sites) can be added in the intermediate mass. In addition, different food additives may be added with various functions:

(a) Acidity correctors
(b) Aromas
(c) Aroma enhancers
(d) Colourant substances
(e) Emulsifying salts for stabilisation
(f) Hydrocolloids for stabilisation
(g) Mineral substances
(h) Preservatives
(i) Starches
(j) Vitamins and vitamin preparations.

The list of food additives may be long enough. Chapter 7 has been dedicated to the problem of food additives and related traceability problems.

### 4.2.5 Water for Processed Cheese Productions

The presence of water is needed when speaking of processed cheeses. As previously discussed, the casein structure of these cheeses has to be able to contain and hold fat matters during all the whole (long) shelf life of the product. As a simple result, more or less demolished casein chains have to be linked with water molecules. Additionally, cheese yield in this production is directly influenced by the amount of this absorbed 'solvent'.

Water should not contain calcium ions in notable quantities; otherwise, the adjustment of pH values in the new intermediate melted mass could be difficult. In addition, calcium ions are naturally present in cheeses and rennet caseins: the 'building' of a well-definite cheese structure cannot be obtained without the partial removal of calcium ions from caseins and the substitution with other cations such as sodium. Metal displacements have to be carried out in a solid aqueous solution. Therefore, food technologists cannot rely only on the water amount of added cheeses, butter ($< 10\%$) and other possible minor components containing aqueous molecules (Parisi et al. 2006, 2009).

Differently from 'true cheeses', the addition of water is not generally omitted from the list of ingredients because of its relative abundance in the product (with relation to European Union legislation, the limit of 5% should be exceeded often).

## 4.3 Traceability in Processed Cheese Productions. The Flow of Output Information

Traceability input data correspond, with relation to normal cheeses only, to six main groups (Sect. 4.2). This number may appear little enough; however, the management of similar data may become difficult when speaking of different raw materials for each mentioned category entering into a single production. In general, the final processed cheese is identified with: name of product; brand; weight; aspect; lot; shelf life; list of ingredients; specific claims, if any.

It should be also noted that processed cheeses can be defined in different ways, with relation to marketing needs, regulatory norms, the typology of product (spreads, foods) and the composition of the food with concern to cheese percentage on the one side, and the introduction of non-dairy components. In the last situation, the normal terms are 'analogue cheeses' or 'imitation cheeses' (Guinee 2007c).

From a regulatory viewpoint, the traceability is defined (Sect. 1.1) in Article 3 paragraph 15 of Regulation 178/2002, as '*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*' (European Parliament and Council 2002).

Foods placed on the market must be identified by means of specific information, where possible. The information flow needs to be updated, archived and quickly available, along the whole food chain that is composed of five main 'blocks': production, preparation, process, wholesale and retail sales/food service (Food Marketing Research and Information Center 2008). It has to be noted that processed cheeses (and imitation cheeses) could be used as ingredients in the same process. Similarly

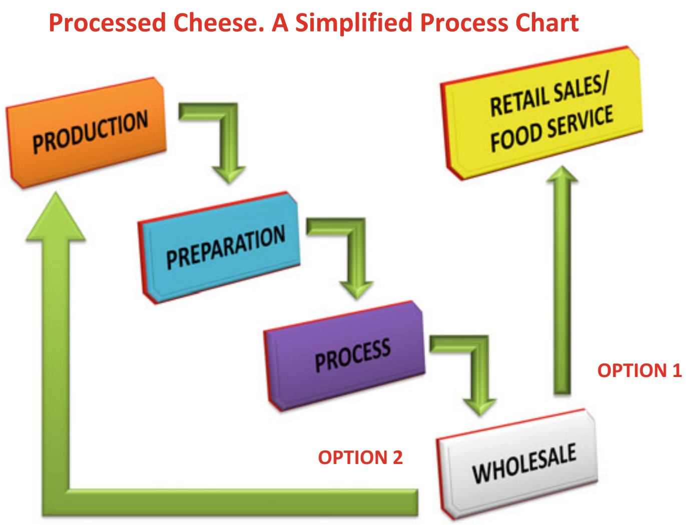


**Fig. 4.2** Information flow concerning processed cheeses needs to be updated, archived and quickly available, along the whole food chain that is composed of five main 'blocks': production, preparation, process, wholesale and retail sales/food service (option 1). It has to be noted that processed cheeses (and imitation cheeses also) could be used as ingredients in the same process (option 2)

to true cheeses (Sect. 3.3), a more complete and general process is shown in Fig. 4.2 (Zhang 2015).

Consequently, a processed or analogue cheese—in our situation—should be traced by means of the following information at least:

(a) Common or widely accepted name of product
(b) Commercial brand of the product
(c) Identification of the cheese producer
(d) Identification of all raw materials entering the process (with identification of related producers)
(e) Weight of the product (with different measure units, when possible)
(f) General and visual aspects of the product (shape, external and clearly non-edible closures such as metallic rings)
(g) Lot/batch of the product with lot size in terms of units number, with additional information concerning the possibility of sub-lots (and related lot sizes)
(h) Data of production
(i) Declared shelf life with storage conditions (this information is particularly relevant when speaking of long-durability products such as these cheeses)
(j) Declared list of ingredients
(k) Specific claims concerning the products, especially with relation to used cheeses in the formulation (when the declaration is important and declared on labelling). Examples are organic cheese(s); declaration of origin; declaration of specific


**Fig. 4.3** A specific item—a processed cheese, in our situation—should be traced by means of different information. It should be considered that a processed or analogue cheese production is subdivided into various steps concerning different FBOs. Several data (displayed in the picture with a different colour) would be shared with increasing complexity

production processes; peculiar products certifications; use of peculiar and traditional ingredients

(l) Data concerning by-products or discarded pieces (production output).

This list may be not complete because of the complexity of different products involving more than a single production process. Generally, a processed or analogue cheese production is subdivided into various steps concerning different FBOs (Fig. 4.3).

The problem of output data can be also challenging because of the number of possible by-products and discarded products without a well-defined identity because of one or more of the following factors:

(1) Different chemical and/or microbiological quality (including also food safety concerns) in comparison with the normal product exiting from the same process. Food safety concerns depend often on the temporary exit of these by-products from the process. An example can be shown here: a determined mass of processed or analogue cheese intermediate is not workable, and it cannot be packaged because of abnormal texture (no food safety problems). However, the mass is temporarily removed from production lines, stored in chillers and destined to reworking (use in the process as an internal additive) in the same process with a defined deadline: 30 min from the exit. Should the deadline be not respected, the reworking material might easily increase the microbial number of certain bacteria (in spite of refrigerated storage) with a visible difference between the normal product before by-product exit and the normal product after this interruption. Moreover, the exit from the process and refrigerated storage can be the cause of additional texture problems. It has to be considered that processed and

analogue cheeses are a relatively residual microbial ecology because of thermal melting treatments (between 75 and 90 °C) for a determined temporal period (e.g. 15 min). As a consequence, exiting by-products may easily have a different microflora if compared with the final product
(2) Different sensorial features in comparison with the normal product exiting from the same process
(3) Unacceptable or different size(s) if compared with the usual shape and size of the normal product
(4) Other minor reasons correlated implying the interruption of the continuous process.

Another notable problem concerning cheeses is related to the amount of the food 'solvent': water (Sect. 3.3) (Parisi et al. 2009). Because of the hydrophilic behaviour of caseins, a certain increase of water in the initial mass exiting from curdling processes should be expected. However, processed cheeses are produced with the aim of absorbing entering and declared water, depending on demolished casein chains and the amount of calcium ions forming metallic bonds between caseins on the other hand. For this reason, the sum of entering raw materials should be approximately equal to the sum of final products (and by-products).

Consequently, cheese productions should take into account the role of entering water in some of the involved steps and the subtraction of by-products from the total weight of products.

As an example, a simulated situation concerning a processed cheese type such as a Mozzarella imitation cheese (without the addition of non-milk products) and a real analogue cheese can be shown and discussed as follows.

### *4.3.1 Traceability Pathways in Processed Cheese Productions*

The production of processed cheese similar to Mozzarella cheeses—a widely recognised type of topping products for pizza productions (Parisi 2002a, 2003; Sheenan 2007)—production flow may be summarised as shown in Fig. 4.4 (Paz et al. 2017; Rodriguez et al. 2014):

(1) Arrival of cheeses
(2) Arrival of other raw materials
(3) Fusion or cooking into adequate 'melters' (the addition of raw materials can be subdivided into more than a single step)
(4) Stretching and moulding
(5) Final packaging
(6) Cooling in refrigerated water
(7) Refrigerated storage and delivery to customers.

The proposed flow chart can be simplified in the following way because of practical and logistic considerations:

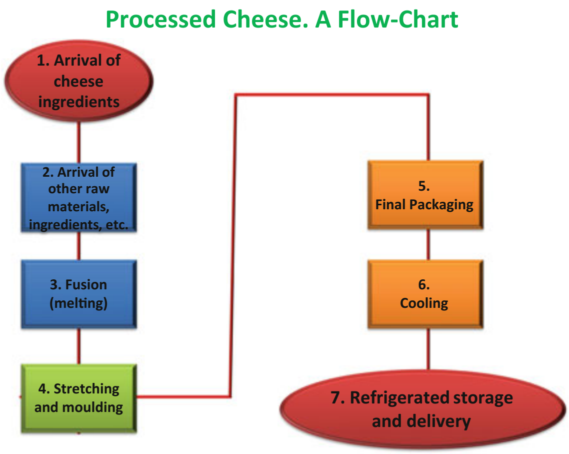


**Fig. 4.4** Production of processed cheese similar to Mozzarella cheeses may be summarised: (1) arrival (and storage) of cheeses; (2) arrival (and storage) of other raw materials; (3) fusion or cooking; (4) stretching and moulding; (5) final packaging; (6) cooling in refrigerate water; (7) refrigerated storage and delivery to customers

(A) Arrival (steps 1 + 2)
(B) Start (fusion, step 3)
(C) Stretching + moulding + cooling + final packaging (steps 4–6)
(D) Storage + delivery.

Each of these 'working blocks' has the following features:

(a) The processed cheese cannot be produced in the same day although several exceptions are possible. As a result, the complete production of processed or analogue cheeses may take some days instead of 1 day only, and this situation is easily observed because of the supposed long durability of ingredients.
(b) Each working block takes a certain time, and additional periods have to be expected between a sub-process and the subsequent step because of logistic operations and delivery between two different processors.
(c) Finally, each processor can perform its own operations in a different way if compared with the idea or technological solutions operated by other FBOs. Consequently, the final cheese should be the result of different working blocks carried out in a different way (and possibly with dissimilar scopes) for practically all used ingredients.

The above-discussed features are observed also in the production of 'true' cheeses; however, the durability of milks or curds is quite limited. Consequently, the temporal period between the collection of milk and the realisation of the final product is short enough if compared with cheeses obtained from many raw materials with shelf-life values ranging from 3 months (cheeses) to more than 1 year (salt, food additives).

Therefore, the traceability of processed cheeses requires that all raw materials are traced, and each of these ingredients has its own history (with related 'working blocks'). Should the ingredient be a simple cheese, the flow chart shown in Fig. 3.7 would be sufficient; on the other hand, ingredients such as butter, caseins and food additives may show additional difficulties. In this situation, the addition of non-milk product is excluded.

### *4.3.2 Traceability Pathways in Analogue Cheese Productions*

The production of analogue cheeses similar to Mozzarella cheeses—a widely recognised type of topping products for pizza productions (Parisi 2002a, 2003; Sheenan 2007)—is shown in Fig. 4.4, similar to processed cheeses. However, the difference is the addition of extraneous (non-milk) raw materials, and the first of these ingredients is represented by vegetable oils (palm oil, coco oil, sunflower oil, mixtures of vegetable oils, etc.). Moreover, the formulation may comprehend certain food additives of animal or vegetable origin that could be questioned by food consumers because of their clear non-milk nature (Sect. 7.1).

Once more, the proposed flow chart for processed cheeses may be simplified in the following way because of practical and logistic considerations:

(A) Arrival (steps 1 + 2)
(B) Start (fusion, step 3)
(C) Stretching + moulding + cooling + final packaging (steps 4 to 6)

(D) Storage + delivery.
Each of these 'working blocks' has the same features discussed in Sect. 4.3.1. It should be considered that the complete production of analogue cheeses may easily take some days instead of 1 day, and this situation is easily observed because of the long durability of ingredients such as vegetable oils.

Interestingly, the origin of vegetable oils should be considered as a practical difficulty in the sector of milk and dairy products.

In fact, the production of milk and milk derivatives—including cheeses, butter, casein—is generally circumscribed in only one or two geographical areas (e.g. for a FBO located in Italy: European Union and Middle East). Reasons are essentially related to cheapness and transportation difficulties, when speaking of raw materials, unless the labelling does not require peculiar origins. However, one of the main reasons for these choices is represented by shelf life: the lower the durability of raw materials, the higher the risk of direct or indirect damages caused by ingredients shipped from a too distant country or geographical area. As a simple example, the European market of coffee products is forced to take into account similar risks because raw coffee is not European products: the main producers are in Brazil, Indonesia and other distant countries. On the other side, milk and cheese producers have not the same difficulty.

The situation of vegetable oils—palm and coco oils can be good examples—is different: these alternative fat materials are originally supplied from Malaysia, Indonesia and other countries; subsequently, the industrial transformation—needed because marketed oils and fats should have at least rheological properties similar to milk fats—is performed in other countries. However, the initial and botanical origin may be a distinctive difficulty when speaking of European or non-South-East producers. Because of the necessity of different steps, the management of traceability for analogue cheeses may be more difficult if compared with processed cheeses.

## 4.4 Traceability in Processed and Analogue Cheese Productions. The Importance of 'off-Line' by-Products

The production of a cheese product 'generates' the final product itself and '*n*' possible by-products. With reference to a single processing step generating one intermediate cheese, these materials, also defined OL products, should correspond to the difference between:

(a) The total amount of produced intermediates in a specific process, and
(b) The amount of final products that can be sold because of their marketability or compliance with current regulatory laws, as shown in Eq. 4.1:

$$[\mathrm{OL}] = \left[\text{Sum of products}\right] - \left[\text{Marketable products}\right] \tag{4.1}$$

Equation 4.1 corresponds to an acceptable estimation of the processing balance mass. It should be noted that this equation does not take into account water losses (Sect. 3.4) because processed and analogue cheeses should theorically absorb water without losses.

Another possible strategy could be used instead of Eq. 4.1. In other terms, it should be implicit that each process has a conversion rate or yield, and this 'performance' could be determined experimentally. Consequently:

(1) It may be assumed that the sum of all raw materials may generate a determined mass of end products and OL materials at the end of the process.
(2) The balance mass of this process would be determined according to the new Eq. 4.2.

$$\left[\text{Sum of all ingredients}\right] = \left\{\left[\text{Marketable products}\right] + [\mathrm{OL}]\right\} \times \mathrm{Y} \tag{4.2}$$

where Y corresponds to an experimental cheesemaking yield (Y) specific for the process. Although this explanation may be satisfactory in certain situations, it should be considered that Y depends on many possible parameters including environmental temperatures, thermal cycles, microbial ecology, type of added ingredients. Y is expected to be approximately equal to 1; different Y values would signal process abnormalities. In this book, the following case studies are considered taking into account the first approach.

## 4.5 Traceability for a Processed Cheese. The ExTra Tool

As discussed in Sect. 3.6.1, this book would describe a practical part of a traceability system into a cheese industry, Gambino Industrie Alimentari SpA (Sicily, Italy), as performed by Dr Ignazio Mania from 02 May 2016 to 29 July 2016, in the ambit of a dedicated training under Dr Salvatore Parisi's supervision. The discussed arguments in this book are related exclusively to processing operations without other non-technological topics.

The above-mentioned company—specialised in the production of Mozzarella cheeses, semi-hard cheeses and dairy products and preparations (processed and analogue cheeses)—has implemented multi-electronic sheet software created by Salvatore Parisi in 2007. This software has been called 'Extended Traceability' (ExTra): the basic aim of this product is to give evidence of all raw materials and other ingredients used in the production of related cheeses.

The ExTra software—subsequently defined 'ExTra tool' only—is able to join all information related to different productions for a single day (Sect. 3.6.1). The use of ExTra tool cannot be possible without the existence of additional data: real documents and other information related to raw materials and obtained products. In fact, the real aim of ExTra is to give evidence of the production for a specific product such as one of the 16 given cheese formulations, provided that other information is supplied. Figure 3.10 shows the overview page of ExTra tool, where 16 different links correlating the page to individual cheese formulations are displayed. With relation to this book, a simplified version of ExTra is shown, and the following formulations are practically discussed in this chapter:

(1) PAL-BAR
(2) PRA-CLP.

The first of these acronyms is for 'processed cheese: bar-shaped version', while the second acronym means 'analogue cheese: cylindrical shape'.

Data related to these products concern two different products in this simplified case study:

(a) A normal processed cheese related to PAL-BAR formulation
(b) An imitation cheese related to PRA-CLP formulation.

Each link is related to a single electronic sheet showing the formulation, identification data for the final product and output data.

### *4.5.1 The ExTra Tool—Processed Cheeses*

Figure 4.5 shows the link page related to PAL-BAR formulation. This sheet contains the following information:

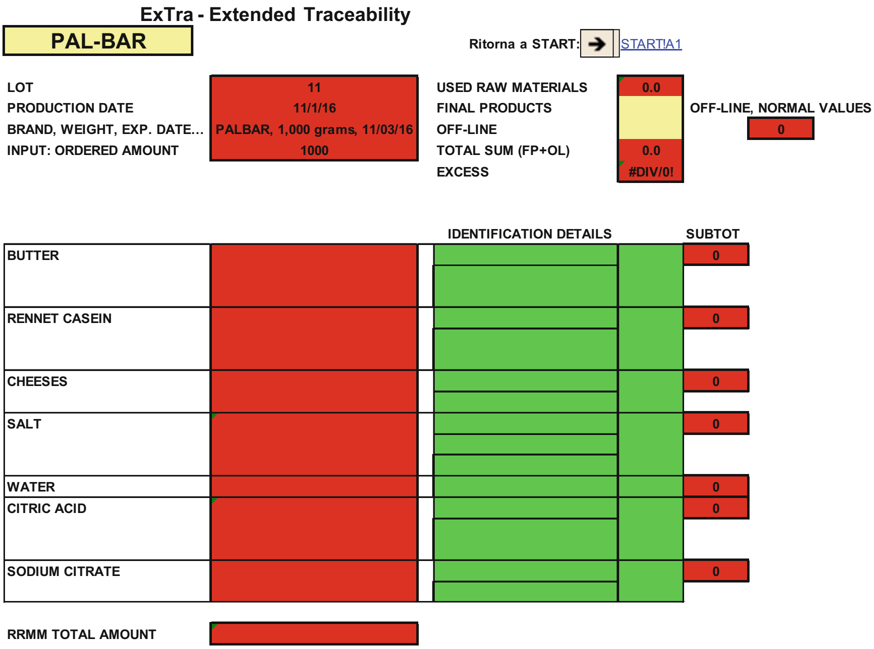


**Fig. 4.5** This image shows the link page related to PAL-BAR formulation. This sheet contains different information. The Operator inserts the following input: lot of the production (011); production date (11 January 2016); brand, weight, etc. (PAL-BAR, 1,000 grams, 11 March 2016); input, ordered amount: 1,000 kg. On these bases, the ExTra tool can calculate the formulation for this product as shown in Fig. 4.6. The shown formula has been created for this simulation only; it is not real (for training purposes only)

(a) The name of formulation acronym (PAL-BAR is displayed on the top left of the picture)
(b) A link to the overview page ('START') grouping all information related to all formulation sheets
(c) The lot of the final product
(d) The production date of the final product
(e) Brand, weight and other interesting data concerning the final product (expiration date, etc.)
(f) Input data to be supplied: ordered amount of the final product
(g) Used raw materials (total sum in kilograms)
(h) Final products (total sum in kilograms)
(i) Off-line (OL) or 'reworking products' (in kilograms). An additional information (Off-line, normal values) can be forecasted on the basis of previous statistical analyses concerning the same production
(j) Total sum (all ingredients)
(k) Excess (an exceeding percentage amount of production dependent on the difference between the total sum and the amount of final products)

(l) Detail of used raw materials. Details are shown on the right of this image, with relation to: name of the producer, arrival, amount, lot/batch information and used amount of the specific raw material
(m) Raw materials total amount (sum of all declared raw materials; this number may be not equal to 'used raw materials') because the last number refers to really used raw materials, and the first number is only a prediction.

