RABBIT MEAT PROCESSING AND TRACEABILITY

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ABSTRACT

Rabbit meat is a highly digestible, tasty, low-calorie food, often recommended by nutritionists over other meats, yet it is still considered a niche product, especially because of its time consuming preparation which requires culinary skills and because of cultural differences among European consumers. For this reason, the processing industry in Europe is gradually improving the availability of rabbit meat in a large variety of processed ready-meals which make it easier to prepare thus meeting the demands of modern consumers. This shift towards further processed products in Europe will soon underscore the necessity for higher standards in rabbit meat in order to improve sensory characteristics and functional properties. Rabbit production and processing involve a series of interrelated steps and the quality of rabbit muscle as food depends upon chemical, physical, and structural changes that occur in the conversion of muscle to meat. During the production and management of rabbits, (preslaughter) factors not only exert important effects on muscle growth, composition, and development, but also determine the state of the animal at slaughter. Moreover, large rabbit industry integration is becoming more important and the development of rabbit meat production is forcing processing plants to improve slaughter capacities by using high-speed and more automated slaughter lines. From the point of view of food safety, these changes can lead to higher microbial risks due to the possible cross-contamination during preslaughter (crating, transportation, and holding conditions) and processing (skinning and evisceration) operations. Furthermore, European rabbit production has been influenced by the introduction of more restrictive regulations and higher consumer attention to food safety aspects. All this has come about as a consequence of the many meat safety crises of previous years which have convinced the European Union to enact several regulations aimed at guaranteeing meat safety and systems to prevent or at least manage similar future crises. From January 1st 2005 (Regulation 178/2002/EC), it will be compulsory for all feed and food operators to adopt a traceability system. The major objective is to enforce the provision of clear and reliable information to consumers at sales points, based on a system of being able to track meat back to the source animal, the slaughterhouse and the cutting unit of origin.

This paper is divided in two sections, the first provides an overview of the steps of rabbit processing and its influence on product quality, while the second focuses on the application of traceability to rabbit production.

Key words: rabbit, slaughtering, processing, product quality, traceability.

INTRODUCTION

Rabbit meat is a highly digestible, tasty, low-calorie food, often recommended by nutritionists over other meats, yet it is still considered a niche product, especially because of its time consuming preparation which requires culinary skills and because of cultural differences among European consumers (DALLE ZOTTE, 2002). For this reason, the processing industry in Europe is gradually improving the availability of rabbit meat in a large variety of processed ready-meals which make it easier to prepare thus meeting the demands of consumers (Fig. 1). The proportion of cut-up and further processed products should increase in the next years. As with poultry, this shift towards further processed products in Europe will soon underscore the necessity for higher standards in rabbit meat in order to improve sensory characteristics and functional properties (BARBUT, 2002). Complex products such as sausages, breaded products and fully cooked heat-and-serve items require an understanding of the contribution of rabbit meat to these products as well as their influence on sensory properties of the food.

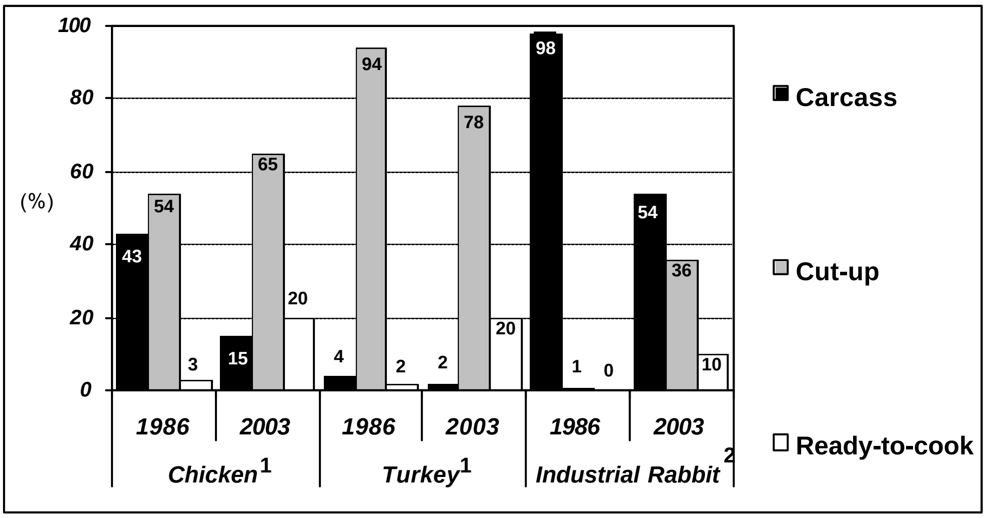

Figure 1. Evolution of meat consumption in Italy ([1]UNA, 2004; [2]Our estimation).

