TraceMEAT, RFID technology in the service of meat traceability

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Abstract
The aim of this work is to evaluate the feasibility of a reliable system for the traceability of carcass and beef, based on RFID technologies. As computer technology is increasingly employed in agricultural business, RFID (Radio Frequency Identification) will offer an efficient method of herd and individual animal management. Nevertheless such traceability isn't currently achievable during slaughtering, where products are identified by lots. RFID is a well-rounded technology if it is right conceived. To achieve this result, we base the research on the know-how of slaughtering process in Italy: we found out that there are different level of industrialization and productivity in slaughterhouse, having reference to two principal situations:A) high industrialized and high productivity abattoir; B) small abattoir. We had simulated a slaughter chain and compiled an animal database recalling the official National Cattle Database. We created and tested different RFID systems, from hardware and software point of view, which can be integrated in current processes, combining Low Frequency and High Frequency device and barcode. RFID technologies are suitable to be implemented in the slaughterhouse. The implementation of an RFID system in the abattoir slashes human errors, favours automation of the process and enables traceability of single carcasses. It's important to customize the system according to the specific process of any single slaughterhouse. Although High Frequency is suitable to be integrated in labels at the end of the process, Low Frequency assures best performances along the slaughter chain, cause it is less disturbed by electromagnetic interferences.

Keywords: Electronic identification, food safety, slaughterhouse, beef.

Introduction

With an increasing demand for security and safety, complete documentations for food products, from field to customer, have become increasingly demanding (Thysen, 2000).

Following the instability in the market in beef and beef products caused by the bovine spongiform encephalopathy crisis, the improvement in the transparency of the conditions for the production and marketing of the products concerned, particularly as regards traceability, has exerted a positive influence on consumption of beef.

In order to maintain and strengthen the confidence of consumers in beef and to avoid misleading them, it is necessary to develop the framework in which the information is made available to consumers by sufficient and clear labelling of the product (Reg. EC n. 1760/2000).

In order to ensure the safety of food, it is necessary to consider all aspects of the food production chain as a continuum because each element may have a potential impact on food safety.

RFID has been accepted as a new technology for a well-structured traceability system on data collecting, and human, animal and product tracking (Sahin et al., 2002).

Many wide national and international projects for livestock EID (Electronic IDentification), particularly about ruminants have been successfully completed. RFID is beginning to be used in a number of countries for tracing individual animals (mainly cattle) from birth to the processing plant. The key to individual animal traceability lies in the ability to transfer animal information sequentially and accurately to sub-parts of the animal during production. RFID-based tracking systems provide an automated method of contributing significantly to that information exchange (Mennecke & Townsend, 2005).

RFID is one of the many automatic identification technologies (a group which includes also barcodes) and offers a number of potential benefits to the meat production, distribution and retail chain too. These include traceability, inventory management, labour saving costs, security and promotion of quality and safety (Mousavi, Sarhavi, Lenk, & Fawcett, 2002). Prevention of product recalls is also considered an important role of RFID technology (Kumar & Budin, 2006). RFID technology has been available for approximately 40 years although it's broad application to packaging is a relatively recent development.

Common RFID frequencies range from low (125 kHz) to UHF (850–900 MHz) and microwave frequencies (2.45 GHz). Lower frequency tags (also named "transponders") use less power and are better able to penetrate objects. These tags are most appropriate for use with meat products, particularly where the tags might be obscured by the meat itself and are ideal for close-range scanning of objects with high water content (Kerry, O'Grady & Hogan, 2006).

Materials and methods

RFID is a well-rounded technology if it is rightly conceived. To achieve this result, we have considered transponder features, slaughering process and the needs of final users.

RFID transponder can be passive or active. In this study we only use passive one. Passive transponders have no battery of their own but contain a capacitor which is charged inductively or radiatively by transmissions from the scanner, and they use the stored energy to transmit their unique alphanumeric code on an appropriate frequency. Having no battery, these tags have unlimited endurance, but the range at which they can be detected is extremely limited (centimetres to a few metres at most) (Reynolds & Riley, 2002)

We checked on the know-how of slaughtering process in Italy: we found out that there are different level of industrialization and productivity in slaughterhouse, referencing to two main situations:

A) High industrialized and high productivity abattoir, with more than 30 employees, with first and second cut laboratory outbuilding; they process about 300 bovines/h.

B) Small abattoir, with less than 10 employees; they process less than 80 bovines/d, 3 days for week. They directly send out half-carcass directly, without cutting.

We had simulated a slaughter chain and compiled an animal database recalling the official National Cattle Database. We created and tested different RFID systems, from hardware and software point of view, which can be integrated in current processes, combining Low Frequency and High Frequency device and barcode.