The work on ExTra files is summarised as follows. The Operator inserts the following input (Fig. 4.5):

(1) Lot of the production (in our simulated case study, it is 011)
(2) Production date (in our simulated case study, it is 11th January 2016)
(3) Brand, weight, etc. (in our situation: PAL-BAR, 1,000 g, 11 March 2016)
(4) Input, ordered amount: 1,000 kg.

On these bases, the ExTra tool can calculate the formulation for this product as shown in Fig. 4.6. The formula—created for this simulation, it is not real—is recorded in the ExTra tool and calculated on the basis of ordered amount (input data). In our case study, 1,000 kg (ordered processed cheese) imply that:

(a) Cheese has to be approximately 49.5% of the ordered amount (495 kg).
(b) Water should be 32%.
(c) Butter and rennet casein should be 7 and 6%, respectively.
(d) Food-grade salt has to be approximately 2.5% of the ordered amount (25 kg).
(e) The considered additives, sodium citrate and citric acid, have to be approximately 1.9 and 1.1% of the ordered amount.

After this operation, the Operator inserts also data related to single raw materials. In the simulation:

(a) Each raw material has to be identified with name of the supplier, arrival date and lot numbers at least (the identification is more correct when speaking of data for single pallet units).
(b) Subsequently, the used amount of raw material per line has to be inserted.
(c) The total sum of raw materials is calculated and expressed as 'used raw materials'.

It should be noted that the formulation has been completely respected in this situation; however, theoretical formulations are not coincident with used raw materials. In general, a limited percentage tolerance is allowed, raw material per raw material, when ordering practically ingredients for food productions.

Moreover, the following circumstances have to be evaluated:

(1) Cheeses come from two different suppliers. It should be recommended in production control sheets that the order of use of the first and the second cheeses are mentioned. In this situation, cheeses have been used in mixture. Consequently, this simulation does not take into account the temporal order and use of the first and the second cheeses.

**ExTra - Extended Traceability**

**PAL-BAR**

Ritorna a ➔ START: START!A1

| | | | | |
|---|---|---|---|---|
| LOT | 11 | USED RAW MATERIALS | 1000.0 | |
| PRODUCTION DATE | 11/1/16 | FINAL PRODUCTS | | OFF-LINE, VALORI NORMALI |
| BRAND, WEIGHT, EXP. DATE... | PALBAR, 1,000 grams, 11/03/16 | OFF-LINE | | 0 |
| INPUT: ORDERED AMOUNT | 1000 | TOTAL SUM (FP+OL) | 0.0 | |
| | | EXCESS | -100.0 | |

| | | IDENTIFICATION DETAILS | | SUBTOT |
|---|---|---|---|---|
| BUTTER | 70 | No 3 Supplier, arrival: 02/01/16, lots: q, w, e | 70 | 70 |
| RENNET CASEIN | 60 | No 4 Supplier, arrival 03/01/16, lot:z1, z2, z3 | 60 | 60 |
| CHEESES | 495 | No 1 Supplier, arrival: 04/01/16, lot x | 250 | 495 |
| | | No 2 Supplier, arrival: 04/01/16, lot: y | 245 | |
| SALT | 25 | No 5 Supplier, arrival: 05/01/16, lot 0101 | 25 | 25 |
| WATER | 320 | Inner water, used: 11/01/16 | 320 | 320 |
| CITRIC ACID | 11 | No 6 Supplier, by ZZZ manufacturer arrival: 02/01/16, lot w88e8w | 11 | 11 |
| SODIUM CITRATE | 19 | No 6 Supplier, by MMM manufacturer arrival: 02/01/16, lot t88t79r | 19 | 19 |
| RRMM TOTAL AMOUNT | 1000 | | | |

**Fig. 4.6** ExTra tool (Fig. 4.5) can calculate the formulation for the PAL-BAR product. Each raw material has to be identified with name of the supplier, arrival date and lot numbers; subsequently, the used amount of raw material per line has to be inserted, and the total sum of raw materials is calculated and expressed as 'used raw materials'. The following circumstances have to be evaluated: **a** cheeses come from two different suppliers; **b** water has been classified as 'inner water'. Consequently, the supplier is the interested FBO; **c** citric acid and sodium citrate are different ingredients. However, the supplier is the same FBO while each product has been initially manufactured by two different FBOs. The shown formula has been created for this simulation only; it is not real (for training purposes only)

(2) Water has been classified as 'inner water'. Consequently, the supplier is the interested FBO. Note that the date of use should be at least mentioned.

(3) Citric acid and sodium citrate are different ingredients. However, the supplier is the same FBO while each product has been initially manufactured by two different FBOs (ZZZ and MMM for citric acid and sodium citrate, respectively). This simple example introduces (Chapter 7) the role of intermediary companies: these subjects are FBO without involvement when speaking of manufacturing and practical operations, while they perform transportation and are responsible for export documentations. As a result, one raw material implies one manufacturer only, while more than one FBO in the food chain may exist before use.

At the end of the production cycle, the Operator writes the amount of final products and the OL quantity (Fig. 4.7). In this simulated case study, the processed cheese is equal to 1,006 kg, while OL is correspondent to 12 kg (the minimum value should be 10.06 kg). In addition, the 'Excess' parameter is calculated automatically: 1.8%

**ExTra - Extended Traceability**

**PAL-BAR** Ritorna a ST START!A1

| | | | | |
|---|---|---|---|---|
| LOT | 11 | USED RAW MATERIALS | 1000.0 | |
| PRODUCTION DATE | 11/1/16 | FINAL PRODUCTS | 1006.0 | OFF-LINE, VALORI NORMALI |
| BRAND, WEIGHT, EXP. DATE... | PALBAR, 1,000 grams, 11/03/16 | OFF-LINE | 12.0 | 10.06 |
| INPUT: ORDERED AMOUNT | 1000 | TOTAL SUM (FP+OL) | 1018.0 | |
| | | EXCESS | 1.8 | |

| | | IDENTIFICATION DETAILS | | SUBTOT |
|---|---|---|---|---|
| BUTTER | 70 | No 3 Supplier, arrival: 02/01/16, lots: q, w, e | 70 | 70 |
| RENNET CASEIN | 60 | No 4 Supplier, arrival 03/01/16, lot:z1, z2, z3 | 60 | 60 |
| CHEESES | 495 | No 1 Supplier, arrival: 04/01/16, lot x | 250 | 495 |
| | | No 2 Supplier, arrival: 04/01/16, lot: y | 245 | |
| SALT | 25 | No 5 Supplier, arrival: 05/01/16, lot 0101 | 25 | 25 |
| WATER | 320 | Inner water, used: 11/01/16 | 320 | 320 |
| CITRIC ACID | 11 | No 6 Supplier, by ZZZ manufacturer | 11 | 11 |
| | | arrival: 02/01/16, lot w88e8w | | |
| SODIUM CITRATE | 19 | No 6 Supplier, by MMM manufacturer | 19 | 19 |
| | | arrival: 02/01/16, lot t88t79r | | |

| | |
|---|---|
| RRMM TOTAL AMOUNT | 1000 |

**Fig. 4.7** At the end of the production cycle for PAL-BAR (Fig. 4.6), the Operator writes the amount of final products and the OL quantity. In this simulated case study, the processed cheese is equal to 1,006 kg, while OL is correspondent to 12 kg (the minimum value should be 10.06 kg). In addition, the 'Excess' parameter is calculated automatically: 1.8% because of the difference between the total sum of production (1,018 kg) and final (marketable) products (1,006 kg). The shown formula has been created for this simulation only; it is not real (for training purposes only)

because of the difference between the total sum of production (1,018 kg) and final (marketable) products (1,006 kg).

It has to be remembered that OL includes the following by-product categories:

(a) Intermediate masses which cannot be packaged because of abnormal shapes
(b) Intermediate cheeses which have been packaged but with some failure (opened or broken packages, incorrect or defective ink printing with concern to lot, expiration dates, etc.)
(c) Intermediate masses, which have been not packaged because of the production end, or because of temporary line stops.

Because of their nature, they may be reworked (reused) in the same process or in another similar process (processed or analogue cheeses, with the exclusion of 'true' cheeses), in the same day or in another subsequent day, on condition that safety and legal requirements are respected.

It should be highlighted that the above-discussed production (Fig. 4.7) is related to the use of two cheeses. Consequently, the higher the number of different cheese items, the more difficult the joint traceability for a single product.

**ExTra - Extended Traceability**

**PAL-BAR**

Ritorna a ST ➔ START!A1

| | | | | |
|---|---|---|---|---|
| LOT | 11 | USED RAW MATERIALS | 1000.0 | |
| PRODUCTION DATE | 11/1/16 | FINAL PRODUCTS | 1000.0 | OFF-LINE, VALORI NORMALI |
| BRAND, WEIGHT, EXP. DATE... | PALBAR, 1,000 grams, 11/03/16 | OFF-LINE | 11.0 | 10 |
| INPUT: ORDERED AMOUNT | 1000 | TOTAL SUM (FP+OL) | 1011.0 | |
| | | EXCESS | 1.1 | |

| | | IDENTIFICATION DETAILS | | SUBTOT |
|---|---|---|---|---|
| BUTTER | 70 | No 3 Supplier, arrival: 02/01/16, lots: q, w, e | 70 | 70 |
| RENNET CASEIN | 60 | No 4 Supplier, arrival 03/01/16, lot:z1, z2, z3 | 60 | 60 |
| CHEESES | 495 | No 1 Supplier, arrival: 04/01/16, lot x | 250 | 495 |
| | | No 2 Supplier, arrival: 04/01/16, lot: y | 245 | |
| SALT | 25 | No 5 Supplier, arrival: 05/01/16, lot 0101 | 25 | 25 |
| WATER | 320 | Inner water, used: 11/01/16 | 320 | 320 |
| CITRIC ACID | 11 | No 6 Supplier, by ZZZ manufacturer | 11 | 11 |
| | | arrival: 02/01/16, lot w88e8w | | |
| SODIUM CITRATE | 19 | No 6 Supplier, by MMM manufacturer | 19 | 19 |
| | | arrival: 02/01/16, lot t88t79r | | |
| RRMM TOTAL AMOUNT | 1000 | | | |

**Fig. 4.8** Processed cheese productions rely on a measurable water absorption. However, this situation can be easily observed when speaking of 'old' cheeses as ingredients. Different (young) cheeses curds can be unable to absorb water because of enhanced casein demolition on the other side. As a result, certain productions may demonstrate the virtual absence of water absorption. This picture shows a simulation with final products equal to the sum of raw materials; actually, the process has a measurable performance, but the Excess parameter is too low (+1.0%). The shown formula has been created for this simulation only; it is not real (for training purposes only)

Finally, the discussed case study has demonstrated that processed cheese productions rely on a measurable water absorption. Different (young) cheeses curds can be unable to absorb water because of enhanced casein demolition on the other side. As a result, certain productions may demonstrate the virtual absence of water absorption (Fig. 4.8) or weight losses (Fig. 4.9—water is expelled during production). Figure 4.8 shows the simulation with final products equal to the sum of raw materials; actually, the process has a measurable performance, but the Excess parameter is too low (+1.0%).

Figure 4.9 shows the same simulation where final products and the total production (including OL) are < raw materials. In this situation, added water is not completely absorbed; on the other side, water linked to casein chains in the original cheeses is progressively expelled because of enhanced protein demolition (Parisi et al. 2006, 2009). Consequently, absorbed water is < 0 and the Excess parameter is globally 0.5%. The result is also caused by OL (40 kg instead of 9.55 kg—the production has demonstrated a low performance). However, water should be traced as an essential medium for the production.

**ExTra - Extended Traceability**

**PAL-BAR** | Ritorna a ST ➔ | START!A1

| | | | | | |
|---|---|---|---|---|---|
| LOT | 11 | USED RAW MATERIALS | 1000.0 | OFF-LINE, VALORI NORMALI | |
| PRODUCTION DATE | 11/1/16 | FINAL PRODUCTS | 955.0 | | |
| BRAND, WEIGHT, EXP. DATE... | PALBAR, 1,000 grams, 11/03/16 | OFF-LINE | 40.0 | 9.55 | |
| INPUT: ORDERED AMOUNT | 1000 | TOTAL SUM (FP+OL) | 995.0 | | |
| | | EXCESS | -0.5 | | |

| | | IDENTIFICATION DETAILS | | SUBTOT |
|---|---|---|---|---|
| BUTTER | 70 | No 3 Supplier, arrival: 02/01/16, lots: q, w, e | 70 | 70 |
| RENNET CASEIN | 60 | No 4 Supplier, arrival 03/01/16, lot:z1, z2, z3 | 60 | 60 |
| CHEESES | 495 | No 1 Supplier, arrival: 04/01/16, lot x | 250 | 495 |
| | | No 2 Supplier, arrival: 04/01/16, lot: y | 245 | |
| SALT | 25 | No 5 Supplier, arrival: 05/01/16, lot 0101 | 25 | 25 |
| WATER | 320 | Inner water, used: 11/01/16 | 320 | 320 |
| CITRIC ACID | 11 | No 6 Supplier, by ZZZ manufacturer arrival: 02/01/16, lot w88e8w | 11 | 11 |
| SODIUM CITRATE | 19 | No 6 Supplier, by MMM manufacturer arrival: 02/01/16, lot t88t79r | 19 | 19 |

| | |
|---|---|
| RRMM TOTAL AMOUNT | 1000 |

**Fig. 4.9** This image shows a processed cheese simulation where final products and the total production (including OL) are < raw materials. In this situation, added water is not completely absorbed; on the other side, water linked to casein chains in the original cheeses is progressively expelled because of enhanced protein demolition. Consequently, absorbed water is < 0 and the Excess parameter is globally 0.5%. The result is also caused by OL (40 kg instead of 9.55 kg—the production has demonstrated a low performance). The shown formula has been created for this simulation only; it is not real (for training purposes only)

## *4.5.2 The ExTra Tool—Analogue Cheeses*

Figure 4.10 shows the link page related to PRA-CLP formulation. This sheet contains substantially the same information shown in Fig. 4.5 with relation to processed cheeses. This time, the Operator inserts the following input data:

(1) Lot of the production (in our simulated case study, it is 011)
(2) Production date (in our simulated case study, it is 11 January 2016)
(3) Brand, weight, etc. (in our situation: PRA-CLP, 3,000 g, 11 April 2016)
(4) Input, ordered amount: 2,000 kg.

This analogue cheese is different from processed cheeses discussed in Sect. 4.3.1 for the following reasons:

(a) The product size is cylindrical, and the closure of the final packaging is not assured by means of thermosealing operations, but with aluminium rings (Parisi 2002a, 2003).

**ExTra - Extended Traceability**

**PRA-CLP**

Ritorna a START: ➔ START!A1

| | | | | |
|---|---|---|---|---|
| LOT | 11 | USED RAW MATERIALS | 3000.0 | |
| PRODUCTION DATE | 11/1/16 | FINAL PRODUCTS | | OFF-LINE, NORMAL VALUES |
| BRAND, WEIGHT, EXP. DATE… | PRACLP, 3,000 grams, 11/04/16 | OFF-LINE | | 0 |
| INPUT: ORDERED AMOUNT | 100 | TOTAL SUM (FP+OL) | 0.0 | |
| | | EXCESS | -100.0 | |

| | | IDENTIFICATION DETAILS | | SUBTOT |
|---|---|---|---|---|
| VEGETABLE OIL | 25.1 | No 7 Supplier, arrival: 02/01/16, lo | 753 | 25.1 |
| | | "special claim: k-certified" | | |
| BUTTER | 2.4 | o 3 Supplier, arrival: 02/01/16, lots: q, | 72 | 2.4 |
| RENNET CASEIN | 25 | No 4 Supplier, arrival 03/01/16, lot | 750 | 25 |
| CHEESES | 15 | No 1 Supplier, arrival: 04/01/16, lo | 225 | 15 |
| | | No 2 Supplier, arrival: 04/01/16, lo | 225 | |
| SALT | 2.5 | No 5 Supplier, arrival: 05/01/16, lo | 75 | 2.5 |
| WATER | 27 | Inner water, used: 11/01/16 | 810 | 27 |
| CITRIC ACID | 1.1 | No 6 Supplier, by ZZZ manufactu | 33 | 1.1 |
| | | arrival: 02/01/16, lot w88e8w | | |
| SODIUM CITRATE | 1.9 | No 6 Supplier, by MMM manufact | 57 | 1.9 |
| | | arrival: 02/01/16, lot t88t79r | | |

| | |
|---|---|
| RRMM TOTAL AMOUNT | 100 |

**Fig. 4.10** This image shows the ExTra link related to PRA-CLP (an imitation cheese) formulation. This sheet contains substantially the same information shown in Fig. 4.5 with relation to processed cheeses, with the obvious difference of ingredients. This analogue cheese is different from processed cheeses discussed in Sect. 4.3.1 for the following reasons: **a** the product size is cylindrical, and the closure of the final packaging is assured by means of aluminium rings; **b** part of the fat matter is replaced with vegetable oils; **c** the formulation of analogue cheeses does not rely on the amount of cheeses; **d** because of the reduced presence of cheeses in the formulation and the corresponding augment of rennet casein at least, the water absorption in imitation cheeses is expected to be higher than in processed cheeses. The shown formula has been created for this simulation only; it is not real (for training purposes only)

(b) Part of the fat matter is replaced with vegetable oils (actually, animal fat can be totally replaced with vegetable fats).