Moreover, large rabbit industry integration is becoming more important and the development of rabbit meat production is forcing processing plants to improve slaughter capacities by using high-speed and more automated slaughter lines. From the point of view of food safety, as observed in poultry, these changes can lead to higher microbial risks due to possible cross-contamination during preslaughter (crating, transportation, and holding conditions) and processing (skinning and evisceration) operations. The microbial risks are also increased by the higher degree of manipulation needed by produce added-value products as for example the use of meat after grinding and the mix with ingredients of different origin (MULDER, 1999). Furthermore, European rabbit production has been influenced by the introduction of more restrictive regulations and higher consumer attention to food safety aspects (VERBECKE, 2001). All this has come about as a consequence of the many meat safety crises of previous years which have convinced the European Union to enact several regulations aimed at guaranteeing meat safety and systems to prevent or at least manage similar future crises. The major objective was to enforce the provision of clear and reliable information to consumers at sale points, based on a system of tracking meat back to animal of origin, the slaughterhouse and the cutting unit. Nowadays, if consumers benefit from EU-wide compulsory beef label system, so far, no compulsory label system is running in rabbit production systems. Moreover major companies have improved voluntary traceability systems and indicators on labels aimed at restoring consumer confidence in meat products (BERNUES *et al*., 2003; GRUNERT *et al*., 2004). However from January 1st 2005 (Regulation 178/2002/EC), it will be compulsory for all feed and food operators to adopt a traceability system. They will be able

> *"to identify any person from whom they have been supplied with a food, a feed, a food-producing animal, or any substance intended to be, or expected to be, incorporated into a food or feed. To this end, such operators shall have in place systems and procedures which allow for this information to be made available to the competent authorities on demand".*

This paper is divided in two sections, the first provides an overview of the steps of rabbit processing and its influence on product quality, while the second focuses on the application of traceability to rabbit production chain.

RABBIT MEAT PROCESSING

Rabbit production and processing involve a series of interrelated steps designed to convert rabbits into ready-to-cook whole carcasses, cut-up carcass parts, or various forms of deboned meat products (Fig. 2).

Fasting
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Crating
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Transportation
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Holding at the processing plant
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Stunning
↓
Hanging
↓
Killing
↓
Bleeding
↓
Skinning
↓
Evisceration
↓
Chilling
↓
Processing
↓
Packaging
↓
Marketing

Figure 2. Preslaughter, slaughter and processing steps of rabbit.

Table 1 summarizes the main operations and issues concerning commercial rabbit processing. The quality of rabbit muscle as food depends upon chemical, physical, and structural changes that occur in the conversion of muscle to meat. During production and management of rabbits, (preslaughter) factors not only exert important effects on muscle growth, composition, and development, but also determine the state of the animal at slaughter. Thus, events which occur both before and after slaughtering of rabbits influence carcass and meat quality (OUHAYOUN, 1992; DALLE ZOTTE, 2002). Short term factors affecting carcass and meat quality are those that occur during the last 24 hours that the animal is alive, such as harvesting (feed and water withdrawal, crating), transportation, plant holding, unloading, hanging, stunning, and killing. It is also likely that the effects that variation in handling during this period and at slaughter can have on quality are greater than those attributable to variation in husbandry practises during rearing.

Table 1. Main operations and issues in commercial rabbit slaughtering and processing.

Harvesting (fasting, crating, transportation and holding at the processing plant) - Feed withdrawal 8-12 h prior to slaughtering - reduce faecal contamination during evisceration - Catching, crating, transport, holding, *ante mortem* inspection - Issues: animal welfare, live shrink, damage, dead-on-arrival
Immobilization (hanging, stunning and killing) - Unloading and hanging on processing line - Stunning, killing and bleeding - Issues: Carcass damage, animal welfare, quality, automation
Skinning and evisceration - Skinning - Removal of forefeet - Opening cut, removal of viscera and uro-genital tract - *Post mortem* inspection by veterinary surveillance - Whole carcass washer - Offal, blood, and skin are collected for disposal - Issues: Carcass damage, sanitation, automation, condemnation
Chilling - Rabbit carcasses must be chilled to reduce microbial growth - Issues: Sanitation, weight loss
Processing, packaging, marketing - Grading - the sorting into lots according to similar quality attributes - Further processing - cut-up parts, deboned meat, formed products, cooking, freezing, etc. - Market distribution - Issues: Market changes, packaging, retail pressure, value added products

Harvesting (fasting, crating, transportation and holding at the processing plant)

Before rabbits are caught, crated, and transported to the processing plant, feed is removed to allow time for the evacuation of intestinal contents. This reduces the incidence of faecal contamination of the carcass which may occur during processing as well as reducing stress during transportation. Fasting refers to the total length of time rabbits are without feed before processing including the time the rabbits are in the farm without feed, as well as the time rabbits are in transport and in the holding area at the processing plant. Thus, attaining optimal feed withdrawal requires cooperation and communication between live production and processing personnel. Length of fasting is important because it affects carcass yield (live weight losses), carcass contamination and product safety (pathogenic and spoilage bacteria) and quality (ultimate muscle pH). Ideally, the length of feed withdrawal before processing should be the shortest amount of time required for the digestive tracts to become empty. Due to caecotrophy, rabbits are usually considered to be very resistant to hunger (LEBAS *et al*., 1986).

