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Application of ontologies to traceability in the dairy supply chain

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ABSTRACT

Systems for tracking products through supply chains range from paper-based records maintained by producers, processors, and suppliers to sophisticated ICT-based solutions. In addition to supporting product traceability, ICTs may also support data capture, recording, storage, and sharing of traceability attributes on processing, genetics, inputs, disease/pest tracking and measurement of environmental variables. A key success factor for a traceability system is the capability to integrate and share information along the supply chain. ICT represents a tool to overcome integration problems, data fusion and information dissemination. In this paper we illustrate the application of ontology as a tool to model business processes and rules within an agri-food chain. The business case is represented by the Bovlac project: a scientific and technologic platform to trace fresh cheese production.

Keywords: Information Integration; Business Process; Ontology; Agri-food Supply Chain; Dairy Chain, Value Chain

1. INTRODUCTION

Food safety is a global concern. Food recalls frighten consumers throughout the world, leading to a widespread awareness about the need to adopt mandatory food traceability systems.

However, mandatory provisions on traceability require the food-processing industry to record only partial details of the full process, usually limited to adjacent suppliers clients. This is also named the one-step-up, one-step-down approach.

On the other hand, sophisticated consumers start demanding more information about the actual quality standards of the food they eat. Transparency about the ingredients being used as well as proven genuineness of origin for distinctive or traditional food and general nutrition information for functional food are becoming increasingly relevant.

The aim of this paper is to introduce the ICT system for the traceability in the dairy and discuss the benefits of tracing data pertaining to the quality of the food process throughout the entire supply chain. Along with data about product movements, this helps optimize traceability and provides a measure of the overall performance of the value chain.

2. TRACEABILITY IN FOOD CHAINS

2.1. Food Safety and Traceability

Food safety is a top priority for consumers and the food industry. The attention paid by the media to food safety and possible food quality problems, the globalization of the international marketplaces, the ever increasing risks associated with liability, the growing complexity of the supply chains all represent strong drivers of traceability. Eventually, safety and security represent the two most important drivers in the food industry as dramatic recalls have frequently been reported around the world.

According to EU law, food and feed businesses - whether they are producers, processors or importers - must make sure that all foodstuffs, animal feed and feed ingredients can be traced right through the food chain, from "farm-to-fork". Each business must be able to identify its suppliers and which businesses it supplied in a one-step-up, one-step-down approach.

In the meantime, some visionary businesses have favoured the development of voluntary traceability, which consists of recording what-goes-where, during the transformation process and along the supply chain.

Even though voluntary traceability involves more tracking activity than in the mandatory framework, the captured data is limited to each single move of the product (what-goes-where). Indeed, the final purpose of both mandatory and voluntary traceability approaches is to allow retrieval of data in a fast and accurate manner all along the supply chain in order to identify the desired items.

The more complex a traceability system is, the more data it will has to handle. Consequently, input data is limited to that of critical events, i.e. the tracing of movements that significantly affect the food product. In this context data pertaining to quality is not perceived as critical and therefore remains excluded from the traceability systems.

Nevertheless, consumers today ask for more information about the quality, origin and handling of the food they purchase and eat. News of recalls and exposure to unsafe practices have made consumers wary.

All the above withstanding, the availability of a traceability system capable of capturing valuable data during the food processing phases and designed to carry this information all along the supply chain, may well represent a remarkable opportunity for a business to differentiate itself in the market.

2.2. ICT and Traceability

As argued by Hall [1], traceability systems are introduced for three main reasons. First, traceability makes it easier, faster, and cheaper to do crisis management. Second, traceability can provide information to consumers and other participants in the distribution chain, and can increase trust in that information ("credence" qualities). Third, companies use traceability in search of efficiency gains, reasoning that better information about how their food moves will help them streamline supply chains.

Systems for tracking products through supply chains range from paper-based records maintained by producers, processors, and suppliers to sophisticated ICT-based solutions. In addition to supporting product traceability, ICTs may also support data capture, recording, storage, and sharing of traceability attributes on processing, genetics, inputs, disease/pest tracking, and measurement of environmental variables.