(c) The formulation of analogue cheeses does not rely on the amount of cheeses. As a consequence, more food additives may be used in comparison with processed cheeses (Sect. 7.1).

(d) Because of the reduced presence of cheeses in the formulation and the corresponding augment of rennet casein at least, the water absorption in imitation cheeses is expected to be higher than in processed cheeses.

The ExTra tool can calculate the formulation for this product as shown in Fig. 4.11. The formula—created for this simulation, it is not real—is recorded in the ExTra tool and calculated on the basis of ordered amount (input data). In our case study, 2,000 kg (ordered analogue cheese) imply that:

**ExTra - Extended Traceability**

**PRA-CLP**

Ritorna a START: ➔ START!A1

| | | | | |
|---|---|---|---|---|
| LOT | 11 | USED RAW MATERIALS | 3000.0 | |
| PRODUCTION DATE | 11/1/16 | FINAL PRODUCTS | 3120.0 | OFF-LINE, NORMAL VALUES |
| BRAND, WEIGHT, EXP. DATE… | PRACLP, 3,000 grams, 11/04/16 | OFF-LINE | 45.0 | 31.2 |
| INPUT: ORDERED AMOUNT | 3000 | TOTAL SUM (FP+OL) | 3165.0 | |
| | | EXCESS | 5.5 | |

| | | IDENTIFICATION DETAILS | | SUBTOT |
|---|---|---|---|---|
| VEGETABLE OIL | 753 | No 7 Supplier, arrival: 02/01/16, lot: j, y | 753 | 753 |
| | | "special claim: k-certified" | | |
| BUTTER | 72 | No 3 Supplier, arrival: 02/01/16, lots: q, w, e | 72 | 72 |
| RENNET CASEIN | 750 | No 4 Supplier, arrival 03/01/16, lot:z1, z2, z3 | 750 | 750 |
| CHEESES | 450 | No 1 Supplier, arrival: 04/01/16, lot x | 225 | 450 |
| | | No 2 Supplier, arrival: 04/01/16, lot: y | 225 | |
| SALT | 75 | No 5 Supplier, arrival: 05/01/16, lot 0101 | 75 | 75 |
| WATER | 810 | Inner water, used: 11/01/16 | 810 | 810 |
| CITRIC ACID | 33 | No 6 Supplier, by ZZZ manufacturer | 33 | 33 |
| | | arrival: 02/01/16, lot w88e8w | | |
| SODIUM CITRATE | 57 | No 6 Supplier, by MMM manufacturer | 57 | 57 |
| | | arrival: 02/01/16, lot t88t79r | | |
| RRMM TOTAL AMOUNT | 3000 | | | |

**Fig. 4.11** ExTra tool can calculate the formulation for PRA-CLP product as shown in Fig. 4.11. The formula is recorded in the ExTra tool and calculated on the basis of ordered amount (input data). After this operation, the Operator inserts also data related to single raw materials. The used vegetable oil has a peculiar 'K-certification'. It may be observed that certain vegetable oils are preferred because of peculiar standards such as the 'Roundtable on Sustainable Palm Oil' (RSPO). These oils have to be traced with particular care. The shown formula has been created for this simulation only; it is not real (for training purposes only)

(a) Cheese has to be approximately 15% of the ordered amount (495 kg).
(b) Water should be 27%.
(c) Butter and rennet casein should be 2.4 and 25%, respectively.
(d) Food-grade salt has to be approximately 2.5% of the ordered amount (25 kg).
(e) The considered additives, sodium citrate and citric acid, have to be approximately 1.9 and 1.1% of the ordered amount.
(f) Finally, vegetable oil (coco oil) should be 25.1% of the total amount of raw materials.

After this operation, the Operator inserts also data related to single raw materials. The following circumstances have to be evaluated:

(1) Cheeses come from two different suppliers. In this situation, cheeses have been used in mixture. Consequently, this simulation does not take into account the temporal order and use of the first and the second cheeses.
(2) Water has been classified as 'inner water'.
(3) Citric acid and sodium citrate are different ingredients. However, the supplier is the same FBO while each product has been initially manufactured by two different FBOs.

(4) Finally, the used vegetable oil has a peculiar 'K-certification'. It may be observed that certain vegetable oils are preferred because of peculiar standards such as the 'Roundtable on Sustainable Palm Oil' (RSPO). These oils have to be traced with particular care.[1]

At the end of the production cycle, the Operator writes the amount of final products and the OL quantity (Fig. 4.11). In this simulated case study, the processed cheese is equal to 3,120 kg, while OL is correspondent to 45 kg (the minimum value should be 31.2 kg). In addition, the 'Excess' parameter is calculated automatically: 5.5% because of the difference between the total sum of production (3,165 kg) and final (marketable) products (3,120 kg).

It should be highlighted that the above-discussed production (Fig. 4.11) is related to the use of two cheeses. Consequently, the higher the number of different cheese items, the more difficult the joint traceability for a single product. It has to be highlighted that the formulation does not take into account many possible food additives (Chap. 7).

Finally, the discussed case study has demonstrated that analogue cheese productions rely on a measurable water absorption because of the low amount of cheeses (15%) and the concomitant high quantity of absorbing casein (25%). Certain productions may demonstrate the virtual absence of water absorption or weight losses. However, this phenomenon is not often observed when speaking of analogue cheeses.

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[1]More information concerning RSPO products and related certifications can be found at the following Web address: https://rspo.org/.

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# Part II
# Food Traceability and Food Additives for Processed and Analogue Cheeses

# Chapter 5
# The Legislative Status of Food Additives in the Cheesemaking Field: The European Perspective

**Abstract** Food additives are substances deliberately added to food to fulfil specific technological functions. The use of additives in the modern food industries cannot be avoided in many ambits. Food production on a large scale is very different from the manufacturing on a small scale; the urgency of new industrial food production techniques has necessarily increased with the aim of developing many different kinds of food additives. Most of these additives solve a fundamental technological function, which actually improves product quality; others additives, as dyes and coating agents, are used to make the product more attractive for consumers. Considering their importance, systems of pre-market approval requirements have been introduced in Europe for synthetic substances added to foods. As a result, the European Union has set up a reliable food safety system that helps to ensure consumer protection against any possible food hazard such as the ones caused by side effects of preservatives and flavourings. For this reason, all food additives currently used in Europe have been examined for safety evaluation by the European Food Safety Authority, and before by its predecessor institution, the Scientific Committee on Food. The general system created by the European Union is based on the so-called positive lists. Only food additives included in the official positive list are allowed in foods and food formulations under specific conditions. With reference to the sector of cheese productions, peculiar additives—including microbial agents—have to be considered. The aim of this chapter is to give an overview of the currently allowed additives in the ambit of cheese productions, according to European Union legislation.

**Keywords** Cheese · European Food Safety Authority · European Union
Food additive · Food business operator · Labelling · Traceability



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## 5.1 Food Additives and the European Union Regulations. The Current Situation

Food additives are substances deliberately added to food to fulfil specific technological functions. In detail, an additive can be defined as 'a*ny substance not normally consumed as a food in itself and not normally used as a characteristic ingredient of food, whether or not it has nutritive value, the intentional addition of which to food for a technological purpose in the manufacture, processing, preparation, treatment, packaging, transport or storage of such food results, or may be reasonably expected to result, in it or its by-products becoming directly or indirectly a component of such foods*', as stated by Regulation (EC) No 1333/2008 (European Commission 2010; European Parliament and Council 2008).

Additives are undoubtedly a necessary component of many foods as they are needed to ensure processed food remains safe and in good condition throughout the journey from factories, during the movement to warehouses and shops, and finally to consumers (Food Standards Agency 2017).

It should be noted that food production on a large scale is very different from the manufacturing on a small scale. The urgency of new industrial food production techniques, with the need to standardise organoleptic features and to allow the storing and the preservation of products avoiding any potential risks, has necessarily increased with the aim of developing many different kinds of food additives, in order to solve any problem connected to the needs of food industries.

Most of these additives solve a fundamental technological function, which actually improves product quality; others additives, as dyes and coating agents, are used to make the product more attractive for consumers.

Considering their importance, since the early 1960s, systems of pre-market approval requirements have been introduced in Europe for synthetic substances added to foods. As a result, the European Union has set up a reliable food safety system, especially in the last decades, that helps to ensure consumer protection against any possible food hazards such as the ones caused by side effects of preservatives and flavourings (European Parliament and Council 1995, 2008; Food Standards Agency 2017; Valant 2015; Van der Meulen et al. 2012; Vapnek and Spreij 2005).

The following and non-exhaustive list (Fig. 5.1) shows that these substances are mainly used to (Alfaro and Rábade 2009; Aung and Chang 2014; FAO Committee on Agriculture 2003; Food Safety Authority of Ireland 2015; Food Standards Agency 2015; Galimberti et al. 2013; Taeymans 2000; Van der Meulen 2013; Will and Guenther 2007):

(a) Guarantee safety and hygiene
(b) Improve product conservation
(c) Increase product availability in all seasons
(d) Improve or maintain nutritional values
(e) Make easier food preparation
(f) Improve the consumers' appetite.

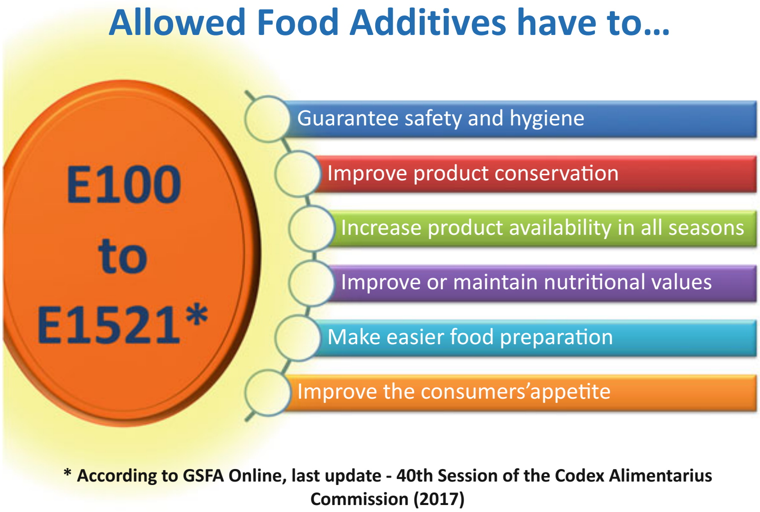


**Fig. 5.1** The European Union has set up a reliable food safety system, especially in the last decades, that helps to ensure consumer protection against any possible food hazard such as the ones caused by side effects of synthetic substances added to foods. These compounds and related categories have different functions, provided that the European Food Safety Authority (EFSA) has evaluated them. The picture shows the E-codification, from E100 to E1521, in accordance to the General Standard for Food Additives (GSFA)—CODEX STAN 192-1995 Online, last update—40th Session of the Codex Alimentarius Commission (2017)

(g) With relation to traceability and correlated legislations concerning the protection of food consumers (the use of food additives concerns traceability), the European framework is the Regulation (EC) No 178/2002. This Regulation (and subsequent amendments and implementation documents) corresponds to the legal basis for many requirements in the EU, including traceability and other useful instruments such as the 'Rapid Alert System for Food and Feed' (European Commission 2004, 2006, 2008b, 2011a; European Parliament and Council 2002, 2003a, 2009, 2014). In addition, three specific regulations concern the traceability of food of animal origin, sprouts and seeds intended for the production of sprouts, and genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms (European Commission 2011a, 2013; European Parliament and Council 2003b).

All food additives that are currently used in Europe have been subject to safety assessments by the European Food Safety Authority (EFSA), the European scientific reference point (Sect. 1.1), and before by its predecessor institution, the Scientific Committee on Food (SCF).

In this field, EFSA carries out three main activities (Fig. 5.2). The first of these activities is the evaluation of safety of new food additives before the European Union (EU) Commission authorises their use; secondly, EFSA acts as the EU scientific


**Fig. 5.2** EFSA carries out three main activities when speaking of food additives

adviser, with the purpose of answering to any ad hoc request by the European Commission on the revision of certain food additives. Finally, EFSA is responsible for the re-evaluation of all food additives already authorised by the EU before 20 January 2009 (EFSA 2015).

The general system created by the EU is based on the so-called positive lists. Only food additives included in the official EU list are allowed to be used in foods and food formulations under specific conditions. Before being included in the list and consequently be added to food products, additives must be considered safe for human health; they must also respect certain purity requirements, the ones laid down in the Regulation (EU) No 231/2012. All other substances that do not comply EU requirements concerning suitability are forbidden (European Commission 2012).

The principle of the positive lists seems to be the first consumer protection guarantee. A food additive may only be authorised on condition that (a) it passes a rigorous health assessment procedure, and (b) it proves to be essential to consumers complying with some requirements. In detail, and because of available scientific data, the use of the additive does not create any safety concerns for human health and its use can reasonably be considered a technical necessity without other similar options.

Article 15 of the EU Regulation No 1333/2008 states that the use of food additives in unprocessed foods is prohibited, except in the cases specified in a specific Annex (Annex II). In fact, as above anticipated, the use of food additives is justified only when their use has a well-defined technological function, such as to preserve the nutritional quality of the food or to enhance food stability (European Parliament and Council 2008). Thus, in some foodstuffs such as olive oil and honey, the use of additives is not allowed because it cannot be technologically justified. In other foods, the use of additives is very limited such as for unprocessed food (milk, fresh fruit and vegetables, fresh meat and water) where only a few additives only are authorised

(Will and Guenther 2007). Generally, the more a food is processed, the more the number of authorised additives increases.

Furthermore, the additive does not mislead consumers and it obviously must create advantages. This means that, for example, it does not react with food components from a chemical point of view. In addition, it does not destroy nutritional principles or hide any alterations and fraud recognisable by analytical tests.

There are hundreds of food additives and thousands of ways to use them in food production. In order to simplify their identification, the EU has defined 27 so-called functional classes of food additives including dyes, sweeteners, preservatives, emulsifiers, antioxidants and coating agents. The list of additive has been edited in order of the displayed E-number (GSFA 2017).

The E-number is the reference number assigned to the additive ensuring that its safety has been confirmed, and it can be used in the EU. In detail, additives used in any food product must be indicated on the label, and the membership class explaining its function must be reported for each one (i.e. dye, emulsifier, antioxidant). The European name or abbreviation E means '*Europe*' followed by three or four numbers.

The numbering scheme follows that of the International Numbering System (INS) as used by the Codex Alimentarius Committee, though only a subset of the INS additives is approved for use in the European Union (Carnazzi 2001; GSFA 2017).

Chemical additives, which are not allowed for food uses, are prohibited in this ambit. The authorisation process involves in-depth tests by the European Food Safety Authority, but EFSA's opinion is not enough to allow its use. Only the EU can authorise a peculiar food additive if the same substance is useful and does not deceive consumers.

The 'positive lists' regimen has been extended to other categories of foods, step by step, because the evaluation of certain chemicals in this area might be considered potentially dangerous for human health. The allusion refers to foods not consumed and sold in the EU before 1997: the so-called novel foods (i.e. genetically modified organisms). From 2004, these foodstuffs form a separate category with a sectorial and specific legislation (Pisanello and Caruso 2018). Approval schemes are different, but there are common aspects such as the scientific risk assessment procedure, or the criterion, which the food may not mislead the consumer for (and it may not be nutritionally disadvantageous compared to a conventional food it would replace).

It should be emphasised that, even when authorised, food additives are always kept under constant observation. When necessary, security assessments are carried out in order to evaluate any new scientific information that would underline a potential risk to health. To update this process, the European Commission asked EFSA in 2010, on the basis of a programme established by the provisions of EU Regulation No 257/2010, to re-evaluate the safety of all previously authorised food additives by 2020, taking into account any recent scientific data (European Commission 2010). Because of EFSA's scientific advice, the European Commission and the Member States could jointly decide to vary the uses of additives or, if necessary, to delete them from the EU list of authorised products to protect consumers (EFSA 2016).

This safety assessment involves the examination of all available scientific studies and data on toxicity and human exposure, from which the scientific group draws conclusions on the safety of the interested substance.

As already said, before deciding whether to authorise the use of a particular ingredient or additive, the EU analyses the scientific opinion. In risk management, the EU applies—once again—the ‘precautionary principle’: if there is a reasonable fear of a risk, the Commission tries to circumvent it. It has to be noted that there is no need to wait for a real proof of the risk existence (Godard 2012).

Of course, this principle should not be used to justify protectionist measures. In fact, if scientists have not definitively confirmed the nature of the risk, they have only to underline the potentially dangerous effects before the Commission can legitimately employ the precautionary principle and take appropriate action(s) on a product intended for human consumption.

It has been underlined an acceptable daily intake (ADI) is normally set for a food additive acceptable for food use (Codex Alimentarius 1989). The maximum consumption threshold of a food additive without generating any demonstrable toxic effect is determined from the observation of the experimental studies results carried out over several generations of cavities. This maximum threshold was defined as ‘no-observed-adverse-effect level’ (NOAEL). As a further precaution, the ‘zero level’ threshold is divided into 100 to take into account the possible differences between the data extracted from analytical observation of animals compared with values considered appropriate for humans and any possible variations between different individuals. This calculation sets a value called ‘acceptable daily intake’ (ADI), corresponds to the estimation of the quantity for a certain substance, calculated on a body weight base, that can be ingested per day over the entire life of a human being without appreciable safety hazards (Dennis and Wilson 2003).

In order to ensure that people do not go beyond defined ADI values by consuming too many products containing a particular additive, the European regulation requires that appropriate research be conducted to evaluate all variations in consumption style. The European Commission has also established specific rules on the purity of additives, the general or specific food categories that each additive is permitted in, and laid maximum levels of use, where necessary. Limit values do not represent a toxicity level, but they indicate a level of prudential assumption (Ilbäck and Busk 2000). Individuals may occasionally exceed the limit value provided that the average daily consumption is less than established. If the ADI was regularly higher than expected with concern to certain categories of population, the SCF may consider necessary to reduce ADI levels or reduce the range of foods which such additives are allowed in (Food Safety Authority of Ireland 2015).

To understand how this instrument works, it could be helpful to bring the opinion of the Commission, through Regulation (EU) No 1093/2014 of 16 October 2014, which amends and corrects Annex II to the Regulation (EC) No 1333/2008 regarding the use of certain colours in some seasoned aromatised cheeses. This opinion states that as ‘*red and green pesto cheese represents a small part of the total cheese market, the use of cochineal, carminic acid, various types of carmine (E 120) in red and aged pesto, bissina, norbissin (E 160) in green and red pesto cheeses will not have* *significant effects on the total exposure to the two coloring substances*' (European Commission 2014b).