Recommended length of time off-feed for rabbits before processing is between 8 to 12 hours because the majority of the rabbits in the flock will have had enough time period to evacuate properly, and effects of the time period without feed weight will be minimal on their carcass. Rabbits lose 3-6% of body weight during the first 12 h of fasting, increasing to about 8-12% at 36-48 h (LEBAS, 1969; ASHBY, 1990; COPPINGS *et al*., 1989; MASOERO *et al*., 1992; SZENDRO and KUSTOS, 1992). Generally, weight loss is slightly lower if fasted rabbits are allowed access to water before crating (JOLLEY, 1990; OUHAYOUN and LEBAS, 1995). In the first 4-6 hours, weight loss in rabbits is mainly due to emptying of the gut, so carcass yield is not negatively influenced (MASOERO *et al*., 1992). After 6 hours, there is also loss in moisture and nutrients from body tissues, which can affect carcass yield as pointed out by SZENDRO and KUSTOS (1992). It is not clear whether transport has any effect on the live weight of rabbits other than through the concomitant fasting. LUZI *et al*. (1992) found that a longer duration of transportation negatively affected weight loss. Furthermore live shrinkage of rabbits was found to be lower if transport is conducted at lower environmental temperatures. Close environmental control in the crates on the vehicle is difficult, mainly because on most vehicles ventilation is passive and is impeded by the close stacking of adjacent crates. Rabbits on the inside of a load may suffer hyperthermia, whereas those on the outside may experience hypothermia. Of course the way in which transport affects the pattern of changes to gut fill depends on whether the rabbits are allowed free access to feed and water before crating. COPPINGS *et al*. (1989) found at least 12 h prior transportation, transport causes no additional weight loss from the gut. If rabbits are allowed free access to feed and water before transportation, loss of gut fill is lower than if rabbits are fasted before transportation. Crating and transportation can also cause a slow rate of transit of feed into the digestive tract and the rupture of caecotrophy practice which leads to higher spillage and rabbit contamination. Solid floors in transport crates are recommended to prevent the transfer of urine and faeces from higher crates in a stack to those below (JOLLEY, 1990).

There is much evidence that harvesting, transport and handling of rabbits are stressful as indicated by physiological and biochemical changes occurring during these phases (JOLLEY, 1990; CANALI *et al*., 2000). This stress causes catecholamine release, muscular contractions and rise in body temperature (HULOT and OUHAYOUN, 1999). Rabbits which are dead-on-arrival (DOA) at the plant represent a complete loss of economic value. There are no experimental data on mortality during transportation, but it is mostly very low as indicated by non-scientific observations of plant personnel. Prior to transport to the slaughter plant, rabbits are removed from the fattening cages and loaded into crates by hand. This method of handling has been associated with animal welfare problems, but also results in injuries which are typically bruises consisting in the rupture of cells and capillaries beneath the skin. The areas of the rabbits most frequently bruised are legs, thoracic muscles and the internal part of the loin region. These bruises are mostly not detectable in the live rabbit and become visible only during slaughter after skin removal.

The influence of feed withdrawal and transportation on rabbit meat quality is poorly understood, however it has been observed that transport increases the depletion of glycogen over fasting irrespective of whether the animals are fed before the journey. Glycogen reserves can be depleted by prolonged feed withdrawal and stress of transport. It has been suggested that glycogen concentration in the liver falls rapidly between 6 and 12 h of fasting (JOLLEY, 1990). The consumption of glycogen reserves determine an increase in muscle ultimate pH leading to a lower degree of protein denaturation with higher water holding capacity and darker colour (OUHAYOUN and LEBAS, 1995; DALLE ZOTTE *et al*., 1995; DAL BOSCO *et al*., 1997). Although these effects are not all detrimental to quality, they could undoubtedly contribute to a variability in quality (JOLLEY, 1990). Moreover, ALLEN *et al*. (1997) reported that darker broiler breast meat with higher pH values has a faster microbiological spoilage than paler breast meat with lower pH. There is no evidence of transport causing pale, soft, exudative (PSE) rabbit meat (JOLLEY, 1990; OUHAYOUN, 1992).

Holding prior to slaughter at the processing plant can contribute to mild the effect of transportation on rabbit meat quality properties. OUHAYOUN and LEBAS (1995) found that holding the rabbits after transportation for 18 hours led to ultimate lower muscle pH values due to the restoration of glycogen stores during holding time (HULOT and OUHAYOUN, 1999). Because processing plant efficiency depends on product uniformity, this effect can contribute to increasing product uniformity among rabbits belonging both to the same flock and to different flocks improving product quality.

Before slaughtering, *ante mortem* inspection of rabbits is required to be conducted based on national legislation to ensure that animals are not affected by diseases as well as animal welfare has been maintained at slaughter.