A key success factor for a traceability system is the capability to integrate and share information along the supply chain. ICT represents a tool to overcome integration problems, data fusion and information dissemination.

The agri-food enterprises operate in a complex and dynamic environment, so, to meet increasing demands of consumers, government and business partners, they have to work on innovations of products, processes and ways of cooperation in the supply chain [2]. ICT provides several technologies, integrated in frameworks, to solve issues related to cooperation along the supply chain [3].

In [4], authors make a survey on the application of ICT technologies to the agri-food supply chain. Several technologies are analyzed and proposed in three different use cases within the application domain of the food sector.

In this paper we propose the use of ontology as a tool to model business processes and rules within an agri-food chain. The business case is applied in the dairy industry.

2.3. The Bovlac Platform

The broader vision of extending traceability to quality data has been taken in the Bovlac project. A project designed by a consortium composed of a dairy industry (ICCA Spa), research teams in veterinary medicine and biotechnologies at the University of Naples "Federico II" and an ICT company (Penelope spa), and funded by Regione Campania – Italy.

The initial idea was to make each process step transparent, from the stable to the consumer, and provide specific information on each single food product as a means of promoting the functional food principle that quality food "is good and does "good".

Within Project Bovlac, the principles described above are fulfilled through the implementation of a computer system capable of tracing not just the production and packaging of the specific product "Fior di latte Napoli"(a traditional Pasta Filata cheese of Naples), but also make all data pertaining to the origin (stable, cow, milk, temperature, etc.) accessible to consumers.

Once traced, the "identity card" of the "Fior di Latte di Napoli" will display information on the breeding of cows, date of milking, milk quality, cow diet, milk production date, milk transfer date and "Fior di Latte Napoli" production date and packaging.

The ValueGo® ICT platform has been developed for the traceability. The system allows consumers – simply scanning the Qr-Code on the package with their smartphones –full reading of the "Fior di Latte di Napoli" history data while purchasing.

ValueGo® is basically a system that uses a web-centric communication infrastructure between active tags and over a wi-fi network for the acquisition and dispatching of data and information. Developed in an open source environment, ValueGo® technology features two distinctive elements: domain ontologies and active and passive tags, *i.e*. RFID and NFC.

A semantic database implements the application domain ontology. Through the use of ontologies, the concepts related to any business or product domain can be shared in multiple application environments, and domain-specific knowledge can be further enriched.

The resulting software architecture builds on standard components and a specific ValueGo® Java Framework, a set of java classes implementing specific services; it includes classes to manage an EPCIS Repository.

Furthermore, ValueGo® operates on standard hardware products, configured in a three-tier architectural model. The system architecture provides three levels of interactions, catering to all active stakeholders in the manufacturer's ecosystem.

ValueGo® employs identification technologies based on radio frequency (RFID or NFC) and bar code (1D and 2D), suitable for professional use and to facilitate interaction with consumers.

Data acquired during the various production phases is transmitted in real-time to a portal that can be consulted by anyone interested. The consumer, by using a smartphone equipped with an NFC reader or with an application capable of reading a 2D-barcode, is addressed to a web page describing the product being considered for purchase. The system is also accessible via internet.

2.4. Ontology in Information Management

A key technology in ValueGo is the domain ontologies.

Ontologies play an important role in information modelling and management. In [5], Gruber defines an ontology as a set of representational primitives with which to model a domain of knowledge. The representational primitives are typically classes (or sets), attributes (or properties), and relationships (or relations among class members). Ontologies are typically specified in languages that allow abstraction away from data structures and implementation strategies. Due to their independence from lower level data models, ontologies are used for integrating heterogeneous databases, enabling interoperability among disparate systems, and specifying interfaces to independent, knowledge-based services.

Several researches argue about the application of ontology in enterprise and business process modeling. In [6] a Business Process Modelling Ontology is proposed as a part of an approach to modeling business processes at the semantic level, integrating knowledge about the organisational context, workflow activities and Semantic Web Services.

2.5. Ontology Application in Dairy Chains

Within ValueGo ontologies have been used to define the operational and business models of a specific production, the fresh cheese Pasta Filata.