The Regulation No 1333/2008 requires that food additives are clearly identified on food packages in order to guarantee consumer safety. This requisite is one of the most important rules in this ambit: food labelling does not mislead consumers regarding the nature and properties of the food they are consuming. In detail, foodstuffs containing additives must comply with both the general labelling provisions for food, as laid down in Regulation No 1169/2011, and with the more specific labelling requirements for food additives, as laid down in Chapter IV of Regulation No 1333/2008 (European Commission 2011b).

It is useful to underline that a food ingredient is '*any substance or product, including flavourings, food additives and food enzymes, and any constituent of a compound ingredient, used in the manufacture or preparation of a food and still present in the finished product, even if in an altered form; residues shall not be considered as ingredients*' (European Commission 2011b). It has been specified and stated that additives present in a food must be specifically mentioned in the product label and packaging.

Labelling requirements may change depending on whether the additive is present in a foodstuff intended for sale to the final consumer, or whether it is in a form intended for sale to and use by industrial food business operators (FBO). There are, i.e., also specific requirements for additives placed on the market in a specific (pure or concentrate) form.

However, there are some exceptions under the Regulation for substances that might normally be considered food additives; instead, the Regulation specifies that the following categories of substances are not considered ingredients (European Commission 2011b), as displayed in Fig. 5.3:

(1) Food additives whose presence in a food is solely due to the fact that they were contained in one or more ingredients of that food, in accordance with the 'carry-over' principle (points (a) and (b) of Article 18, Regulation 1333/2008), provided that they serve no technological function in the finished product
(2) Additives which are used as processing aids
(3) Carriers and substances, which are not food additives but are used in the same way and with the same purpose as carriers and which are used in the quantities strictly necessary.

These substances do not have to be declared on the label because additives present in a food must be indicated in the list of ingredients only if they perform a technological function. Anyway, traceability has to be assured (GS1 2013; Regattieri et al. 2007; Sarig et al. 2003).

There are no quantitative references to determine if a product can be defined as an ingredient or a processing aid, at present. The main difference is based on the fact that an additive becomes, directly or indirectly, a component of the final food and it must be included in the list of ingredients.

On the contrary, 'technological aids' are *s*ubstances added to a food during the processing step, but they are removed in some manner before the product is packaged in its finished form. Alternatively, technological aids are substances converted into

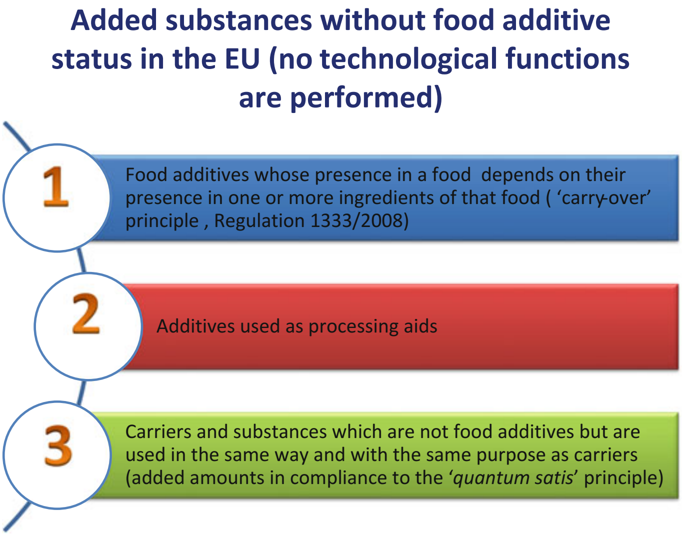


**Fig. 5.3** Several substances and/or categories may be not considered ingredients in the EU although they are added to food and beverage products, provided that they do not perform technological function in the finished product. These substances do not have to be declared on the label because additives present in a food must be indicated in the list of ingredients only if they perform a technological function

normal constituents for the produced food, without significant increase of related amounts in the food itself. In addition, technological aids can be substances that are added to a food for their technical or functional effect in the processing, but they are present in the finished food at negligible levels and do not have any technical or functional effect in that food.

## 5.2 Food Additives in the Milk and Dairy Sectors

With particular relation to the milk and dairy sector, it should be noted that milk for dairy use—the raw material that has suitable characteristics for acidification and coagulation—needs to be added with substances allowing the fundamental physical and chemical transformations for cheesemaking production. These substances are lactic acid bacteria (LAB) and enzymes such as rennet: these ingredients are defined cheese adjuvants.

Consequently, the list of ingredients in dairy product labels is unnecessary if only milk is used, because the ingredients are the same components of milk itself (Reg. No 1169/2011, art 19 letter d). Instead, the list of ingredients used to make cheeses become of fundamental importance if other ingredients other than the constituents of milk, salt or enzymes, and crops of microorganisms necessary for their manufacture, have been added. Several exceptions exist (Chandan 2014; European Commission 2011b).

As an example, micro-organisms used for cheese production and cover fluids used for freshly made pasta cheeses (mozzarella cheeses) are not considered as ingredients; therefore, they are not listed in the label. Milk proteins (casein and caseinates) are considered as ingredients; therefore, they must be included in the list of ingredients if used directly for the manufacture of cast cheeses.

Rennet, as already said, is considered a technological aid without any function in the finished product where it is present only in residual quantities; consequently, it has not to be declared among ingredients.

The crust is considered a part of the finished product. As a result, additives used as preservatives on the crust (calcium or potassium sorbates) are also considered as ingredients, whereas materials or substances used as a protection of the crust (such as paraffin and protective envelopes for provolone cheese or similar cheeses) are not considered as ingredients. The list of ingredients is always needed for fruits or sugared yogurt, cheeses made with spices or herbs (United Nations 2007).

Unlike processing aids, which are indispensable, other substances are used to face microbiological problems or to improve and settle milk chemical composition.

If, for example, the raw material is contaminated because of the presence of bacteria such as butyric clostridia, the addition of antibacterial agents such as lysozyme (E1105) could be helpful. These additives have to be used carefully and only if strictly necessary. *Clostridium* bacteria are a huge problem for companies using milk for the production of medium- and long-lasting cheeses as they produce spores able to survive to environmental adversities. Clostridia germinate in cheese during seasoning causing undesirable fermentation.

Clostridia can normally be found in the soil and are imported into the farm through food, in particular fodder contaminated with soil or organic fertilisers. A proper handling of spore problems could reduce the need for additives. Their use can be avoided by maintaining high levels of cleanliness, i.e. by avoiding overcrowding. In addition, critical factors are the correct management of milking operations and maintenance operations in the plant in order to prevent the possible contamination of milk with spores. For these reasons, the use of additives may be sometimes avoided.

Another example is the use of calcium chloride, which has many applications in the food industry where it is used both as a food additive and as a food processing agent.

Different factors can affect the calcium content in the original raw material. Milk stored at low temperatures releases calcium; thus, the pasteurisation process (heating) and the subsequent rapid cooling of treated milk may contribute to its reduction. In addition, the late lactation season milk has low calcium content. As it is an effective coagulant, calcium chloride is often added to milk at the beginning of cheesemaking in order to compensate for calcium precipitation. It is listed as a permitted food additive in the EU as a sequestrant and firming agent. In addition, it is also used in the cheesemaking process with the aim of increasing the size and strength of intermediate curds.

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# Chapter 6
# Food Additives in Cheese Substitutes

**Abstract** Over the past decade, the increasingly consumer demand for low-fat food products influenced by many health-related concerns has led modern food industry to research healthier products in order to reduce the amount of fat, salt and additives. Dairy manufacturers have answered with the development of cheese alternatives. Even not being harmful to health, these alternatives may give a lower nutritional benefit due to the reduction of calcium content and may contain different artificial flavours and colours. Therefore, many strategies have been proposed to improve low-fat cheeses such as making process modification and the use of fat replacers with the main objective of obtaining a reduction in the caloric value. At present, there are on the market both cheese substitutes and imitation products which can now unanimously be defined as products which clearly imitate cheese produced from milk by means of the partial or total substitution of milk components with non-dairy ingredients. The main advantages of these cheese types are related to the price and shelf-life values. Since many inexpensive ingredients can be used in its production, it is typically more interesting to manufacture these foods than traditional cheeses; the above-mentioned cheapness makes them attractive to food business operators. The European Legislator is aware that some products obtained from mixtures of dairy ingredients and some fats or protein matters from other sources are marketed as 'cheese analogues'. Consequently, he has restricted the use of the designation 'cheese' to products which are manufactured from milk and from milk products and where milk ingredients are not replaced by a constituent not occurring naturally in milk. For this and other reasons, the traceability of similar foods is critical at present. The aim of this chapter is to give a description of these products from the European regulatory viewpoint.

**Keywords** Analogue cheese · Vegetable oil · European Union · Food additive
Food business operator · Labelling · Traceability



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## 6.1 Cheese Analogues and Food Additives: A Technical Introduction

Over the past decade, the increasingly consumer demand for low-fat food products influenced by many health-related concerns (e.g. obesity, cardiovascular diseases) has led modern food industry to research healthier products in order to reduce the amount of fat, salt and additives.

Dairy manufacturers have responded to consumer demands with the development of cheese alternatives. It has to be noted that low-fat dairy products, such as milk and yogurt products, have been available for many years, but the removal or the reduction of fat matter adversely affects both the flavour and texture of the product itself. Even not being harmful to health, these alternatives may give a lower nutritional benefit due to the reduction of calcium content and may contain different artificial flavours and colours. Therefore, many strategies have been proposed to improve the features of low-fat cheeses such as making process modification and the use of fat replacers with the main objective of obtaining a reduction in the caloric value.

Today, among different processed cheeses that can be bought on the market, it is possible to find both cheese substitutes and imitation products which can now unanimously be defined as foods which clearly imitates the 'true' cheese (cheese produced from milk) by means of the partial or total substitution of milk components with non-dairy ingredients (e.g. vegetable raw materials).

It has to be highlighted that the definition of 'imitation cheese' is often overlapped with the 'substitute cheese' definition. Actually, there is a difference between these two kinds of product. Substitute cheese is usually made with a low content of milk solids. Imitation cheese, on the contrary, is made of a mixture of vegetable oil(s) and casein, with the replacement of milk solids. While the taste of these two types of cheese is very similar, there are some differences such as texture, showing the imitation cheese an enhanced firmness (Bachmann 2001; Muir et al. 1999; Pereira et al. 2001).

As for the traditional cheeses which can be categorised considering different criteria such as ripening conditions or the coagulation agent, substitute cheese products can also be classified depending on the used ingredients and manufacturing pro cedures. Cheese substitute may also be categorised depending on the fat and/or protein origin (dairy or vegetable). Consequently, it is possible to outline three groups:

- Dairy cheese products where dairy fat and proteins (casein, caseinates, milk fat, butter oil, etc.) are used as main component in
- Partial dairy cheeses produced using only a part of milk product(s) (casein, caseinates, etc.). In this kind of cheese, some dairy components are partially replaced; in detail, milk fats are mainly substituted by vegetable oils, and this replacement is justified by functional benefits or just because it may simply be cheaper;
- 'Non-dairy' cheeses produced through components other than milk, i.e. vegetable proteins (soya protein, vegetable oil, soya oil, etc.). In non-dairy cheese products, both the protein and the fat contents come from a vegetable source.

The main type of cheese substitutes is analogue cheeses, made from milk proteins, such as rennet casein and caseinates, vegetable oils, water and emulsifying salts (Abou El-Nour et al. 1998; Bachmann 2001; Badem and Gürkan 2016; Fox et al. 2016; Guinee et al. 2004). As a result, they are usually manufactured by mixed ingredients, including non-dairy fats or proteins, to create a cheese-like product that can meet specific needs. As above mentioned, different kinds of non-dairy alternatives, vegetable proteins such as peanut or soya bean protein and vegetable fats or oils take the place of the traditional milk proteins and milk fat.

The main advantages of these cheese types are related to the price and shelf-life values (Parisi 2003). Since many inexpensive ingredients can be used in its production, it is typically more interesting to manufacture these foods than traditional cheeses; the above-mentioned cheapness makes them attractive to food business operators (FBO).

In fact, the low cost of oils from vegetable origins compared to butterfat makes these products obviously cheaper than processed cheeses. Furthermore, the lack of dairy products other than casein in these cheeses helps the product to exhibit enhanced durabilities (Parisi 2003) with specific and required properties such as different melting points.

Since the manufacture method of analogue cheeses is very similar to techniques used for the production of processed cheeses with the aid of heat and mechanical shear (from formulation to packaging passing through blending, heating, and cooling), the market of analogues has grown in a very easy and quick way (Bachmann 2001).

As for processed cheeses, their quality is influenced by composition, formulation and processing conditions. Particularly, the production of cheese analogues is mainly conditioned by the chemical–physical system obtained with dairy components and emulsifying salts. Moreover, the quality of the final product depends on the use of heat treatment and the duration of mechanical processing fragmentation methods (Bachmann 2001; Badem and Gürkan 2016; Wani et al. 2013; Tamime 2011).

In order to ensure all textural and functional properties required in a cheese product, it is fundamental to develop a suitable method, which can combine fat and proteins with other components. As already said, the production of cheese analogues requires also the use of non-milk based ingredients. These ingredients deeply affect the microstructure and, consequently, texture and functional properties of processed cheeses such as their meltability, flavour and firmness (Bachmann 2001).

## 6.2 Cheese Analogues and Food Additives: The European Regulatory Perspective, and Influence on Labelling and Traceability

From a chemical point of view, the appropriate blend of emulsifying salts can allow the reduction of calcium concentration linking para-casein molecules in order to give the desired textural and cooking features.

For example, due to their nutritive and functional properties such as a better emulsifying capacity, the main protein sources in analogue cheese products are caseinates or rennet casein. It has to be noted that caseinate is mainly used for spreadable cheese (Cunha et al. 2010). On the other side, rennet casein is used mainly for semi-hard block cheeses giving a better stretchability to the final product. Moreover, sodium caseinates are largely used in detail in spreadable analogue cheese because of their high water-binding capacity and emulsification properties (Abou El-Nour et al. 1998).

In order to simulate features of the natural product as closely as possible, different dairy and non-dairy ingredients are usually added to cheese analogues such as (Anonymous 2017; Eymery and Pangborn 1988; European Parliament and Council 2006; Gupta and Reuter 1993; Liu et al. 2008; Hsieh et al. 1993; Jana et al. 2010; Mohamed et al. 2013; Mounsey and O'Riordan 2001, 2008):

(a) Milk protein
(b) Skimmed milk powder or whey powder
(c) Whey protein concentrates
(d) Milk fat and/or vegetable oil(s)
(e) Emulsifying salts
(f) Acidifying, colouring and flavouring agents
(g) Thickeners (locust bean gum, pectin, starch, etc.)
(h) Spices.

Furthermore, health attributes of imitation cheese could be improved by adding nutritionally beneficial ingredients such as dietary fibre and by lowering the fat content.

Since emulsification is one of the most important steps in analogue cheese productions, many emulsifying salts can be used (Bachmann 2001). Moreover, agents such as non-fat dry milk, whey (protein), casein or caseinates may be used.

Used salts, improving the protein hydration and the emulsification of fat molecules, are incorporated to prevent oiling and moisture exudation during the production and the cooling steps. Usually, since some salts perform better than others, they can be blended and used in combination with the aim of enhancing their features. The main factors influencing mixture composition are the type of analogue cheese, related material properties and the chosen processing method. As a simple example, the degree of fat emulsification may depend on the peculiar type of used salt.

Imitation cheese products could be manufactured using carrageenan. On the other side, it is also possible to develop cheese analogues from soya protein, gelatine and different gums such as arabic and guar gum.

Even if analogue cheeses have many similar characteristics if compared with natural cheeses, they also show evident deficiencies deriving from the absence of the most typical dairy components. The most important negative aspect is surely identifiable in the neutral flavour that is very different with comparison to 'real' cheeses. Different flavour systems can be used to make imitation cheeses similar to natural ones as much as possible and to make them more suitable for the market.

Some FBO could use artificial flavours, while others may be of natural origin. In any case, the addition of specific enzymes or micro-organisms in certain steps can allow obtaining flavoured cheeses. At the same time, it is also possible to use food grade acids to adjust pH values. These acidic constituents, such as adipic, citric, lactic, acetic acids—or a blend of them—may be added as separate ingredients during the production or maybe a natural component of some ingredient(s). Moreover, during the final production steps, it is also possible to add vitamins and minerals to imitation cheese formulations, with the aim of giving nutritional values similar to natural cheeses.

With relation to traceability and correlated European legislations concerning the protection of food consumers, the European framework is the Regulation (EC) No 178/2002. This Regulation (and subsequent amendments and implementation documents) corresponds to the legal basis for many requirements in the EU, including traceability and other useful instruments such as the 'Rapid Alert System for Food and Feed' (European Commission 2004, 2006, 2008, 2011a; European Parliament and Council 2002, 2003a, 2009, 2014). In addition, three specific regulations concern the traceability of food of animal origin, sprouts and seeds intended for the production of sprouts and genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms (European Commission 2011a, 2013; European Parliament and Council 2003b).

Currently, there is no regulation that rules the management of substitutive and analogue cheeses in a unified manner. Nevertheless, the European Legislator has provided many indications that allow outlining a regulatory framework suitable for this type of products. These provisions are aimed at protecting the final consumer (European Commission 2011b).

The starting point of this discipline can be identified in the Regulation (EU) No 1308/2013, which establishes a common organisation of markets trading agricultural products.

First of all, Article 78 of this Regulation deals with definitions, designations and sales descriptions for certain sectors and products while restricting the use of certain terms. In detail, it states that '*the definitions, designations or sales descriptions provided for in Annex VII may be used in the Union only for the marketing of a product which conforms to the corresponding requirements laid down in that Annex*' (European Parliament and Council 2013).

The Annex VII in part III provides that *'milk products' means products derived exclusively from milk, on the understanding that substances necessary for their manufacture may be added, provided that those substances are not used for the purpose of replacing, in whole or in part, any milk constituent* (European Parliament and Council 2013).

Therefore, these terms shall be reserved exclusively for the following milk products: whey, cream, butter, buttermilk, butter oil, caseins, anhydrous milk fat, cheese, *yogurt*, *kefir, koumiss, viili/fil, Smetana, fil, rjaženka, rūgušpiens*.

The European Legislator is aware that some products obtained from mixtures of dairy ingredients and some fats or protein matters from other sources are marketed as 'cheese analogues'. As a result, the use of the designation 'cheese' can be used only for products which are manufactured from milk and from milk products and where milk ingredients are not replaced by a constituent not occurring naturally in milk. The Regulation (EU) No 1308/2013 establishes the principle that sales descriptions of milk and milk products may not be used for products other than those described in Part III of Annex VII of that Regulation (European Parliament and Council 2013). Moreover, the Regulation prohibits that non-dairy products (products whose dairy component has been partially or totally replaced with non-dairy components) are designed using dairy terms. In addition, in order to not mislead the consumer, the Regulation prohibits any kind of direct or indirect suggestion of a dairy association for dairy product alternatives banning labels, publicity materials or any form of advertising which claims, implies or suggests that a non-dairy product is a dairy product.