Immobilization (stunning, hanging and killing)

Rabbit slaughtering starts with the individual unloading of rabbits from transport crates after which they are stunned. The goal of stunning is to render the rabbit unconscious prior to killing for human slaughter issues complying the legislation requirements. In addition, it has been widely reported stunning techniques are critical for processing efficiency and product quality. For many years mechanical stunning was replaced by electrical stunning in rabbit slaughtering. Nowadays the use of gas stunning in rabbit slaughtering is not reasonable for economic impact. Electrical stunning is usually applied using devices which produce anaesthesia by passing an electric current through the brain of the animal. From an animal welfare point of view, ANIL *et al*. (1998; 2000) stated that electrical stunning can be achieved using currents with minimal amperage of 140 mA which can be obtained with the application of 100 V. These conditions could yield an adequate time of unconsciousness for the neck to be cut and sufficient blood to be lost so as to kill the rabbit before it regains consciousness. The stunning of rabbits affects meat quality by influencing *post mortem* muscle acidification. DAL BOSCO *et al*. (1997) evidenced that electrical stunning conducted at low voltage (45 vs. 80 V), independent of amperage applied, slowed the rate of *post mortem* pH fall as compared with stunning by cervical dislocation. On the contrary LAFUENTE and LOPEZ (2000) found that electrical stunning accelerates early muscle acidification when compared with stunning by cervical dislocation. These differences in muscle pH during early rigor development, however, do not affect ultimate muscle pH, tenderness values, or meat quality (DAL BOSCO *et al*., 1997; LAFUENTE and LOPEZ, 2000) confirming results found in poultry (FLETCHER, 2002).

Usually, after stunning, the rabbits are hung by the hind feet at the processing line and killing is conducted by cutting the jugular veins and carotid arteries on one or both sides of the neck. Once the neck has been cut, the rabbits are allowed to bleed for 2-3 minutes. During this period the rabbit loses most of its blood, which eventually causes brain failure and death. Insufficient blood loss due to bad neck cutting can cause residual blood engorging vessels and absence of muscular contraction favouring the emptying of blood vessels. This can produce carcasses with visible engorged veins and dark meat.

Skinning and Evisceration

Although the removal of skin is becoming more automated, it is still largely carried out manually worldwide. This phase is critical for bacterial cross-contamination of carcasses originating from the contact of skin and the tools or the machines used for skinning. After the skin, forefeet are removed and the carcass, while still hanging, is opened to remove the viscera.

As for skin, this operation is mainly conducted by hand even if it is becoming partially automated. Evisceration is the removal of viscera and it has conducted as follows: i) the body cavity is opened via an incision from the lower part of the abdomen near the anus to the mid-point of the lowest rib; ii) the viscera including the gastrointestinal tract and associated organs (stomach, caecum and intestinal contents) and the uro-genital tract with empty urinary bladder are taken out. On the contrary liver, kidneys, and the organs located in the thorax and neck (lungs, oesophagus, trachea, thymus and heart) remain inside the carcass. Reducing faecal material at slaughter is an important practice which reduces contamination during processing which can occur either because of leakage of the contents of the intestinal tract onto the carcass, or through spillage resulting from ruptures of the gastrointestinal tract and viscera during evisceration. Incidence of faecal contamination, assumed to be primary pathway for pathogen contamination of carcasses, can be used as an indicator of process control during slaughter. Prevention and removal of faecal contamination is considered a critical part of the HACCP plan in slaughter plants. At the time of evisceration, veterinary service carried out *post mortem* inspection of the carcass of every rabbit to evaluate if carcass parts or organs fit for human consumption or have to be condemned.

Chilling

After evisceration rabbit carcasses are submitted to chilling. The primary objective of chilling rabbit carcasses is the reduction of microbial growth to a level that maximizes both food safety and time available for marketing (shelf-life). The most common method of chilling is by air.

Air chilling involves passing the carcasses hung on the processing line through large rooms of circulating cold air. To enhance cooling, the product can be sprayed with water, which absorbs heat as it evaporates. Humidity can also be controlled to maximize the air ability to absorb heat from the carcasses and also the air ability to evaporate the surface water for evaporative cooling. Air-chilled rabbit carcasses usually exhibit slight weight loss during chilling. Rapid chilling of rabbit carcasses mainly serves to reduce microbial growth, but also serves to increase the firmness of the muscle and stiffness of the skeleton to facilitate portioning and deboning. However exposure to low temperatures when ATP is still present in the muscle cell, such as prior to the development of *rigor mortis*, has been demonstrated to toughen the meat thorough a process termed "cold shortening" (OUHAYOUN, 1992; HULOT and OUHAYOUN, 1999). Electrical stimulation pulses electricity through a carcass immediately after death has been proposed as a method of preventing cold shortening. Firstly electrical stimulation accelerates ATP depletion and secondly it hastens the decline of *post mortem* pH while muscle temperatures are still high, possibly enhancing the action of endogenous proteases and finally it induces physical disruption of muscle fibres (HULOT and OUHAYOUN, 1999). However, as stated in poultry by FLETCHER (2002), although most researchers agree that electrical stimulation accelerates early rigor development, the magnitude of such effects and its subsequent applicability for commercial utilisation is still in question.