We created two different user interfaces, one for each case (A and B). We checked on the usability of these interfaces, particularly for case B, testing the system with 10 users scarcely skilled in technology.

Although this tracking scheme is for quality control purpose, employee accountability and precision cutting, and does not extend beyond the cutting room floor or provide

information about the individual animal with the final product, it does exemplify the developing use of RFID technology within the meat industry (Kerry, O'Grady & Hogan, 2006).

We finally investigated on what is provided for beef labelling by the European Union. The label shall contain the following indications:

(a) a reference number or reference code ensuring the link between the meat and the animal or animals;

(b) the approval number of the slaughterhouse at which the animal or group of animals was slaughtered and the Member State or third country in which the slaughterhouse

is established;

(c) the approval number of the cutting hall which performed the cutting operation on the carcass or group of carcases and the Member State or third country in which the hall is established (Reg. EC n. 1760/2000).

CASE A (fig 1)

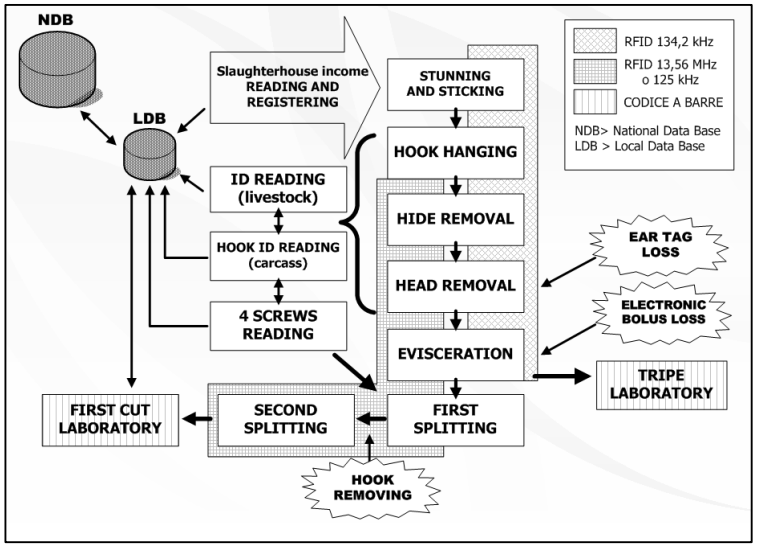

Figure 1. The scheme represent an RFID system in all steps of the slaughter process. Critical points where the identity can be lost are underlined in the figure

The animal (X), electronically identified by a bolus (fig 2) or an ear-tag (fig 2), enters in the abattoir and it is read by an ISO 11785/11785 controller and antenna. This code is compared with that one recorded on the National Data Base, and so it is possible to ensure if every information is correctly stored in each field of this DB.

Before this ID is removed from the carcass, its code is matched with the one of the hook on which the carcass hangs H(X). To do that hooks are pre-emptively identified with an HF (High Frequency) ISO 15693 tags.

Along the slaughtering, before the carcass is removed from H(X), its ID is matched with the ID code of four electronic screws, each one of them put on a quarter of beef. Each quarter gets to the first cut laboratory where, thanks to the reading of the screw, some conventional paper labels are printed; each printed label contains all the informations about the animal origin, obtained from the local database, combined with those required by EU legislation, related to the slaughterhouse and first cut plant. The quantity of labels printed depends on the number of cuts related to the single carcass. The whole process is managed by a single controller and each step is visible and verifiable through a web interface (Fig 4).

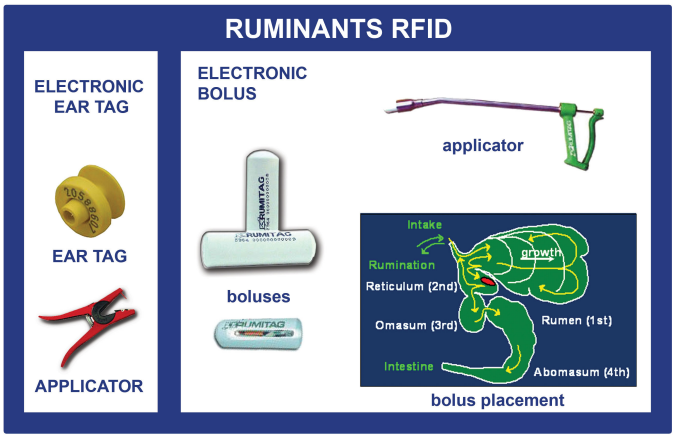

Figure 2. Transponders for electronica animal identification and their applicators