Specifications have been analyzed w.r.t. the definition of product characteristics (like geographical area of milk origin and characteristics of the cheese) and processing chain of the milk-cheese.

In particular, the concept of "Pasta Filata" can be defined as a function of a series of fundamental properties, such as the aging time, the temperature of the curd, the consistency of the dough, the fat content and the place of origin. In addition, the concept of "Pasta Filata" can certainly be defined as a specialization of the concept of "Cheese" and the concept of "FiordiLatte-di-Napoli" as a specialization of the concept of "Italian-Cheese". The taxonomy of the previous concepts is reported here: (**Figure 1**)

The general concept of "Cheese" is related to the other concepts of the taxonomy through the following properties:

- has-vesting-time
- has-temperature-curd
- has-pasta-consistency
- has-fat-content
- has-origin-area

The first four properties are of type "ObjectProperty" and they are given the sets of permissible values, the remaining ones are of type "DatatypeProperty" and they are the types of values that can take.

The concept "Fiordilatte-of-Naples" can be defined through the following properties:

- Fiordilatte-of-Naples

has-aging-time	Aging Fast
has-temperature-curd	Pasta-Spun
has-pasta-consistency	Spring-Pasta
has-fat-content	Fat Cheese
has-origin-area	Naples

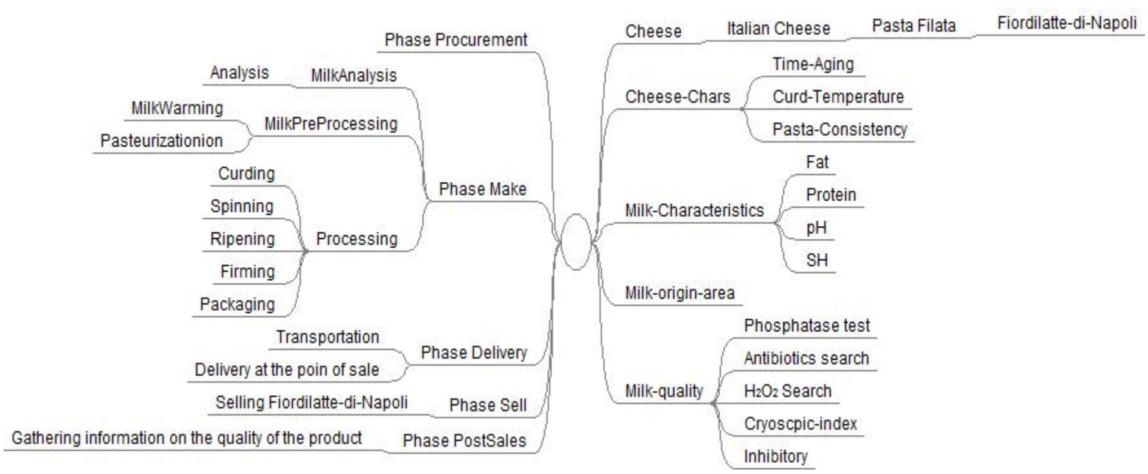


Figure 1. Taxonomy of pasta filata fresh cheese.

Business processed have been modelled w.r.t. the entire dairy chain in terms of specific business use cases. These use cases describe the people involved in all stages of the process, their roles and activities of each of them. The use cases can be traced to the macro-phases of the supply chain, as follows: (**Figure 2**)

The knowledge of the domain of interest, formalized in business use cases of business, allows to identify, in addition to significant figures involved, also all concepts and properties required to model, the activities of each stage. In particular, this modeling was performed by representing the events related to the transitions between activities of each stage of the production process.

2.6. Tracing the Product

Concepts modeled with ontologies have been used to trace information made available to consumer via smartphone or computer. Organization of traceability information reflect the structure of the model. As example information about quality of milk are associated to concepts Milk-Characteristic and Milk-Quality in the ontology. (**Figure 3**)

3. CONCLUSIONS

Making the quality of products transparent for the consumer means being able to monitor the work procedures of each individual company (internal traceability), all along the supply chain. This view is consistent with the principle stating that: "The creation of systems of internal traceability is a prerequisite without which there can be no traceability". This implies the ability to certify the quality of production with tools capable of automatically recording information about each transformation process and the subsequent distribution.