Processing, packaging, marketing

Once the rabbits have been converted into carcasses and chilled to the required temperature, they can be packaged and marketed whole or be converted into some other forms as portioned or boneless meat. Usually the rabbit industry develops voluntary grading systems for classifying and sorting carcasses into lots according to similar quality attributes (i.e. weight, carcass conformation, fleshing, etc.). With the evolution of modern lifestyles and the industrialisation of rabbit production and slaughtering, a shift towards convenience rabbit products such as carcass parts or restructured and further processed products has come about. Many different portions can be obtained from a carcass. It can be simply cut in two halves for grilling, or it can be cut into many portions. The main commercial cuts are loin cut, the hind part, the loin (the *L. lumborum* muscles with or without ribs and bones), fore legs and hind legs. Some further processed meat products are starting to gain attention in the market. Deboned rabbit meat can be included in roll products or grounded and used for prepare hamburger-type products or sausages. Some major processing plants are trying to develop further processed ready-to-cook and ready-to-eat products. The residual meat remaining attached to bones can be harvested by mechanical deboning equipment, and the meat obtained is called mechanically-deboned-meat (MDM) which can be used for frankfurter-type products. Until now the development of further processing in rabbit has already been accompanied by few investigations on the property of this meat during processing and storage. The amount of free fatty acids sharply increases during the refrigerated storage especially that of long chain polyunsaturated fatty acids (ALASNIER *et al*., 2000). Because rabbit meat is naturally rich in unsaturated fatty acids (DALLE ZOTTE, 2002), it is likely that it can undergo lipid oxidation in processed (grinding, mixing, tumbling, etc.) and cooked products (JENSEN *et al*., 1998; CASTELLINI *et al*., 1998; DALLE ZOTTE, 2002; CAVANI *et al*., 2003). Its innate instability can be counteracted in part by feeding increased amounts of tocopherols, particularly α-tocopherols (vitamin E) (CORINO *et al*., 1999; DAL BOSCO *et al*., 2004) and using appropriate modified atmosphere packaging. Further investigations are needed to examine this topic under commercial conditions and evaluate the effects of the atmosphere on microbial population evolution and lipolysis specificity. In fact the spoilage pattern of rabbit meat and the growth dynamics of the various microbial groups, also in relation to the package atmosphere, remains little known (GUERZONI *et al*., 2004 in preparation).

RABBIT MEAT TRACEABILITY

Numerous meat safety crises including Bovine Spongiform Encephalitis (BSE), dioxins, Foot and Mouth disease (FMD) and pathogens have recently hit the European livestock and meat chains (VERBECKE, 2001). These crises attracted massive media attention and led to a decline in consumer confidence and subsequent economic losses for the meat industry. Since the emergence of these crises, consumers are demanding traceability at retail and catering levels for all animal products (ZANDERNOWSKI *et al*., 2002). This demand extends to the farm of origin and includes the feedstuffs, feed ingredients, and the chemicals administered to the animals or to which the animals are exposed. Recent researches have shown that consumers have considerable difficulties in forming meat quality expectations (VERBECKE *et al*., 1999; BERNUES *et al*., 2003; GRUNERT *et al*., 2004). In response to growing concerns about meat safety, the European Union produced the "White Paper on Food Safety" with the aim of improving food safety to defend and promote the health of consumers.

With the introduction of White Paper on Food Safety, EU legislation assumes a horizontal approach which means that regulations are applied on all food chains with the aim to harmonize the legislation of State Members. The two main innovative aspects are the following: i. the establishment of a Food Authority, recently placed in Parma (Italy);ii. the introduction of the concept of traceability which entails the ability to trace products through the production and distribution chains. The introduction of traceability allows the consumers to follow the food product "from farm to table". Several Regulations and Directive have been adopted by the EU to regulate the labelling and the traceability of foods (Table 2).

EC Regulation 178/2002 contains general provisions for traceability (applicable from January 1st 2005) which cover all food and feed, all food and feed business operators, without prejudice to existing legislation on specific sectors such as beef, fish, GMOs, etc. In addition to EU Regulations, several countries have introduced their own regulations on traceability. In Italy, for example, the Italian Standards Institute (UNI) has enacted specific legislative measures as UNI 10939 "Traceability system in agricultural food chain – General principles for design and development" of April 2001, and UNI

11020 “Traceability systems in agro-food industries – Principles and requirements for development” of December 2002.

But what are the market incentives that could push operators in this sector to invest in traceability over and above legal obligations? These incentives could be identified synthetically: i. internal: the possibility of industrial cost reduction, based also on UNI 11020 norms, through more efficient methods of obtaining production factors for producing, stocking and marketing food products (for example through electronic markets); ii. chains: improvement of quality control. The main benefit is represented in the reduction of the risk of a negative impact of a food crisis on the image of the companies involved; iii. value: the possibility of differentiating the product in function of the attributes that might satisfy the needs of a particular group of customers who are willing to pay a premium price for such attributes. In such cases, the traceability of the food product would contribute to giving value to so called "credence" attributes, i.e. the characteristics of the product that consumers are unable to perceive but for which they require a guarantee (LIDDELL and BAILEY, 2001).