However, there are some exceptions for non-dairy products to use dairy terms. These are products which are clearly of non-dairy origin but have traditionally used 'dairy' terms (e.g. peanut butter, cocoa butter). However, point 5 of Annex VII specifies that '*this provision shall not apply to the designation of products the exact nature of which is clear from traditional usage and/or when the designations are clearly used to describe a characteristic quality of the product*' (European Parliament and Council 2013). The use of 'dairy terms' is also authorised and acceptable with the aim of describing clearly and unambiguously a non-dairy product: as an example, a soya product may be defined as a 'non-dairy alternative to cheese'. Authenticity issues are always important (Cuollo et al. 2013; Food Standard Agency 2009; Monakhova et al. 2013; European Parliament 2011).

A fundamental principle is contained in '*The Food Information for Consumers*' (FIC), in accordance with Regulation (EU) No 1169/2011, Article 7, under '*Fair Information Practices'* definition. It establishes that food information in the form of labelling or advertising should be accurate, clear and easy to understand, but should not mislead the consumer.

In detail, food information '*shall not be misleading the consumer*' (European Commission (2011b). Moreover, it is established in Annex VII (indication and designation of ingredients) which contains specific provision concerning the indication of ingredients by descending order of weight that: '*for ingredients, which are similar or mutually substitutable, likely to be used in the manufacture or preparation of a food without altering its composition, its nature or its perceived value, and in so far as they constitute less than 2% of the finished product may be referred to in the list of ingredients by means of the statement 'contains' … and/or …*', where at least one of no more than two ingredients are present in the finished product (European Parliament and Council 2013).

In order to enforce the application of the European Union (EU) legislation, Chap. 5 of the above-mentioned Regulation provides the possibility to indicate voluntary food information, which is information about a food that is not legally required and is used at the discretion of the food business.

Imitation foods such as analogue cheeses must be made clear in the labelling. As a result, the Annex VII of Regulation (EU) No 1308/2013 provides a definition of 'sales description' as the name under which a food is sold within the meaning of Article 17 of the FIC Regulation (European Parliament and Council 2013). The name of a food is a 'mandatory particular' as set out in Article 9.1, letter a, of the FIC Regulation; therefore, it must be placed in a conspicuous position on pre-packaged foods, easily visible and clearly legible within a prescribed minimum font size. It must not be in any way hidden, obscured, detracted from or interrupted by any other written or pictorial matter or any intervening material (Article 13).

Finally, the FIC Regulation No 1169/2011, Annex VI ('*Name of the food and specific accompanying particulars*') provides mandatory indications that must accompany the denomination of the food and explains (European Commission 2011b) that '*in the case of foods in which a component or ingredient that consumers expect to be normally used or naturally present has been substituted with a different component or ingredient, the labelling shall bear—in addition to the list of ingredients—a clear indication of the component or the ingredient that has been used for the partial or whole substitution:*
*(a) in close proximity to the name of the product; and*
*(b) using a font size which has an x-height of at least 75% of the x-height of the name of the product and which is not smaller than the minimum font size required in Article 13(2) of this Regulation*'.

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# Chapter 7
# Food Additives for Analogue Cheeses and Traceability: The ExTra Tool

**Abstract** This chapter is explicitly dedicated to a particular and multi-faceted category of entering raw materials (input data) for the production of processed cheeses and cheese imitation products. The entering information in a traceability (tracking and tracing) system for these products has to concern many possible ingredients, including food additives. Different chemicals may be added with various functions when speaking of processed cheeses, but the production of analogue cheeses appears more interesting. In general, the classification of food additives takes into account the particular function(s) these compounds are expected to perform during the production and in the subsequent steps. Moreover, the proposed use of these compounds has to be declared on food labels. At the same time, traceability has to take these information—specific for each possible additive—into account. The aim of this chapter is to describe the complex operations—named joint 'traceability'—with exclusive concern to 'minor' ingredients (food additives) by means of a software product: the ExTra tool. Discussed simulated products are a processed cheese and a general imitation cheese.

**Keywords** Analogue cheese · Extended Traceability · European Union
Food additive · Food business operator · Off-line · Traceability

## 7.1 Analogue Cheeses and Food Additives: An Overview

This chapter is explicitly dedicated to a particular and multi-faceted category of entering raw materials (input data) for the production of processed cheeses and imitation cheeses (Fig. 4.1) (Guinee 2007a). As discussed in Sect. 4.1, the entering information in a traceability (tracking and tracing) system for these products has to concern (Barbieri et al. 2014; Barone et al. 2017; Delgado et al. 2016; Laganà et al. 2017; Mania et al. 2016; Steinka and Parisi 2006):

(a) The used cheese(s), including in this step curds also (in spite of the clear difference between finished products and curdled materials).
(b) The used fat (butter).



I. Mania et al., *Traceability in the Dairy Industry in Europe*,
https://doi.org/10.1007/978-3-030-00446-0_7

(c) The used protein ingredient (casein, caseinates, total milk proteins, whey proteins only, etc.).
(d) The used food additives: melting agents, corrector acidity agents, compounds with other functions, on condition that their use is needed and allowed.
(e) The used salt.
(f) The used water.

Different food additives may be added with various functions when speaking of processed cheeses, but the production of analogue cheeses is more interesting (Sect. 4.5.2).

From a general viewpoint, the European framework for traceability and other food-related matters is the Regulation (EC) No 178/2002. This Regulation (and subsequent amendments and implementation documents) corresponds to the legal basis for many requirements in the EU, including traceability and other useful instruments such as the 'Rapid Alert System for Food and Feed' (European Commission 2004, 2006, 2008, 2011; European Parliament and Council 2002, 2003a, 2009, 2014). In addition, three specific regulations concern the traceability of food of animal origin, sprouts and seeds intended for the production of sprouts and genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms (European Commission 2011, 2013; European Parliament and Council 2003b).

In general, the classification of food additives takes into account the particular function(s) these compounds are expected to perform during the production and in the subsequent steps. The following list takes into account the main roles of commonly used and allowed additives in this sector:

(a) Acidity correctors
(b) Aromas
(c) Aroma enhancers
(d) Colourant substances
(e) Emulsifying salts for stabilisation
(f) Hydrocolloids for stabilisation
(g) Mineral substances
(h) Preservatives
(i) Starches
(j) Vitamins and vitamin preparations.

The list of food additives may be long enough. However, the proposed use of these compounds has to be declared on food labels. At the same time, traceability has to take these information—specific for each possible additive—into account.

## 7.2 Traceability in Analogue Cheese Productions and Food Additives: The Flow of Output Information

Processed cheeses can be defined in different ways, with relation to marketing needs, regulatory norms, the typology of product (spreads, foods) and the composition of the food with concern to cheese percentage on the one side and the introduction of non-dairy components. In the last situation, the normal terms are 'analogue cheeses' or 'imitation cheeses' (Guinee 2007b).

As discussed in Sect. 4.3, processed or analogue cheese, in our situation—should be traced by means of different information, including specific claims concerning cheese products. This obligation is especially true with relation to used cheeses in the formulation (when the declaration is important and declared on labelling). At the same time, food additives could justify some marketing, technical or health-related claim. On the opposite hand, the formulation may comprehend certain food additives of animal or vegetable origin that could be questioned by food consumers because of their clear non-milk nature (Sect. 4.3.1).

Another notable difficult concerning the use of food additives in cheese formulations is related to the nature of 'off-line' (OL) by-products (Sect. 4.3) obtained during and at the end of the production. These by-products may be reused, depending on their safety and technological conditions, in similar or different productions, when speaking of cheeses. However, the presence of declared food additives in certain situations can surely constitute a notable problem for the reuse of OL in other productions. As a simple example, the presence—and the analytical detection—of titanium dioxide in a particular OL implies that this OL cannot be used for the production of analogue cheeses without a declaration of titanium dioxide in labels. This problem introduces also the well-known matter of 'cross-contamination': the possible and undesired interconnection and interchange between different productions in the same site, where certain ingredients, additives, technological agents and (naturally) microbial life forms may be found in products (McNab 1998).

Because of the complexity of this matter, food additives are practically discussed with reference to the ExTra tool (Chaps. 3 and 4) in selected situations concerning analogue cheeses (Sect. 4.5.2).

## 7.3 Traceability and Food Additives for Analogue Cheeses: The ExTra Tool

With reference to the Extended Traceability (ExTra) tool (Sects. 3.6 and 4.5), Fig. 7.1 shows the link page related to an imitation cheese. In detail, the product is an 'analogue cheese: cylindrical shape' (PRA-CLP) with the addition of selected food additives. This sheet contains substantially the same information shown in Fig. 4.10 with relation to analogue cheeses. This product is different from imitation cheeses discussed in Sect. 4.5.2 for the following reasons:

**ExTra - Extended Traceability**

**PRA-CLP**

Ritorna a ➔ START: START!A1

| | | | | | |
|---|---|---|---|---|---|
| LOT | 11 | USED RAW MATERIALS | 3000.0 | | |
| PRODUCTION DATE | 11/1/16 | FINAL PRODUCTS | 3120.0 | OFF-LINE, NORMAL VALUES | |
| BRAND, WEIGHT, EXP. DATE… | PRACLP, 3,000 grams, 11/04/16 | OFF-LINE | 45.0 | | 31.2 |
| INPUT: ORDERED AMOUNT | 3000 | TOTAL SUM (FP+OL) | 3165.0 | | |
| | | EXCESS | 5.5 | | |

| | | IDENTIFICATION DETAILS | | SUBTOT |
|---|---|---|---|---|
| VEGETABLE OIL | 753 | No 7 Supplier, arrival: 02/01/16, lot: j, y | 753 | 753 |
| | | "special claim: k-certified" | | |
| BUTTER | 72 | No 3 Supplier, arrival: 02/01/16, lots: q, w, e | 72 | 72 |
| RENNET CASEIN | 750 | No 4 Supplier, arrival 03/01/16, lot:z1, z2, z3 | 750 | 750 |
| CHEESES | 450 | No 1 Supplier, arrival: 04/01/16, lot x | 225 | 450 |
| | | No 2 Supplier, arrival: 04/01/16, lot: y | 225 | |
| SALT | 75 | No 5 Supplier, arrival: 05/01/16, lot 0101 | 75 | 75 |
| WATER | 705 | Inner water, used: 11/01/16 | 705 | 705 |
| CITRIC ACID | 33 | No 6 Supplier, by ZZZ manufacturer: arrival: 02/01/16, lot w88e8w | 33 | 33 |
| SODIUM CITRATE | 57 | No 6 Supplier, by MMM manufacturer-arrival: 02/01/16, lot t88t79r | 57 | 57 |
| BETA-CAROTENE | 30 | No 7 Supplier, by MMM manufacturer-arrival: 05/01/16, lot urt5805 | 30 | 30 |
| CARRAGEENAN | 75 | No 6 Supplier, by XXX manufacturer-arrival: 08/01/16, lot P0921 | 75 | 75 |

| | |
|---|---|
| RRMM TOTAL AMOUNT | 3000 |

**Fig. 7.1** This picture shows the ExTra link page related to an imitation cheese (PRA-CLP formulation) with the addition of selected food additives. This sheet contains substantially the same information shown with relation to analogue cheeses (Chap. 4). This product is different from imitation cheeses discussed in Sect. 4.5.2 for the following reasons: **a** the formulation of analogue cheeses does not rely on the amount of cheeses; **b** the water absorption in imitation cheeses is expected to be higher than in processed cheeses. The ExTra tool can calculate the formulation for this product. The formula is recorded in the ExTra tool and calculated on the basis of ordered amount (input data). The shown formula has been created for this simulation only; it is not real (for training purposes only)

(a) The formulation of analogue cheeses does not rely on the amount of cheeses. As a consequence, the production requires certain food additives.
(b) Because of the reduced presence of cheeses in the formulation, the water absorption in imitation cheeses is expected to be higher than in processed cheeses. However, the simple presence of rennet casein could be not sufficient. Consequently, the use of food additives is needed.

The ExTra tool can calculate the formulation for this product as shown in Fig. 7.1. The formula—created for this simulation, it is not real (for training purposes only)—is recorded in the ExTra tool and calculated based on the ordered amount (input data). In our case study, the following additives have been used (Guinee 2007b):

(1) Acidity correctors: citric acid (other acids may be phosphoric acid; lactic acid; acetic acid)
(2) Emulsifying salts for stabilisation: sodium citrate (other agents: sodium phosphates)
(3) Aromas: sodium chloride (other solutions are possible)
(4) Colourant substances: beta-carotene (E160d), although other solutions are acceptable (paprika, etc.). The use of mineral whitening agents such as titanium dioxide is contemplated by the Codex Alimentarius (GSFA 2017), but it is not allowed in several Countries

(5) Hydrocolloids for stabilisation: carrageenan (other solutions are possible: xanthan gum is one of the more popular options).

This formulation has excluded the use of:

(a) Mineral substances such as titanium dioxide, zinc oxide, calcium chloride
(b) Preservatives, such as sorbic acid, potassium sorbate, calcium sorbate, even if the legislation is still evolving (European Commission 2018)
(c) Starches: potato starch, maize starch, etc.
(d) Vitamins and vitamin preparations, e.g. folic acid, riboflavin
(e) Protein replacements such as soya proteins (these compounds are more researched at present because of their importance as source of microingredients such as magnesium, potassium zinc, ω-3 and ω-6 fatty acids) (Wallis and Orobetz 2017)
(f) Collagen ingredients (gelatine, etc.) (Anonymous 2016).

The formulation shown in Fig. 7.1 highlights the following traceability 'problems':

(1) The higher the number of input data, the higher the complexity of the entire output information in terms of component data that should be considered and recorded during and after the declared shelf life of the product. Imitation cheeses are generally long-life products. Consequently, related information has to remain available for a long time (e.g. five years after the production). In this simulation, there are 11 traced raw materials, including water.
(2) There are 10 raw material categories and 11 traced ingredients. The number of traceable items—in terms or goods, name, brand, weight, number of units or pallets, shelf life, documents of transport, invoice, health authorisation, etc.—can be very notable. In addition, there are more traced items than raw material categories, and this situation is easily observed depending on the dimension of productions. In other words, the higher the amount of produced units (and OL!), the more probable the subdivision of used raw materials in different ingredients (with the same definition).
(3) There are only seven suppliers, but 11 traced ingredients. Once more (Sect. 4.5.2), the importance of intermediary companies cannot be excluded. The role of these food business operators (FBO) has to be traced.
(4) The possibility of specific claims can also give additional difficulty when speaking of food additives.
(5) Obtained OL contain sodium citrate, citric acid, carrageenan and β-carotene (E160d). These OL cannot be used in other productions excluding the presence of similar additives. Otherwise, the so-called cross-contamination would be observed. However, it has to be highlighted that a specific site producing both analogue cheeses displayed in Figs. 4.11 and 7.1 has to manage carefully the OL materials avoiding contamination. The cheese formulation observed in Fig. 7.1 contains risky information: the formula is named 'PRA-CLP' as in Fig. 4.11, but the product is completely different. As a result, the traceability management

has to take into account these differences and rename the second products as 'PRA-CLP-1' or similar (but completely different) acronyms!

It should be highlighted that the above-discussed production (Fig. 4.11) is related to the use of two cheeses. Consequently, the higher the number of different cheese items, the more difficult the joint traceability for a single product. It has to be highlighted that the formulation does not take into account many possible food additives (Chap. 7). In addition, certain mineral substances such as calcium chloride or titanium dioxide are used as whitening agents for colour purposes, while the specific aroma of certain cheeses might be obtained indirectly when using lactic acid or related salts (because of their strong 'lactic' flavour and taste). Consequently, the use (and the recommended/allowed amount) of these additives may depend also on these collateral features.

A final reflection should be considered with relation to aqueous absorption. The discussed case study has demonstrated that analogue cheese productions rely on measurable water absorption because of the low amount of cheeses and the concomitant high quantity of absorbing casein. However, water increase is also dependent on the use of selected food additives (Guinee 2007b; Parisi et al. 2006):

(a) Hydric absorption of casein and cheeses can be enhanced with the use of sodium polyphosphates (trisodium citrate is not as good as polyphosphates).
(b) The use of carrageenan, xanthan gum, guar gum, etc., can give remarkable water absorption (these compounds are carbohydrate polymers, and the number of possible hydrogen bonds is extremely abundant if compared with possible links between water and caseins).

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# Part III
# Traceability of Food Packaging Materials for the Cheese Industry

# Chapter 8
# Food Packaging and the Mandatory Traceability in Europe

**Abstract** The globalisation in the food industries contest requires more and more guarantees in order to protect consumers. Under these conditions, a good food traceability system can help to compensate for this loss of control minimising the production and the distribution of unsafe quality products as well as improving consumer confidence. The management of food product traceability depends on different factors. One of these factors is the consumer demand, which reflects the public need of food safety and security. In order to comply with this need, consumers must be reassured not only with concern to the origin of products and their traceability, but also on contaminants, which can be added to foodstuff. Because of the nature of contaminants and of the predictable negative impact on food quality and safety, the European Union has introduced a number of provisions to reduce these phenomena. For these reasons, this chapter is particularly focused on food-contact materials and the need of a mandatory traceability related to these materials. This analysis is performed from the European viewpoint, taking into account the existing regulatory and related provisions. Anyway, traceability of food contact materials is mandatory exactly as the same traceability for food products—including cheeses—and related ingredients. Because of the synergic food/packaging interaction in the 'packaged food' item, the same requirement is needed when speaking of edible ingredients and food contact materials at the same time.

**Keywords** Cheese · European Food Safety Authority · European Union
Food-contact material · Food business operator · Migration limit · Traceability

## 8.1 Why Food Packaging and Traceability Should Be Connected?

The globalisation in the food industries contest demands more and more guarantees in order to protect consumers, but as a matter of fact control required to ensure the safety of any manufactured product diminishes over distance. Under these conditions, a good food traceability system can help to compensate for this loss of control



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minimising the production and the distribution of unsafe quality products as well as improving consumer confidence.

The management of food product traceability depends on different factors. One of these factors is the consumer demand, which reflects the public need of food safety and security. In order to comply with this need, consumers must be reassured not only with reference to the origin of products and their traceability, but with concern to contaminants also, which can be added to foodstuff.

With relation to traceability and correlated legislations concerning the protection of food consumers, the European framework is the Regulation (EC) No 178/2002. This Regulation (and subsequent amendments and implementation documents) corresponds to the legal basis for many requirements in the EU, including traceability and other useful instruments such as the 'Rapid Alert System for Food and Feed' (European Commission 2004, 2006, 2008, 2011a; European Parliament and Council 2002, 2003a, 2009, 2014). In addition, three specific regulations concern the traceability of food of animal origin, sprouts and seeds intended for the production of sprouts, and genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms (European Commission 2011a, 2013; European Parliament and Council 2003b).