What makes ValueGo® a suitable instrument is its ability to adapt to different product processes and various supply chain models. Adaptation of ValueGo® to a specific production model takes place at the value chain

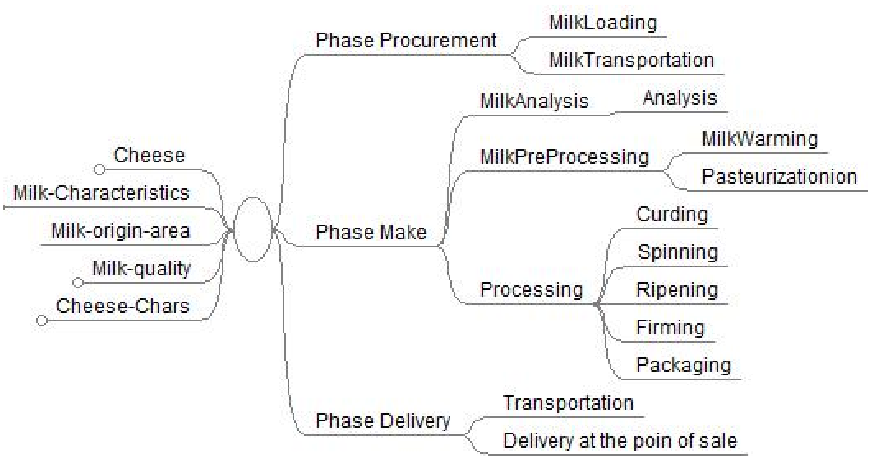
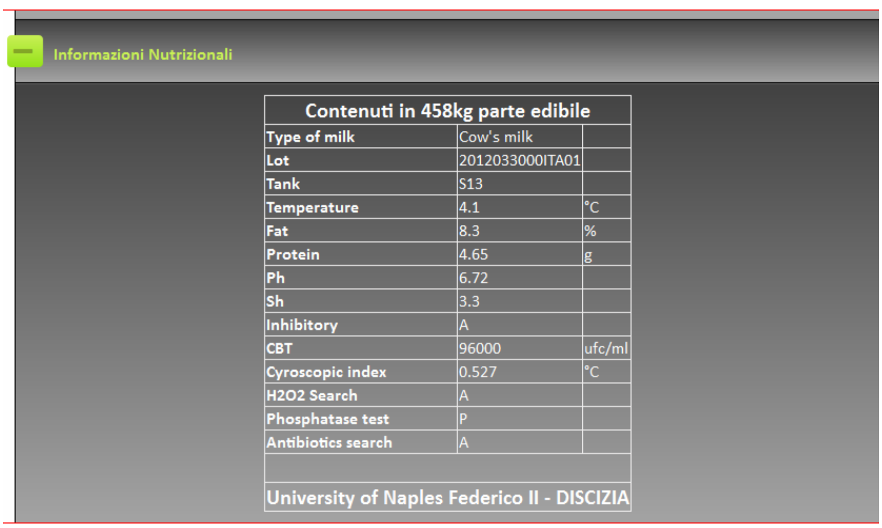


Figure 2. Taxonomy of processes.



Contenuti in 458kg parte edibile		
Type of milk	Cow's milk	
Lot	2012033000ITA01	
Tank	S13	
Temperature	4.1	°C
Fat	8.3	%
Protein	4.65	g
Ph	6.72	
Sh	3.3	
Inhibitory	A	
CBT	96000	ufc/ml
Cyroscopic index	0.527	°C
H2O2 Search	A	
Phosphatase test	P	
Antibiotics search	A	
University of Naples Federico II - DISCIZIA		

Figure 3. Traceability of milk quality.

level. Firstly, by tuning the software rules, which may be standardized for most businesses but still need some degree of customisation, Secondly, working on characteristics of product and processes that are more company-specific.

Through the adaptation of the specific business processes, ValueGo® is able then to detect and record in a database all quality-related events throughout the lifecycle of each product, thus enabling the consumer to easily trace all available product information at purchase time.

4. ACKNOWLEDGEMENTS

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