Table 2. European Union legislation in force on traceability and food labelling.

Source	Acts or Regulations
European Commission 12 January 2000	**White paper on food safety** Introduction of the concept of traceability and the establishment of a European Food Authority.
European Parliament and Council 17 July 2000	**EC Regulation 1760/2000** Establishing a system for the identification and registration of bovine animals and regarding the labelling of beef and beef products.
European Parliament and Council 12 March 2001	**EC Directive 18/2001** Release of genetically modified organisms was adopted by the European Parliament and the Council of Ministers in February 2001 and entered into force on 17 October 2002.
European Commission 25 July 2001	**Regulation proposal EC of 25/07/2001 2002/C 125/14** Opinion of the Economic and Social Committee on the "Proposal for a Regulation of the European Parliament and of the Council concerning traceability and labelling of genetically modified organisms and traceability of food and feed products produced from genetically modified organisms and amending Directive 2001/18/EC".
European Parliament and Council 28 January 2002	**EC Regulation 178/2002** Definition of traceability as the ability to trace and follow food, feed, and ingredients through all stages of production, processing and distribution.
European Parliament and Council 22 September 2003	**EC Regulation 1830/2003** Concerning the traceability and labelling of genetically modified organisms and the traceability of food and feed products produced from genetically modified organisms.

In the past 10-15 years, computer technology has made traceability of food possible in new and innovative ways (GLEDHILL, 2002). Nowadays there are sophisticated meat traceability software systems that can enable producers to track a meat product all the way from animal birth to the supermarket display case and every step along the way.

Few rabbit production companies are highly integrated in that each company or organisation virtually controls all the aspects of rabbit production chain, i.e. (in reverse order) marketing, processing, feed compounding, commercial rearing and breeder management (Fig. 3). The identity of the rabbit carcasses and meat products from a farm can be maintained by collecting the documentation and labelling. The introduction of traceability procedures results more difficult for company or organisation partially or not vertically integrated because it requires a suitable level of organization within the companies involved in rabbit chain. A single farm, slaughtering plant or cutting unit would, in fact, have great difficulty in adopting traceability system independently, or even simply in participating in a such a system without a technical and organisational support. This paper presents a case of rabbit pathway traceability of a company, or organisation, which is vertically integrated and controls all aspects of rabbit production. However, this approach can be also adopted by each component of rabbit production chain.
Tables 3a,b summarize the procedures and the documents needed in each production step for ensuring traceability of rabbit meat products. It is recommended to serve documentation at least for two years.

Breeding
Nowadays rabbits reared for commercial purpose belong mainly to breeds or hybrids developed by breeding companies. The economics of animal production prevent the possibilities of cross breeding and back-breeding from grand-parents to commercial levels and indirectly serve to protect the integrity of the traceability. Full records are available at each genetic level. While this extraordinary depth of traceability has developed for productivity reasons, it can also be used to provide quality and safety guarantees to the consumers.

From the perspective of traceability, all rabbits born the same day, in the same house from the same genetic group of rabbit breeders can be considered a single production unit. This means that the synchronisation of births is very important in the rearing management of rabbit does. Traceability procedures are different depending on whether breeding and fattening are conducted in the same (closed-cycle) or separate (open-cycle) farms. Weaned rabbits are usually placed in fattening cages in rabbitries that may contain up to a few thousand rabbits. Considering a closed-cycle farm, the weaned rabbits are directly transferred from the breeding to the fattening house. The adoption of "all-in all-out" practise could facilitate traceability procedures. In open-cycle farms, weaned rabbits are usually transported by trucks from the breeding to the fattening farm. It is suggested to send each production unit to one single fattening farm. An accompanying document has to contain the identification of the farm of origin and the map of the disposition in the trucks of the weaned rabbits.

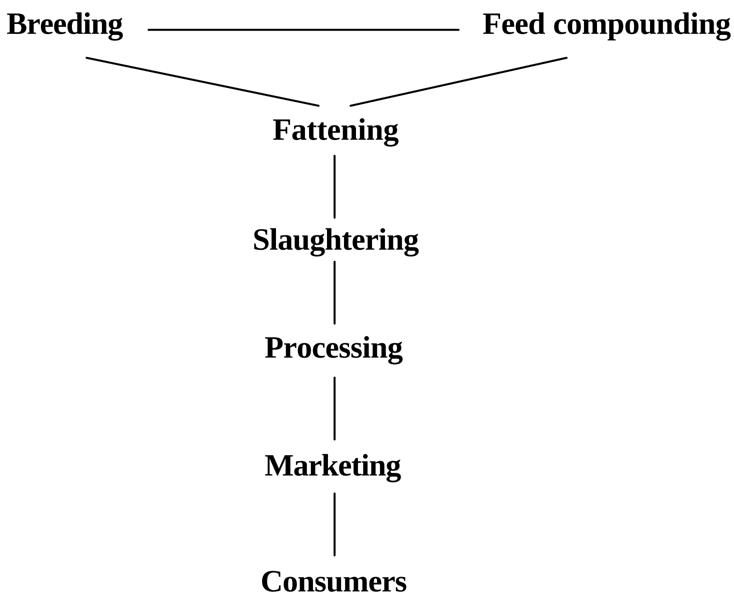

Figure 3. Food chain of rabbit products.