The European Commission defines contaminants as '*substances that have not been intentionally added to food*' which '*may be present in food as a result of the various stages of production, packaging, transport or holding*' (European Commission 2017). They also might result from environmental contamination. Since they can cause a negative impact on food quality and they can be dangerous to human health, the European Union (EU) has introduced a number of provisions to reduce these phenomena (Hegarty 2012).

This chapter is particularly focused on possible contamination episodes concerning the so-called food-contact materials (FCM) and justifying the need of a mandatory traceability related to these materials. In order to analyse this problem, firstly the definition of packaging process must be provided.

## 8.2 What Is Food Packaging?

Packaging process is the technological method aimed to protect foodstuff from different alterations. It can also be defined, by considering other keys to interpretation, as a coordinated system thought to manage transport, distribution and storing steps, or as a mean to ensure that a product reaches the consumer in good and edible conditions. Finally, it can be defined as an economic function aimed at minimising distribution costs and maximising profits.

The last interpretation explains the constant interest from the industry in packaging research and innovation, with a particular concern to shelf-life extension. This term means the commercial durability of a product, and it represents the time limit within which, under certain storage conditions, the progression of different reactions occurring in a food product translates in evident sensory effects. A more prolonged storage of food is useful both to producers, who have the opportunity to manage the logistical aspect and to retailers who can better storage the product at their shops.

However, food packaging mainly solves containment and a protection function (from micro-organisms, air, light, heat, and dust). The containment function represents the historically most traditional feature, which is needed especially for some foodstuffs such as the liquid and the granular ones. These products require specific containers at any stage of the chain, from their production to the storage, passing through the transport phase. The protective function, instead, represents the interface between the product and the environment, and it allows the preservation of food, protecting it from possible microbial and chemical contamination.

These requisites are the main necessities that have led to an increase of the scientific research in the packaging industry to find solutions, which can guarantee the optimal preservation of products.

The research was originally focused on the production of films in contact with food, representing the ideal solution to maintain organoleptic properties. Currently, there are many preservation techniques, and each of which is functional to the specific needs of any agri-food sector because the choice of the material to be used is made considering the nature and the composition of each foodstuff.

Therefore, a specific food packaging to be declared suitable (for the purpose, which it is made for) must demonstrate at least the requirement of functional suitability, which is a guarantee to preservation food.

Before analysing the legal discipline that regulates the use of food-contact materials, it should be underlined that food packaging solves two additional functions; the first of these is the promotion concerning the development of trade activities and of consumer loyalty. Since the packaging has a high value of communication, the image, the colour and the structure of packaging contribute to the commercial success of a product.

The second function is the communicative one aimed at facilitating handling and labelling procedures, having to inform the consumer of each product feature and data useful for its traceability. For these reasons also, food packaging is a constantly evolving sector.

## 8.3 Food Packaging, Traceability and the European Regulatory Situation

Food-contact materials are regulated by different Directive types in the EU. Starting from the European discipline, the first document to be mentioned is the EU Regulation No 1935/2004 (European Parliament and Council 2004a). This Regulation provides a harmonised legal framework establishing the general requirements to be respected by all these materials and objects, and it also sets out the general principles of inertness for food-contact materials (FCMs), taking into account Regulations (EC)

No 178/2002 and (EC) No 882/2004 (European Parliament and Council 2002, 2004b; Schäfer 2007).

In particular, it establishes (Karamfilova 2016) that all materials and articles must be produced respecting the so-called good manufacturing practices (GMPs). Under normal or foreseeable conditions of use, these materials do not release constituents into food at levels harmful to human health, or lead to an unacceptable change in the composition of food products or even lead to a deterioration of their organoleptic characteristics (taste, odour, colour and texture at least).

The EU definition of food-contact materials is very broad. It includes both food package materials and any other materials and articles (i.e. kitchen tools such as pots, plates and glasses; containers and food machinery) that are expected to come into contact with food under normal and foreseeable use conditions. The Regulation is also extended to active materials (which can release substances in products food) and intelligent materials (which can control the conditions of the product food themselves) (Parisi 2009).

The (EU) Regulation No 1935/2004 also establishes that if an object is intended to come into contact with food, it must be labelled appropriately or it has to indicate a ‘glass and fork’ symbol (Karamfilova 2016). This information can be omitted if the use is unequivocal and it makes unmistakable the contact with food products. Moreover, labelling must not be ambiguous or misinterpreted by the food consumer (European Commission 2015; Food Standard Agency 2009).

The Regulation lists 17 groups of materials and articles which specific measures can be taken for. Among these groups, there are natural gums, plastics and silicones. Moreover, besides the general framework rules, some FCM (i.e. ceramic, regenerated cellulose film, plastics, as well as active and intelligent materials) are covered by specific EU measures (Massi 2011).

These specific measures may concern the identification of a positive list of authorised ingredients, the indication of purity criteria for each ingredient and the particular conditions, which the allowed ingredient must comply to, or even the materials, which they can be used in, and the possible harmonisation between different requirements concerning FCM and other non-food products (Geueke et al. 2014). Measures can also concern the indication of global and specific migration levels.

It has to be underlined that FCM is regulated by both EU and national measures. For some types of food contact materials (i.e. coatings, adhesives, and paper) which there is no specific measures at EU level for, many EU Member States have set their own national provisions. These regulations, although different, have a similar structure, which provides a subdivision into food categories, a discrimination of products according to the duration and contact temperature with foods, a positive list of ingredients that can be used, and a migration test with simulant media (Simoneau et al. 2016).

The structure of each legislation is based, as anticipated, on the so-called positive lists of substances that can be used in the production of these materials with the related limitations and restrictions, as well as on the procedure to check and control the food-contact suitability. The positive lists are different from each other list with this accepted name, and they change depending on the type of food or the category of manufactured product because certain ingredients are allowed only for a specific food type.

With relation to FCM, an important role is played in the EU by the Regulation (EC) No 2023/2006, which defines common rules for GMP application. In order to constantly guarantee the conformity and safety of finished products, all the FBOs involved in the production, processing and distribution of materials and objects intended to come into contact with foods are bound to respect these procedures (European Commission 2016).

GMP, as anticipated, is a set of rules that a company defines and implements to ensure that products are constantly in compliance with the legislation and do not cause a danger to human health during their use. In particular, these procedures are defined autonomously by each company with the aim of managing and monitoring over time product features and to guarantee the inertness of the final materials (FEICA 2014). Good manufacturing rules have to be applied in any step of the manufacturing chain of FCM, even if the production of materials is covered by other legislation.

There are many stakeholders involved along the supply chain of food-contact materials, and they could be identified following each step or each ring of the packaging chain (Fig. 8.1).

The starting point for FCM is certainly represented by the original raw materials. The last ones correspond to the manufacturing of the final FCM or food-contact object, starting from FCM parts (where possible). The intermediate step is the production of FCM parts (Fig. 8.1). It should be noted that the whole chain could be developed within the EU area; in some cases, a part of the chain can be outside the EU area. Consequently, the role of another stakeholder—the importer—is crucial.

In general, companies supplying food-contact materials and chemical additives on the one side, and food companies on the other side, need to comply with EU food-contact regulations.

As a legal obligation, food-contact materials, articles, and other similar containers have to be accompanied by adequate documentation always reporting all appropriate information. Each operator ensures that any key information is passed to customers, i.e. the producer name and address, the article number and the production date or the identification of the product itself (Reg. No 1935/2004, art. 15).

FCM traceability is achieved only if each stakeholder complies with the provision that allows to identify the supplier going back along the chain from downstream to upstream users.

The starting point of the whole discipline is undoubtedly the traceability definition laid down in the Article 17 of the EU Regulation No 1935/2004 which specifies that (European Parliament and Council 2004a):

1) The traceability of materials and articles shall be ensured at all stages in order to facilitate control, the recall of defective products, consumer information and the attribution of responsibility.
2) With due regard to technological feasibility, business operators shall have in place systems and procedures to allow identification of the businesses from which and to which materials or articles and, where appropriate, substances or products covered by this

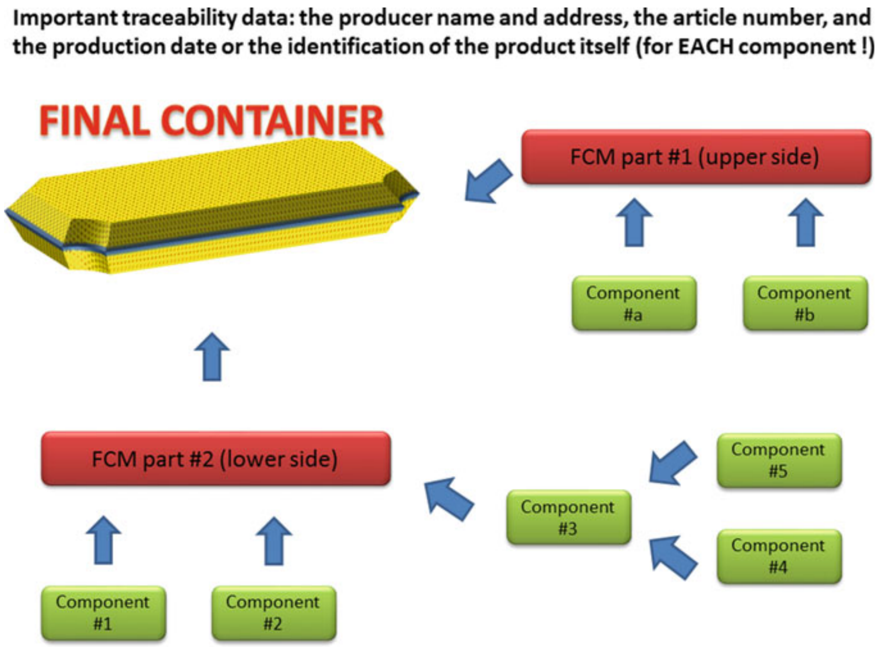


**Fig. 8.1** Starting point for FCM is certainly represented by the original raw materials or components. The last ones correspond to the manufacturing of the final FCM or food-contact object, starting from FCM parts (where possible). The intermediate step is the production of FCM parts, in our situation the upper and the lower side of the final container. FCM can be related with suppliers of FCM 'as they are' and suppliers of raw materials, and chemicals needed for FCM production. FCM has to be accompanied by adequate documentation always reporting all appropriate information (Reg. No 1935/2004, art. 15)

Regulation and its implementing measures used in their manufacture are supplied. That information shall be made available to the competent authorities on demand.

3) The materials and articles which are placed on the market in the Community shall be identifiable by an appropriate system which allows their traceability by means of labelling or relevant documentation or information.

'Food packaging' can be subdivided in four groups: primary materials (in direct contact with foods); secondary (in contact with the primary material, and it combines the primary packages into a box or similar container); tertiary (combining all of the secondary packages into a pallet unit), and finally quaternary (container). Phenomena of material transfer to packaged products may occur from the first packaging type at least (Parisi 2012, 2013).

Starting from materials which are directly in contact with foods, the provisions require that FBO has to record and store specific information related to these packaging materials or objects; FBO is required to guarantee that this information flow has not to be interrupted. The mandatory traceability is essentially based on the registration of any packaging information related to each batch of packaged food. The type of connection between food and packaging material in each stage of the chain is not relevant (whether it consists of manual document storage or electronic archiving), providing that an unequivocal and unambiguous link can be demonstrated and recorded for future controls.

With concern to the second category of materials (articles intended to be brought into contact with foods or to be sold in the retail stage), the identification system cannot be confused with the foodstuff identification system. In these situations, it is necessary that information such as the manufacturer's name, the date and place of production must be maintained until the retail stage.

Finally, the last category is composed of material and articles that can reasonably be expected to be brought in contact with foods or to transfer their constituents to foods. These materials can come in contact with foods for various reasons and in different steps of the food chain. Moreover, it should be noted that this kind of contact could occur indirectly.

Since a transfer of harmful components can take place along the already mentioned chain rings, FBO has the responsibility and the obligation to supervise the chain to avoid that materials can be a source of contamination for food products by transferring undesirable or otherwise foreign substances to the food itself (Hegarty 2012).

The extent of migration depends on several factors including the nature and the composition of the material itself (and related substances) as well as the nature and composition of foods, the contact surface, the contact time and the contact temperature (Castle 2007).

In order to keep this phenomenon under control, the European provisions mainly act on two factors, namely (a) the control of the composition of the materials through the positive lists and (b) the management of limits with reference to allowed uses. Thus, risk assessments are made taking into account the tolerable daily dose. The compliance of FCM can be verified by means of the so-called migration test. In detail, the specific migration limits (SMLs) and the overall migration limits (OMLs) have to be considered for each material. It has to be highlighted that OML refers to the total amount of chemicals that migrates from a packaging to a foodstuff and usually expressed as mg/kg of food. Alternatively, OML can be expressed as mg/dm$^2$ of food-contact surface area in different Legislations (Attwood 2015). Instead, SML values are the amount of a specific substance that can be migrated from FCM into the foodstuff expressed in mg/kg, and it allows finding traces of an individual ingredient yielded in a product (EFSA Panel on Food Contact Materials, Enzymes, Flavourings and Processing Aids 2016; Norwegian Scientific Committee for Food Safety 2009).

Rules for FCM suitability concern different FBO, from the FCM producers to importers and the distributors, passing through the FCM users that are the food operators mainly required to comply with regulatory provisions.

According to (EC) Regulation No 1935/2004, art. 16, specific measures pointed out in art. 5 of the same Regulation provide that materials and objects, which they refer to, must be accompanied by a written declaration attesting their compliance with the Regulation itself. The competent authorities, in order to check this conformity, can demand for a proper documentation which therefore has to be always available (European Parliament and Council 2004a). In detail, proceeding along the chain (downstream flow), it is essential that the FCM producer releases its own declaration of conformity to the transformer which will keep that declaration and will release its own declaration connected to the transformed product. In turn, the FCM wholesaler will keep the above-mentioned declaration, and he will release his own version to the FCM user (the final distributor of pre-wrapped foods) who will keep the declaration of his supplier upstream.

The declaration of conformity is an assumption of responsibility from the FCM producer who certifies FCM suitability with regard to the foodstuff contained therein, according to the current Regulations.

The validity period of the declaration is generally of two years, but it may vary according to specific situations. Furthermore, in case of significant changes in production that may lead to variation in migration levels, and in presence of new scientific data or legislation changes, the declaration of conformity must be updated. This declaration must follow the material and the object in all steps, excluding the one related to the final consumer.

The release of the declaration of conformity by the FCM manufacturer does not exclude that the FCM user can perform further checks in order to confirm the suitability of the material, reporting, in case of non-conformity, any discrepancies with respect to the indications provided by the manufacturer.

FBO that use a FCM must also guarantee a suitable system of storage and conservation of these materials; in terms of food hygiene, they are required to adapt the self-control plan indicating the management systems used (acquisition of declarations of conformity, management of non-conformity, traceability systems, storing, etc.).

Before concluding, it is necessary to mention active and intelligent packaging systems which have specific features if compared with normal FCM (Parisi 2009).

In active and intelligent packaging systems, the material(s) or the container are designed to perform a function, not traditionally attributed to packaging. With the Commission Regulation of 29 May 2009 No 450/2009, the (EC) Regulation No 1935/2004 was implemented extending its scope to active and intelligent materials (European Commission 2015; Food Standard Agency 2009; Karamfilova 2016; Massi 2011).

According to this Law, '*active materials and articles' means materials and articles that are intended to extend the shelf-life or to maintain or improve the condition of packaged food; they are designed to deliberately incorporate components that would release or absorb substances into or from the packaged food or the environment surrounding the food*'. In addition, '*intelligent materials and articles' means materials and articles which monitor the condition of packaged food or the environment surrounding the food*' (European Commission 2009).

The (EC) Reg. No 1935/2004 has also established a list of substances that can be used in active and intelligent objects; moreover, active and intelligent products intended to come into contact with food products must be produced in accordance with GMP (European Parliament and Council 2004a). Finally, substances deliberately incorporated into active packaging materials and objects intended to be released into foodstuffs are considered as ingredients within the meaning of Article 2 (2), letter f), of the Regulation (EU) No 1169/2011. According to this Regulation, an ingredient is defined as '*any substance, including additives and enzymes, used in the manufacture or preparation of a food product and still present in the finished product, even if in modified form*' (European Commission 2011b). This kind of materials must be labelled to indicate their function.

In addition to the requirements provided by the (EC) Reg. No 1935/2004, the label—if it is composed of materials or parts of them appearing to be edible—must indicate the words '*do not eat*' and, when is technically possible, the symbol reproduced in Annex I to the same Regulation, in order to identify the inedible material(s).

Finally, the obligation of art. 16 of Reg. (EC) 1935/2004 (the presence of a written Declaration of Compliance) is expressly prescribed for these object during all steps, except for the sale to the final consumer, whether or not they come into contact with foodstuffs (European Commission 2015; European Parliament and Council 2004a; Food Standard Agency 2009).

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# Chapter 9
# Food Packaging Materials in the Cheesemaking Field

**Abstract** Every kind of foodstuff requires a unique packaging model. This statement is especially true when speaking of peculiar products such as milk, dairy products and cheese. There are some additional needs to take into consideration (i.e. manufacture, transport, 'shelf appeal', branding and packaging functionality) in addition to the traditional ones. Moreover, the type of packaging material(s) for dairy products become of primary importance because of its impact on quality, safety, odour control, toughness and flexibility. These reasons explain the continuous development of the packaging market towards new technologic processes, new materials and innovative solutions. Food packaging may be designed to enhance the product image, to differentiate the product in comparison with other competitors, adding variety for consumers, and finally offering a great potential to build the brand awareness and differentiation. However, these changes have led many innovations within the entire supply chain as well as in product development, packaging, branding and sales channels. Retailers respond to this new market demand in the milk and dairy sector by moving packaging innovation (e.g., portion-controlled, snack-sized, re-sealable and fit-for-purpose models). The aim of this chapter is to give an overview of the most common food packaging solutions related to cheese products, taking into account different needs, production and preservation technologies and sustainability.

**Keywords** Barrier · Cheese · European Union · Food-contact material
Food business operator · Plastic film · Traceability

## 9.1 Food Packaging Materials for Cheeses. Needs of the Current Market

Every kind of foodstuff has its own characteristics; because of these inner peculiarities, each product requires a unique packaging model thought to fit these specific needs.

In detail, and talking about milk and dairy packaging, it has to be noted that there are some additional need to take into consideration (i.e. manufacture, transport,



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'shelf appeal', branding and packaging functionality) in addition to the traditional ones. Moreover, the type of packaging material(s) for dairy products become of primary importance because of its impact on quality, safety, odour control, toughness and flexibility. These reasons explain the continuous development of the packaging market towards new technologic processes, new materials and innovative solutions (Karaman et al. 2015; Majid et al. 2016).