Figure 3. Esempio di etichetta stampata nel caso A

GATE INGRESSO

	Codice Anagrafe	Bolo	Razza	Origine allevamento	Ora ingresso in macello
	FR034000652342	983040000019221	BLONDE D'AQUITAINE/GARONNESE	AZ. LILLE	27/07/2006 17:46:15

GATE 2

	Codice Anagrafe	Bolo	Razza	Origine allevamento	Tag Gancio	Ora Abbinamento con Gancio
	FR034000652342	983040000019221	BLONDE D'AQUITAINE/GARONNESE	AZ. LILLE	3873AC00000104E0	27/07/2006 17:49:15

GATE 3

	Codice Anagrafe	Bolo	Razza	Origine allevamento	Id Pin	Ora Abbinamento con Pin
	FR034000652342	983040000019221	BLONDE D'AQUITAINE/GARONNESE	AZ. LILLE	D0F59D07000104E0	27/07/2006 17:56:15
	FR034000652342	983040000019221	BLONDE D'AQUITAINE/GARONNESE	AZ. LILLE	59F59D07000104E0	27/07/2006 17:56:15
	FR034000652342	983040000019221	BLONDE D'AQUITAINE/GARONNESE	AZ. LILLE	8EFF9D07000104E0	27/07/2006 17:56:15
	FR034000652342	983040000019221	BLONDE D'AQUITAINE/GARONNESE	AZ. LILLE	3FF79D07000104E0	27/07/2006 17:56:15

Figure 4. Interface of the application in case A

CASE B

The animal (X), electronically identified by a bolus (fig 2) or an ear-tag (fig 2), enters in the abattoir and its identity (ID) is read. If the bovine is not identified with an electronic device, operators can manually enter the conventional code of the animal, taking from animal passport or conventional ear-tag. The system automatically verifies if the animal is correctly registered in the National Data Base, and in this case the operator can insert the number of label to print. In this system we use RFID labels, made by a special food paper and cointain an HF (High Frequency) ISO 15693 Tag. RFID labels do not influence meat colour more than traditional labelling system (Vorst, Clarke, Allison & Booren, 2004).

Figure 5. Esempio di etichetta stampata nel caso

Information about the animal origin, obtained from the local database, combined with those required by EU legislation, related to the slaughterhouse are written in three ways: visual, on a bi-dimensional barcode (standard PDF 417) and on the chip of the tag.

Printed labels are thrust upon the carcass, one for each quarter. For a correct stick of the label, it is important that the carcass is already hot.

We have tested the system (case B), in order to evaluate the "effectiveness, efficiency and work satisfaction of users to reach aims at concrete task and environment" id est to evaluate the "usability" of the system. (Ref. ISO 9241 'Ergonomic requirements for office work with visual display terminals (VDTs)', part 11). More in detail, the effectiveness of a system is the ability of the system itself to produce a desired amount of an effect, while its efficiency is the rate between the achieved results and the effort spent to reach them. We performed the usability study in the Usability and Accessibility Lab (Laboratorio di Usabilità ed Accessibilità – LUA) of CATTID and we've chosen 10 users scarcely skilled in technology, with any previous knowledge about RFID systems, in order to simulate the final target of the application (slaughterhouse operator). We provided them with a summary description of the RFID technology before starting the tests.

Figure 6. Example of one of the interface of the application in case B

Results

Both systems result efficient and reliable to guarantee traceability during slaughtering. Implementation in case A is more expensive but assures the traceback to the origin of the carcass in any point of the slaughter chain, also when more carcasses are contemporaneously cutted (sicura? che vuole dire?). The system in case B results suitable for small abattoir where operators work on one carcass at a time.

Although High Frequency is suitable to be integrated in labels at the end of the process, Low Frequency assures best performances along the slaughter chain, because it is less disturbed by electromagnetic interferences.

Usability studies conducted on the application revealed an high degree of effectiveness (all the users success to perform the assigned tasks) and of efficiency (the effort spent to reach the desired task was quite low). The users highlighted a good level of satisfaction, too. These parameters were estimated through the observation of the users while interacting with the prototype and through the analysis of the survey carried out to them.

Conclusions

RFID technologies are suitable to be implemented in the slaughterhouse. The implementation of an RFID system in the abattoir slashes human errors, favours automation of the process and enables traceability of single carcasses. It is important to customize the system according to the specific process of any single slaughterhouse. Although the implementation of intelligent packaging of meat products using RFID technology is still largely hypothetical, indications suggest it is unlikely to remain so for very much longer (Kerry, O'Grady & Hogan, 2006).

Growth of the RFID industry worldwide, driven by the development of technologies combining electronic article surveillance and bar code replacement systems, as well as by an increasing number of other applications is leading to smaller, 'smarter', but still inexpensive, passive transponders.

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