Fattening and Feed compounding
From a traceability point of view, the main points to check during the fattening period feeding, medication and vaccination treatments and the chemicals to which rabbits may have been exposed. The identification of feed is given during manufacturing in the feed mill by registering the type and the source of each raw material. After January 1st 2005, companies must also be able to trace feed and feed materials used in feed compounding. An accompanying document for feed should also contain information concerning the storage silos at the feed mill and at the farm, respectively. Care should be taken to avoid possible cross-contamination between unmedicated and medicated feed during compounding, transportation and storage phases.

All animal tests and medications during the animal lifecycle must be administered under veterinary surveillance and recorded. Concurrent storage of paper and electronic data may be used as an alternative method for the collection and storage of data. Technical personnel should check the compliance of the rules concerning feeding, environment and sanitary treatment at least every 2 weeks as well as the documentation recording.

Slaughtering
For good management of slaughter and traceability procedures, the collection of the production units (rabbit flocks) from the farms should be planned well in advance. At the farm, the fattening rabbits must be crated in order to maintain the identification of the production units. The accompanying document must contain the disposition of crates on the truck if different production units are present. Upon arrival in the holding area of the processing plant, the blocks of crates must be unloaded from the trucks, placed separately and identified by production unit. Each production unit must be separately slaughtered and it is useful to space two consecutive production units by leaving a gap

of some minutes as well as by hanging a mark on the processing line with the traceability code. Critical points for traceability during processing depend on the type of technology and particular attention must be paid when carcasses are temporarily removed from processing line. After chilling each carcass or at least each box in which carcasses are placed must be labelled with the traceability code. Apart from the utilisation of the carcasses (further chilling, refrigeration storage, packaging, portioning or deboning) well-identified blocks containing carcasses belonging to the same production unit should be formed.

Further processing

The blocks of carcasses can be moved inside the same processing plant or transported to an external plant. The latter case requires accompanying documents. The carcasses sold as whole must be packaged and the labelling must contain information variable depending on the different countries, but also the traceability code and some voluntary information concerning farm of origin, place of slaughtering, some characteristics of feeding (no GMO, vegetable diet, etc.). The traceability code may be formed from production line numbers, shift number, time of production, etc., in any combination. This may additionally be encoded within a bar code (PETTITT, 2001).

Major difficulties arise when carcasses are portioned into parts prior to retail packaging. As for processing, the quantities of meat needed for portioning, deboning and further processing should be planned in advance. Any kind of production must be separately conducted for each unit and the products should be packaged in continuum after portioning or deboning. If this is not possible, it has been suggested to maintain group differentiation by physical separation and manual records. The packaging and labelling of cut-up and deboned products must be conducted following the same indications given above for the whole carcasses. Traceability must be guaranteed for ready-to-cook products containing additives and further raw materials such as other kinds of meat or vegetables. In these environments, the implementation of process control practises utilising mechanical separation and written documentation (of type described by the International Organization for Standardization in ISO 9000) offers opportunities to maintain such identify sys tem control (MCKEAN, 2001).

Marketing and measures of recall

In order to comply to legislation, measures of recall of products must be carried out. Notification has to be sent to all members of the network to verify whether the products on the market have reached their market yet so they can take the necessary measures.

Definition of responsibilities

By virtue of their complexity, these integrated business have developed specialised management to oversee elements of the enterprise. It would be desirable for experts in agriculture, nutrition, veterinary medicine and food science to be employed. Each part of the enterprise (e.g. the feed mill, the breeding flocks, the reproduction and the rearing farms and the processing establishment) must have an assigned manager who is responsible for optimising the output of his section.

Future developments

The development of biological identification technologies and DNA testing allows for straightforward traceability of individual animals such as cattle and pork (SANCRISTOBAL-GAUDY *et al*., 2000; PORTETELLE *et al*., 2000; CUNNINGHAM and MEGHEN, 2001; MAUDET *et al*., 2002; EGGEN and HOCQUETTE, 2003). However systems of individual identification are unlikely for commercial rabbits. Ear-bands have traditionally been used to identify individual rabbits at elite breeding level, principally for research purposes. As each flock/production unit of rabbits has similar status and the existing systems are well developed, individual rabbit identification does not appear to offer any advantages. Individual identification would contribute no useful additional information to what already exists. Some trials have been undertaken in poultry on using various automatic methods for identifying individual carcasses by bath code at the grading line (FALLON, 2001). Inkjet and laser systems have been tested. The laser systems appear to be the more successful, but both system suffer from consumer resistance to the appearance of the marked part of the carcass. In either case, this identification is rapidly lost as the carcass is further processed. Computer systems for maintaining traceability of batches of product to the farm of origin are likely to be adopted by the integrations not already doing so. The sophistication and automation of the systems already functioning in some places will no doubt continue to be refined. The limiting factor of these systems is the situation in which the volume of a particular product produced from a batch of meat falls below the minimum required for industrial handling. In the case of certain specialised products, raw materials may be sourced from many different flocks. These products may in themselves from an ingredient, which is added to other batches of product.