Before talking about innovations, it has to be underlined that cheese has always been considered as a typical 'bulk product'. Some small cheesemakers tend to see the creation of their product as an art (and consequently, they have initially designed a packaging that could fit that image). On the other side, cheese has been thought to be a daily consumption product, manufactured and packaged with cost-effective technology and, as any other industrialised product, with the aim to reach the market for an affordable price. This need has restricted the retail market to the opportunity of making technical improvements for a long time. However, the continuing changing lifestyles, the most modern health trends and the more today complex lifestyle or new consumer's demands (i.e. the need to save time by eating and drinking 'on-the-go') motivate cheese producers to invest in innovative and value-added dairy products.

In other words, packaging could be defined as the face of a product; sometimes, this element is the only product component consumers assess in order to purchase foods. Consequently, distinctive or innovative packaging can increase sales in a competitive environment. As a result, packaging may be designed to enhance the product image, to differentiate the product in comparison with other competitors, adding variety for consumers, and finally offering a great potential to build the brand awareness and differentiation.

However, these changes have led many innovations within the entire supply chain as well as in product development, packaging, branding and sales channels. Retailers respond to this new market demand in the milk and dairy sector by moving packaging innovation (e.g., portion-controlled, snack-sized, re-sealable and fit-for-purpose models).

Generally, food packaging should be able to contain and preserve foods in a cheap or cost-effective way: the need of food industry is to make profits, while consumers want to have an economically sustainable access to packaged foods with the mandatory requirement of food safety (Parisi 2009).

From a historical point of view, the evolution of milk and dairy packaging can be summarised in a few steps. Until the end of the nineteenth century, milk was poured from large containers into consumer's small cans. The first considerable innovation in packaging of milk came with the introduction of sterilised milk processes and, at the same time, of the glass bottle. The glass container was used until the mid of 1900s; subsequently, waxed paper containers were introduced, and they were followed by plastic-coated papers. Plastic materials (initially polyethylene in 1940), both alone and in combination with paper, proved to be the best suitable solution for milk and dairy products packaging.

As regarding milk derivatives, the packaging has always been designed to contain three main cheese types: natural cheese, powdered cheese and processed (melted, analogue) cheese.

Natural cheese is manufactured from pasteurised milk without further processes; manufacturers carry out the ageing process, and ageing continues ‘on the shelf’. This product requires a packaging with strong barrier properties because of the high risk of spoilage and the concomitant oxygen exposure.

Powdered cheese is obtained by means of the dehydration of natural cheese that is reduced to powder in order to add flavour and aroma in snack foods.

Processed cheese, instead, derives from melting natural cheeses with the addition of whey, water, salt, and emulsifiers to enhance shelf-life values and technological properties. This treatment allows to ‘pasteurise’ the cheese itself at high temperatures for a convenient time.

## 9.2 Food Packaging Materials for Cheeses. Protection and Eco-friendly Solutions

As already said (Sect. 8.1), the principal role of food packaging is to protect foodstuff from deterioration and to maintain the benefits of food processing after the process is completed, maintaining product quality and freshness during distribution and storage until the final consumption. In detail, packaging provides protection from these external influences:

- Chemical modifications
- Biological spreading
- Physical dangers (also known as presence of foreign bodies: wood, plastics, metals, insect fragments, etc.).

Chemical protection allows to avoid or at least to reduce inner changes due to environmental influences such as exposure to oxygen and other gases, change in relative humidity (environmental conditions), or light.

Biological protection avoids spoilage and pathogenic contamination by providing a physical barrier to microorganisms and insects. Moreover, biological ‘shields’ create adequate conditions to control ripening and seasoning process, with the reduction of aroma transmission and the effective protection or the internal cheese environment.

Physical barriers are designed to protect foodstuff from damages encountered during the distribution process (impacts, abrasions and crushing damages).

Nowadays, cheese industries have to develop new technologies balancing food protection with other needs such as production costs, mandatory consumeristic information and the growing environmental consciousness. Traceability, information for consumers and fraud control are issues of more and more increasing importance. For example, package labelling satisfies legal requirements for product identification, nutritional value, ingredient declaration, net weight and manufacturer information. Moreover, the container conveys information about the product such as brand identification and pricing. Food manufacturing companies incorporate distinctive codes on package labels of their products allowing the track of products throughout each ring of the distribution chain. Codes are available in various formats (printed barcodes, Radio-Frequency IDentification or RFID devices) and can be read manually or by dedicated machines.

In order to keep intact all sensorial properties, different types of packaging solutions are suitable for various and specific types of cheese product. The oxidation of oils and fats can lead to the change in the composition of cheese, altering colours and flavours. Permeability to oxygen and water vapour for packaging films become one of the most essential factors when speaking of packaging composition.

Today, the most part of milk and dairy products on the market are packaged in plastic films (a vacuum pack, a shrink wrap, or a cellophane wrap). Among the materials that have traditionally been used in food packaging, it is also possible to mention glass, metals (i.e. aluminium, foils and laminates), paper and paperboards.

Just as an example, vacuum protection provides a barrier to oxygen, helping cheese to maintain proper moisture levels and freshness as well as reduce food waste from mould growth. For pasteurised yogurt products, a laminated material barrier is usually used with the purpose of ensuring long shelf-life periods and enhancing protection from oxidation, as well as a light barrier in order to avoid the fading of colours and light-induced oxidation. Drinking-dairy products are packaged in high-density polyethylene bottles sealed with either aluminium foil laminate heat-seal closures. Bottles made from polyethylene terephthalate (PET), opaque or semi-opaque packaging materials may also be used.

It has to be noted that, in order to realise new packaging tools, the combination of different materials can provide proper solutions allowing exploiting each material properties (Karaman et al. 2015). In addition, the modified atmosphere packaging (MAP) technique can be applied to cheeses with the purpose of managing spoilage problems and extending their shelf life. Oxygen scavenging, carbon dioxide absorbing, moisture scavenging (desiccation) and antimicrobial systems can be mentioned among available active packaging techniques. These solutions, exploiting substances that absorb moisture, oxygen, carbon dioxide, flavours and odours, or release carbon dioxide, antimicrobial agents, antioxidants and flavours, help to enhance shelf life and prevent deterioration.

The use of a non-thermal preservation technology, such as pulsed electric fields (PEFs) and high-pressure technology (HPP), could also provide an alternative to obtain a lasting pasteurised product without altering sensory and nutritional properties (Lado and Yousef 2002).

Nowadays, the development of these technologies involves also sustainability issues and the need to reduce the environmental impact of the food packaging system. Plastics such as polyethylene (PE) and polypropylene (PP) must be coated with synthetic polymers in order to block moisture and keep oxygen out of the container. Most of these polymeric compounds such as ethylene vinyl alcohol (EVOH) and polyvinylidene chloride (PVDC) derive from petroleum; since it is almost impossible to separate each individual layer, these packaging materials cannot be reused or recycled (Parisi 2012–2013; Piergiovanni and Limbo 2016).

For this reason, at present the research is heading towards 100% biodegradable materials that would have a lower environmental impact if compared to traditional plastic packaging, which comes from non-renewable resources. As an example, since cheesemaking process generates tonnes of whey, the reuse of this by-product in the making of milk and dairy packaging could aim to reach this goal reducing the need for synthetic packaging. Wasted whey can be filtered and dried to extract pure whey protein that can be used in several thin layers to create a biodegradable plastic film for use in food packaging. Protein-based films, replacing the synthetic components with plastic fibres coated with proteins derived from whey, can efficacy avoid oxidation phenomena and promote the prevention of food spoilage. After the use of packaging, whey proteins can be chemically removed and the underlying plastic can be recycled or reused to make new packaging materials (Anonymous 2016).

These casein-based films are biodegradable and sustainable compounds. Some efforts are already been made such as starch-based packages, but starch-made films are porous and let the oxygen go through microholes. The casein solution, instead, seems to have smaller pores that allow creating a closer network avoiding oxygen permeation.

Even companies that produce whey (as by-product) could make a good profit turning it into a new material for cheese packages. The new packaging would be environmentally sustainable, economic and safe.

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# Chapter 10
# The ExTra Tool—Practical Simulations of Traceability for Cheese Packaging Materials

**Abstract** The world of food-contact materials and objects is continually evolving at present because of different exigencies that could be defined 'needs', including extended shelf-life values, marketing targets and other minor factors. The role of these materials as accessory ingredients of a specific food product is no longer accepted, and the European Union has recently issued the (EC) Regulation No 1935/2004 in this ambit with concern to specific traceability systems and procedures for food-contact materials. As a result, the problem of traceability in food industries concerns food ingredients, additives and other substances that should be defined 'edible' and food packaging materials on the other hand. This innovation has an important impact on the management of food business operators, including non-food industries producing articles for the food industry. Traceability is one of the main pillars of the modern food safety strategy worldwide. In addition, because of the complexity of different food sectors and sub-sectors, foods and beverages cannot be managed in the same way when speaking of processed meats, eggs, seafood products, cheeses and so on. As a result, the matter is new enough and should be discussed critically, and the ambit of cheese products is interesting. With concern to packaged cheese products, the aim of this chapter is to describe in practice the complex operations—named jointly 'traceability'—related to food-contact materials used. Three case studies are evaluated in this ambit, with concern to different cheeses and food packaging materials. The flow of input and output information is critically discussed and analysed when speaking of information complexity.

**Keywords** Cheese · European Union · Extended traceability
Food-contact material · Food business operator · Packaging business operator
Plastic film



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## 10.1 Traceability for Food Packaging Materials in the Cheese Industry

The world of food-contact materials and objects is continually evolving at present because of different exigencies that could be defined 'needs', including extended shelf-life values, marketing targets and other minor factors (Mania et al. 2016; Parisi 2009).

The role of these materials as accessory ingredients of a specific food product is no longer accepted, and the European Union has recently issued the (EC) Regulation No 1935/2004 in this ambit (European Parliament and Council 2004). With relation to traceability, it has been clearly stated (Article 17, point 1) that '*The traceability of materials and articles shall be ensured at all stages in order to facilitate control, the recall of defective products, consumer information and the attribution of responsibility*'. Consequently, business operators are requested to put in place traceability systems and procedures with the aim of assuring the correct identification of the material(s): origin, name and identification of the initial supplier, date of production (also specified as batch), name of the consignee, etc. It is important to know that these information are required and have to be made readily available to competent authorities. Finally, these materials and objects have to be easily identifiable by means of adequate traceability systems (documents, PC-readable information, labelling and prints on the material itself, etc.). The meaning of 'traceability' is not different from other definitions: '*the ability to trace and follow a material or article through all stages of manufacture, processing and distribution*' (Reg. 1935/2004, Article 2, point 1, comma a).

The problem of traceability in food industries concerns food ingredients, additives and other substances that should be defined 'edible' and food packaging materials (FCM) on the other hand.

In general, with relation to traceability and correlated legislations concerning the protection of food consumers, the European framework is the Regulation (EC) No 178/2002. This Regulation (and subsequent amendments and implementation documents) corresponds to the legal basis for many requirements in the EU, including traceability and other useful instruments such as the 'Rapid Alert System for Food and Feed' (European Commission 2004, 2006, 2008, 2011; European Parliament and Council 2002, 2003a, 2009, 2014). In addition, three specific regulations concern the traceability of food of animal origin, sprouts and seeds intended for the production of sprouts, and genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms (European Commission 2011, 2013; European Parliament and Council 2003b).

This innovation has an important impact on the management of food business operators (FBO). In fact, the mandatory requisite of traceability, both from raw materials to final products and vice versa, has to be assured by FBO related to the food industry, and FBO belonging to non-food industries producing articles for the food industry. This evolution has also determined the birth of dedicated food certification systems such as BRC Global Standard for Packaging and Packaging

Materials (GSPP), by the British Retail Consortium (BRC), UK, and other voluntary certification standards (Kawecka 2014; Stilo et al. 2009).

Relations between food traceability and safety concerns are one of the most important problems at the international level (Allata et al. 2017; Chen 2017; King et al. 2017; Lewis et al. 2016). Because of the relation between some safety risks and food packaging materials, existing legislations have considered the problems in the same way of food ingredients and additives (the nature of passive microbial contamination vehicles should be taken into account) (Brunazzi et al. 2014; Parisi 2012). In addition, the undeclared presence of allowed additives with some specific food allergenic reaction could be sometimes ascribed to particular FCM because of migration episodes (e.g. mineral substances, such as titanium dioxide, zinc oxide; organic and prohibited colourants) (Parisi 2012, 2013). At present, the attention of national and international authorities working with food and beverage controls is focused on these topics, and the list is virtually infinite because of new (Kok 2017; Lacorn et al. 2018; Moyer et al. 2017; Pisanello and Caruso 2018; Silvis et al. 2017).

As discussed, the situation is continually evolving, and the most part of food and beverage sectors are trying to find different solutions. Because of the new and non-accessory role of FCM as active subjects in the more general food safety assessment, traceability concerning packaging only should have the following requisites (Mania et al. 2016):

(1) FCM units should be clearly identified.
(2) Secondly, these units may be put together or separated when speaking of their number and association into a complex number of different commodities with various products, sizes, weights and so on. The transformation of FCM towards the final product(s) determines a complication in the traceability. In addition, the traceability of FCM components (e.g. polyethylene for plastic polycoupled films; inks for metal cans) has to be assured.

In addition, different packaging business operators (PBO) can use dissimilar systems performing (or giving the evidence of) these operations. Manual records were diffused enough in the recent past with reference to paper-based systems. At present, the panorama shows the evolution of information and communications technology (ICT) integrated approaches, the use of dedicated nanosensors, the application of radio frequency identification (RFID) on packages or the diffusion of 'smart' packages (Allain et al. 2018; Bibi et al. 2017; Ferrero et al. 2018; Parisi 2009, 2012, 2013). Differently from food and beverage industries, the packaging sector is more accustomed to work with advanced and PC-readable documentation; consequently, the evolution of paper-based methods to ICT-based technologies and hybrid systems is expected when speaking of PBO, at present.

As discussed in Sect. 2.1, traceability should be considered as the evidence of a whole flow of information among the food operators with a continuous data exchanging. The same thing has to be assured when speaking of PBO; also, PBO and FBO are expected to cooperate jointly.

In this way, transparency, product quality, food safety and finally integrity along the food and packaging supply chain could be easily guaranteed. In detail, it should be considered that a good definition of 'food and packaging supply integrity' should concern the capability of FBO and PBO to demonstrate their compliance '*with respect to food safety and quality in communication to stakeholders such as consumers and government bodies*'. This definition does not take initially into account PBO, but the evolving legislation considers the role of PBO in the same way. Moreover, the traceability requisite is particularly important and requested when speaking of high perishable foodstuff subject to rapid deterioration (such as cheeses). In other words, traceability can be used to demonstrate the performance of food products not only in relation to food safety, food frauds and so on, but also when speaking of expiration or use-by dates (Parisi 2002a, b, 2004). Because of the known active role of FCM in the food/packaging assembled system (Parisi 2012), FCM- and PBO-related information have to remain in the integrated traceability chain for some years.

On these bases, it may be inferred that traceability is one of the main pillars of the modern food safety strategy worldwide. In addition, because of the complexity of different food sectors and sub-sectors—including dedicated FCM—foods and beverages cannot be managed in the same way when speaking of processed meats, eggs, seafood products, cheeses and so on (Golan et al. 2004). As a result, the matter is new enough and should be discussed critically, sector by sector.

With relation to FCM, the field of milk and dairy productions can show an extremely variegated situation because of the many possible packaging solutions associated with the general 'cheese' products. Moreover, different packaging materials can be more or less resistant to thermal and/or safety treatments carried out on raw materials, intermediate masses and final cheeses. Consequently, it might be affirmed that 'one product, one container' (where the single contained is often the synergic sum of different components).

The aim of this chapter is to describe in practice the complex operations—named jointly 'traceability'—related to FCM used for cheeses (the category of food-contact objects, namely those materials that are part of different machines and equipment, and consequently separated from FCM as permanent containers, is excluded). Three case studies are described here in this ambit, with concern to different FCM.

## 10.2 Traceability for Food Packaging Materials in the Cheese Industry—The Flow of Input Information

With reference to FCM used for cheeses, the following product types should be mentioned at least:

(1) Packaging category (e.g. plastic films; glass containers; aluminium rings; plastic boxes, trays and rigid containers; plastic buckets; paper and cardboard materials; metal cans) (Parisi 2012)
(2) Food- or non-food-contact classification of packaging materials, namely 'primary packaging' (in contact with foods and beverages), 'secondary packag-

ing' (containing a specified number of packaged foods) and 'tertiary packaging (namely, materials able to contain and be assembled around a specified amount of secondary packages). It has to be considered that secondary packages are generally folding cartons, polystyrene containers or big cardboard boxes, and these boxes are jointly grouped in a tertiary unit (also named 'pallet') by means of plastic wrapping films and wooden or plastic bases

(3) Approximated composition of FCM with concern to basic materials, for example polymeric compounds; wood; glass; paper; electrolytic tin plate, tin-free steel, aluminium alloys (for metal cans) (Parisi 2012)
(4) The FCM nature, in terms of single container (without detachable parts), single packaging material (obtained by more than one component) or component of a future container (in this situation, more than one components have to be assembled to form the final packaging)
(5) The name and address of the FCM manufacturer. It has to be noted that the PBO is responsible for (a) the supplied product itself, (b) the related declaration of food-contact compliance (in the European Union (EU) at least) and (c) the shared design of the FMP with the final user(s). The last point is extremely important because the final FBO, responsible for the food product, is also responsible for all possible failures indirectly or directly dependent on the used packaging, for EU authorities. In other words, should the technological compliance of the food packaging material be questioned, the FBO would be considered totally responsible (Parisi 2012, 2013)
(6) Other data of interest, including the production rate, the detailed batch number and related supporting documentation (delivery transport documents; invoices; supporting analyses and similar documents) (Italian Institute of Packaging 2011).

This list may be not completely exhaustive. It should be also noted that the traceability has to be assured for all possible FCM and FCM components throughout the whole chain; consequently, single component or basic materials for a peculiar FCM—originally used to realize intermediates for different FMP—have to be traced. With relation to FCM, the formulation can be really complex and sometimes challenging, because of the presence of different ingredients and additives in a small amount (e.g. glues in paper packages; inks and adhesives in polycoupled films; inks and lubricant substances in metal cans).

Three different situations are discussed in this chapter concerning food products already mentioned in Chaps. 3, 4 and 7.

### 10.2.1 Mozzarella Cheeses Packaged in Plastic Thermosealed Films

This book would describe a practical part of a traceability system into a cheese industry, Gambino Industrie Alimentari SpA (Sicily, Italy), as performed by Dr.

**ExTra - Extended Traceability**

**MZR-BAR**

Ritorna a START: START!A1

| | | | | | |
|---|---|---|---|---|---|
| LOT | 11 | USED RAW MATERIALS | 1000 | | |
| PRODUCTION DATE | 11-1-16 | FINAL PRODUCTS | 1032 | OFF-LINE, NORMAL VALUES | |
| BRAND, WEIGHT, EXP. DATEÖ | MZRBAR, 1,000 g, 11/02/2016 | OFF-LINE | 17 | | 10 |
| INPUT: ORDERED AMOUNT | 1000 | TOTAL SUM (FP+OL) | 1049.0 | | |
| | | EXCESS | 4.9 | | |

| RAW MATERIALS | | IDENTIFICATION DETAILS | | SUBTOT |
|---|---|---|---|---|
| CURD | 960 | No 1 Supplier, arrival: 02/01/16, lots: q, w, e | 960 | 960 |
| SALT | 30 | No 2 Supplier, arrival 03/01/16, lot: r | 30 | 30 |
| CITRIC ACID | 10 | No 3 Supplier, arrival: 04/01/16, lot: t | 10 | 10 |
| RR MM TOTAL AMOUNT | 1000 | | | |

USED PACKAGING MATERIALS

| | FPM 1 | FPM 2 |
|---|---|---|
| PACKAGING CATEGORY | polycoupled plastic film | polycoupled plastic film; |
| SUPPLIER AND MANUFACTURER | supplier: PBO1; manufacturer: PBO2 | supplier: PBO1; manufacturer: PBO3 |
| BRAND NAME | TOP | END |
| COLOUR CODE | D | W |
| ARRIVAL DATE | 02-01-2016 | 02-01-2016 |
| BATCH | WE012016 | DA022016 |
| NUMBER OF UNITS | spools: 15 | spools: 09 |
| INITIAL AND FINAL USE DATES | 03rd January 2016 – /// | 04rd January 2016 – 09th January 201 |
| CHAIN INFORMATION? | No | No |

**Fig. 10.1** ExTra tool displayed in Fig. 3.13 with concern to MZR-BAR formulation does not appear complete because of the lack of information concerning packaging materials concerning the formulation acronym MZR-BAR. Actually, the ExTra tool can be shown completely in this picture. In the lower part of this picture, the sheet mentions also interesting data concerning the used primary FCM: the category of used FCM or FCM component; the name of the supplier and/or manufacturer; brand name of the used FCM, if any; the colour code (white, transparent or dedicated); the date of arrival; batch code(s) and other related data, if any; number of items (spools, boxes, etc.); initial and final dates of use. The shown formula has been created for this simulation only; it is not real (for training purposes only)

Ignazio Mania from 02 May 2016 to 29 July 2016, in the ambit of a dedicated training under Dr. Salvatore Parisi's supervision. Traceability is quite a complex argument: for this reason, the discussed arguments in this book are related exclusively to processing operations without other non-technological topics.

The above-mentioned company—specialized in the production of Mozzarella cheeses, semi-hard cheeses, and dairy products and preparations (processed and analogue cheeses)—has implemented a multi-electronic sheet software created by Salvatore Parisi in 2007. This software has been called 'Extended Traceability' (ExTra): the basic aim of this product is to give evidence of all raw materials and other ingredients used in the production of related cheeses. The role of packaging materials cannot be excluded.

The ExTra software—subsequently defined 'ExTra tool'—is able to join all information related to different productions for a single day (Sect. 3.3). Figure 3.13 shows the link page related to MZR-BAR formulation, as discussed in Sect. 3.6.2.1. However, Fig. 3.13 does not appear complete because of the lack of information concerning packaging materials concerning the formulation acronym MZR-BAR.

Actually, the ExTra tool can be shown completely in Fig. 10.1. In the lower part of this picture, the sheet mentions also interesting data concerning the used primary FCM:

(1) The category of used FCM or FCM component
(2) Name of the supplier and/or manufacturer
(3) Brand name of the used FCM, if any
(4) The colour code (white—W, transparent—N and dedicated or multi-printed—D)
(5) Date of arrival
(6) Batch code (and other related data, if any)
(7) Number of items (spools, boxes, etc.)
(8) Initial and final dates of use
(9) Peculiar chain information (e.g. organic food).

In our situation, the Mozzarella cheese (MZR-BAR) production, brand MZR-BAR, produced on 11 January 2016, has been packaged with the following materials (inserted data are not real):

(a) Top or cover (polycoupled) plastic film; supplier: PBO1; manufacturer: PBO2; brand name: TOP; colour code: D; arrival, 02 January 2016; batch code: WE012016; number of spools: 15; initial and final dates of use: 03 January 2016—not still finished; no chain indication
(b) End (polycoupled) plastic film; supplier: PBO1; manufacturer: PBO3; brand name: END; colour code: W; arrival, 02 January 2016; batch code: DA022016; number of spools: 09; initial and final dates of use: 04 January 2016—09 January 2016; no chain indication.

On these bases, the ExTra tool can show the lacking information concerning FCM. It has to be highlighted that:

(1) The cheese is packaged with the use of two different FCM components, and the final container corresponds to a thermosealed package where the 'top' film is on the upper side, and the 'end' film is on the lower side
(2) Two different manufacturers are mentioned, but the supplier (PBO1) is identical
(3) The colour code identifies clearly the cover polycoupled film as a multi-printed packaging material. This plastic material has to show all mandatory information at least, including the brand, the nutritional labelling, lot and expiration (or use-by) date. The mention of the so-called knife and fork icon is obligatory according to the (EC) Reg. 1935/2004. In addition, this material could mention adequate traceability codes or images with reference to the FCM (including also the PBO identification)
(4) The 'end' polycoupled film is not printed, and the corresponding Colour code is W (white). This material easily contains white inorganic pigments in its formulation (more than two materials such as low-density polyethylene (LDPE) and polyamide (PA) (Brunazzi et al. 2014; Parisi 2012; Piergiovanni and Limbo 2016)). At the same time, the 'top' or 'cover' material contains many additives: '*n*' inks for '*n*' colours, and naturally an adhesive substance. Consequently, this material also may have an *n*-layered structure
(5) The last information concerns a peculiar 'chain information'. In fact, the possible replacement of a 'top' film dedicated to a non-organic food with another similar

film dedicated to organic products (with similar names) is not allowed. This example concerns possible 'cross-contamination' episodes between different production lines, even if no edible ingredients are replaced.

At the end of the production cycle, the Operator writes the amount of final products and the 'Off-Line' (OL) quantity (Sect. 3.6, Fig. 3.13). In this simulated case study, the amount of used spools should be mentioned, and the production of OL by-products means that a certain amount of FCM has been included in this count. However, the reuse of these FCM is practically impossible because OL products are substantially damaged products, and the reuse of edible materials would imply the destruction of residual FCM. For this reason, Fig. 10.1 does not show the amount of destroyed FCM, but the global use only.

This discussion has demonstrated that the simple traceability of a simple product such as a thermosealed container for a Mozzarella cheese implies different information. In addition, the complication of the 'brand' name forces often FBO to order and use a dedicated (or multi-printed) material for a single product only. The dimensions and shapes are also important because a 1,000 g-cheese is not equal to a 3,000 g product: each cheese has its own 'cover film'. Finally, the mention of two films implies that a minimum number of FCM components are related to the used FCM:

(1) The cover has two plastic layers (e.g. LDPE and PA), one adhesive substance at least and 'n' colours. Should n = 5, this film would be composed of '2 + 1 + 5' = 8 different components
(2) At the same time, the end film would be composed of two layers, one adhesive substance at least, and one (white) colour. The total number of FCM components would be '2 + 1 + 1' = 4 components
(3) As a result, the joint container would be composed globally of 12 components.

Interestingly, processed and analogue cheeses such as PAL-BAR (Sect. 4.5.1) can be packaged with the same materials. On the other side, processed cheeses and imitation cheeses cannot be confused with 'true' cheeses; as a result, the traceability of materials—both multi-printed and neutral or white materials—has to be assured.

### 10.2.2 *Semi-hard Cheeses Packaged in Plastic Thermosealed Films*

Figure 3.17 shows the link page related to a semi-hard formulation, as discussed in Sect. 3.6.2.2. Figure 3.18 does not appear complete because of the lack of information concerning packaging materials concerning the semi-hard cheese (SDU-BAPS) formulation.

Actually, the ExTra tool can be shown completely in Fig. 10.2. As discussed in Sect. 10.2.2, the sheet mentions several data concerning the used primary FCM, with an important addition: the mention of the used superficial treatment, if any. In fact, certain semi-hard cheeses may be artificially or naturally smoked, or be treated with

**ExTra - Extended Traceability**

**SDU-BAPS**

Ritorna a ➔ ART: START!A1

| | | | | |
|---|---|---|---|---|
| LOT | O15012 | USED RAW MATERIALS | 2000.0 | |
| PRODUCTION DATE | 12-1-16 | FINAL PRODUCTS | 2005.0 | OFF-LINE, NORMAL VALUES |
| BRAND, WEIGHT, EXP. DATE… | SDUB, 250 g, 15/03/2016 | OFF-LINE | 20.0 | 20 |
| INPUT: ORDERED AMOUNT | 2000 | TOTAL SUM (FP+OL) | 2025.0 | |
| | | EXCESS | 1.3 | |

| RAW MATERIALS | | IDENTIFICATION DETAILS | | SUBTOT |
|---|---|---|---|---|
| CURD | 1880 | No 1 Supplier, arrival: 02/01/16, lots: q, w, e<br>No 2 Supplier, arrival 03/01/16, lot: r | 1880 | 1880 |
| SALT | 80 | No 3 Supplier, arrival: 04/01/16, lot: t | 80 | 80 |
| CITRIC ACID | 40 | | 40 | 40 |

| | |
|---|---|
| RR MM TOTAL AMOUNT | 2000 |

USED PACKAGING MATERIALS

| | FPM 1 | FPM 2 |
|---|---|---|
| PACKAGING CATEGORY | polycoupled plastic film | polycoupled plastic film; |
| SUPPLIER AND MANUFACTURER | supplier: PBO4; manufacturer: PBO4 | supplier: PBO5; manufacturer: PBO5 |
| BRAND NAME | COVER | ENDMAT |
| COLOUR CODE | D | N |
| ARRIVAL DATE | 02-01-2016 | 02-01-2016 |
| BATCH | W0118 | D11987 |
| NUMBER OF UNITS | spools: 5 | spools: 05 |
| INITIAL AND FINAL USE DATES | 03rd January 2016 – /// | 04rd January 2016 – 09th January 2016 |
| SUPERFICIAL TREATMENT ? | No mention | No mention |
| CHAIN INFORMATION? | No | No |

**Fig. 10.2** ExTra tool displayed in Fig. 3.18 with concern to SDU-BAPS formulation does not appear complete because of the lack of information concerning packaging materials concerning the formulation acronym. The ExTra tool can be shown completely in this picture. In the lower part of this picture, the sheet mentions also interesting data concerning the used primary FCM, as already shown in Fig. 10.1. Certain semi-hard cheeses may be artificially or naturally smoked, or be treated with antimicrobial substances (potassium sorbate is used against moulds), or coated with anti-mould polymers. Consequently, the 'superficial treatment' mention on FCM has to be considered. The shown formula has been created for this simulation only; it is not real (for training purposes only)

antimicrobial substances (potassium sorbate is used against moulds), or coated with anti-mould polymers.

In our situation, the SDU-BAPS, brand SDUB, produced on 11 January 2016, has been packaged with the following materials:

(a) Top or cover (polycoupled) plastic film; supplier: PBO4; manufacturer: PBO4; colour code: D; arrival, 02 January 2016; batch code: W0118; number of spools: 5; initial and final dates of use: 03 January 2016—not still finished; superficial treatment: no mention; no chain indication.
(b) End (polycoupled) plastic film; supplier: PBO5; manufacturer: PBO5; colour code: N; arrival, 02 January 2016; batch code: D11987; number of spools: 05; initial and final dates of use: 04 January 2016–09 January 2016; superficial treatment: no mention; no chain indication.

On these bases, the ExTra tool can show the lacking information concerning FCM. It has to be highlighted that:

(1) The cheese is packaged with the use of two different FCM components, and the final container corresponds to a thermosealed package where the 'top' film is on the upper side, and the 'end' film is on the lower side

(2) Two different manufacturers are mentioned, and these PBO are also manufacturers
(3) The colour code identifies clearly the cover polycoupled film as a multi-printed packaging material. This plastic material has to show all mandatory information at least, including the brand, the nutritional labelling, the superficial treatment (if any), lot and expiration (or use-by) date, etc. The mention of the so-called knife and fork icon is obligatory according to the (EC) Reg. 1935/2004. In addition, this material could mention adequate traceability codes or images with reference to the FCM (including also the PBO identification)
(4) The 'end' polycoupled film is not printed, and the corresponding colour code is N (transparent). This material does not contain pigments in its formulation (two materials only, such as LDPE and PA (Brunazzi et al. 2014; Parisi 2012; Piergiovanni and Limbo 2016). At the same time, the 'top' or 'cover' material contains many additives: '*n*' inks for '*n*' colours, an adhesive substance, and two layers such as PE and polyethylene terephthalate (PET). Consequently, this material also may have an *n*-layered structure
(5) The last information concerns a peculiar 'chain information'. In fact, the possible replacement of a 'top' film dedicated to a non-organic food with another similar film dedicated to organic products (with similar names) is not allowed. This example concerns possible 'cross-contamination' episodes between different production lines, even if no edible ingredients are replaced.

At the end of the production cycle, the Operator writes the amount of final products and the OL quantity. The amount of used spools should be mentioned. Once more, Fig. 10.2 does not show the amount of destroyed FCM, but the global use only.

This discussion has demonstrated that the simple traceability for a simple product such as a thermosealed container for semi-hard cheese implies different information. The complication of the 'brand' name forces often FBO to order and use a dedicated (or multi-printed) material for a single product only, depending also on the superficial treatment (if any). The dimensions and shapes are also important because a 300-g cheese is not equal to a 200-g product: each cheese has its own 'cover film'. Finally, the mention of two films implies that a minimum number of FCM components are related to the used FCM:

(1) The cover has two plastic layers (e.g. PE and PET), one adhesive substance at least and '*n*' colours. Should $n = 6$, this film would be composed of '$2 + 1 + 6$' = 9 different components
(2) At the same time, the end film would be composed of two layers and one adhesive substance. The total number of FCM components would be '$2 + 1$' = 3 components
(3) As a result, the joint container would be composed globally of 12 components, similarly to MZR-BAR (Sect. 10.2.1). However, the composition of the container is different.

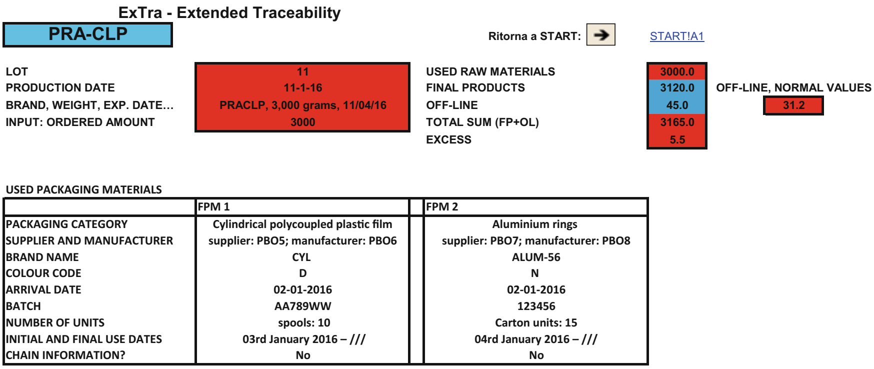


**Fig. 10.3** ExTra tool displayed in Fig. 4.11 with concern to PRA-CLP formulation does not appear complete. This picture shows the complete information with relation to this imitation cheese (packaging traceability). In our situation, the PRA-CLP product, brand PRA-CLP, produced on 11 January 2016, has been packaged with a cylindrical (polycoupled) plastic film and aluminium rings (used for FCM closure). The shown formula has been created for this simulation only; it is not real (for training purposes only)

### 10.2.3 *Imitation Cheeses Packaged in Cylindrical Plastic Films*

The last case study concerns PRA-CLP formulation (Sect. 4.5.2, Fig. 4.11).

Figure 4.11 shows the link page related to PRA-CLP formulation, without information concerning packaging materials. The ExTra tool can be now shown completely in Fig. 10.3. In the lower part of this picture, the sheet mentions FCM data concerning the used primary materials, as discussed in Sect. 10.2.1.

In our situation, the analogue cheese (PRA-CLP) product, brand PRA-CLP, produced on 11 January 2016, has been packaged with the following materials (inserted data are not real):

(a) Cylindrical (polycoupled) plastic film; supplier: PBO5; manufacturer: PBO6; brand name: CYL; colour code: D; arrival, 02 January 2016; batch code: AA789WW; number of spools: 10; initial and final dates of use: 03 January 2016—not still finished; no chain indication
(b) Aluminium rings (used for FCM closure); supplier: PBO7; manufacturer: PBO8; brand name: ALUM-56; colour code: N; arrival, 02 January 2016; batch code: 123456; number of carton units: 15; initial and final dates of use: 04 January 2016—not still finished; no chain indication.

On these bases, the ExTra tool can show the lacking information concerning FCM. This time, it has to be highlighted that:

(1) The cheese is packaged with the use of one plastic material only, but the closure is assured by means of two aluminium rings (risk of foreign bodies)
(2) Two different manufacturers and two different suppliers are mentioned

(3) The colour code identifies clearly the polycoupled film as a multi-printed packaging material. This plastic material has to show all mandatory information at least, including the brand, the nutritional labelling, lot and expiration (or use-by) date. The mention of the so-called knife and fork icon is obligatory according to the (EC) Reg. 1935/2004. In addition, this material could mention adequate traceability codes or images with reference to the FCM (including also the PBO identification)

(4) Aluminium rings cannot show peculiar identification data. For this reason, these materials are of common (universal) use and defined N as colour code. The risk of foreign bodies should be considered with relation to PRA-CLP products and other productions. At the same time, the 'top' or 'cover' material contains many additives: '*n*' inks for '*n*' colours, and naturally an adhesive substance. Consequently, this material also may have an *n*-layered structure.

At the end of the production cycle, the Operator writes the amount of final products and the OL quantity. In this simulated case study, the amount of used spools and aluminium rings should be mentioned. Figure 10.3 does not show the amount of destroyed FCM, but the global use only.

This discussion has demonstrated that the simple traceability of a simple product such as a cylindrical container without thermosealing operations for a Mozzarella cheese implies different information. In addition, the complication of the 'brand' name forces often FBO to order and use a dedicated (or multi-printed) material for a single product only (aluminium rings may be used for different cheeses). The above-mentioned situation is easily verified if the cheese has to be vacuum-sealed into single-use thermoretractable films; in these situations, one single material is considered. On the other hand, this material could show too specific information with possible problems when speaking of used for new or improved cheese formulations.

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