CONCLUSIONS

The compulsory introduction of traceability systems in the EU after 2005 for all feed and food operators represents an opportunity for the European rabbit production chain to improve food assurance procedures and restore consumers confidence.

This adoption must definitively guarantee the ability to effectively remove a single production unit from sale and consumption if any doubt arises as to the status of produce. The ability to recall a limited quantity of produce, based on product traceability, can prevent food diseases, but also reduce costs and even limit brand damage. Moreover the adoption of traceability systems is a part of food assurance for the companies which can have an instrument to improve all food quality aspects by finding out exactly where problems originate along the production chain. By the way, it has been underlined that transport and handling before slaughter are of utmost importance for product and meat quality. Good manufacturing practices include benefits that are in the interest of every party involved: the farmer, the slaughterhouse, the consumer and the animal. Rabbit product quality can be considerably improved through respecting a recommended feed withdrawal period and holding time prior to slaughter. Additionally, further studies on slaughter and *post* slaughter handling techniques such as stunning, chilling, electrical stimulation, deboning to examine their influence on rabbit meat quality and stability are needed.

Table 3. Procedures and documents needed in feed compounding, breeding and fattening for ensuring traceability of rabbit meat products.

Rabbit production phase	Procedures	Documents
FEED COMPOUNDING	Traceability of main raw material components	Accompanying document of raw materials Document of receipt and storage of raw materials Feed formula and Report of feed compounding Document of traceability of raw materials
	Traceability of additives	Accompanying document of additives (medicaments, integrators) Document of receipt and storage of additives (medicaments, integrators) Feed formula and Report of feed compounding Document of traceability of additives (medicaments, integrators)
	Identification of feed storage silos	Accompanying document of feed
	Identification of production unit of feed	Chemical composition of feed Accompanying document of feed Feed formula and Report of feed compounding Document of receipt and storage of raw materials and additives
BREEDING	Identification of production unit of weanlings	Accompanying document of weanlings Document for traceability of does Technical document of farm management
	Identification of feed storage silos	Accompanying document of feed
	Identification of weanling exposed to pharmacological treatments	Recording of medications administered Accompanying document of medications, detergent and sanitizing products Technical document of farm management
	Identification of rabbitry	Accompanying document of delivered weanlings
	Identification of detergent and sanitizing products	Accompanying document of medications, detergent and sanitizing products
FATTENING	Identification of production unit of fattening rabbits	Accompanying document of bought weanlings Document for traceability of does Technical document of farm management
	Identification of feed storage silos	Accompanying document of feed
	Identification of rabbits exposed to pharmacological treatments	Recording of medications administered Accompanying document of medications, detergent and sanitizing products Technical document of farm management
	Identification of rabbitry	Accompanying document of delivered fattening rabbits
	Identification of detergent and sanitizing products	Accompanying document of medications, detergent and sanitizing products
	Identification of transport company and vehicle	Accompanying document of bought rabbits with map of disposition

Rabbit production phase	Procedures	Documents
SLAUGHTERING	Identification of cages in holding area	Accompanying document of fattening rabbits, Slaughtering schedule Document for check of production units at arrival Signal and mark for production unit identification
	Identification of production units during slaughtering	Slaughtering schedule Accompanying document of fattening rabbits Slaughtering recording document and Traceability coding
	Identification and labelling of each carcass	Slaughtering schedule, Slaughtering recording document, Traceability coding
	Packaging of production units	Slaughtering schedule, Slaughtering recording document, Traceability coding
	Forming of pallets	Slaughtering schedule, Slaughtering recording document, Traceability coding
	Identification of detergent and sanitizing products	Accompanying document of medications, detergent and sanitizing products
	Identification of clients	Accompanying document of products
CUTTING	Storage and identification of pallets or production unit	Accompanying document of pallets
	Cutting of carcasses for each production unit	Processing schedule Signals and marks for production unit identification Traceability document for portioned and packaged products
	Packaging Identification of box containing packaged products	Processing schedule Traceability document for portioned and packaged products Traceability document for portioned and packaged products Labels for production unit identification
	Identification of box containing raw meat for further product preparation	Traceability document for portioned and packaged products and further processed products Signals and marks for production unit identification Processing schedule
	Weight and labelling of packaged products	Traceability document for portioned and packaged products and further processed products
	Identification of detergent and sanitizing products	Accompanying document of medications, detergent and sanitizing products
	Identification of clients	Accompanying document of products
FURTHER PROCESSING	Identification of box containing raw meat for further product preparation	Traceability document for further processed products Traceability document for raw meat Signals and marks for production unit identification
	Identification of raw materials for further product preparation	Signals and marks for production unit identification
	Preparation and packaging of products	Traceability document for further processed products
	Identification of box containing packaged products	Traceability document for further processed products Labels for production unit identification
	Weight and labelling of packaged products	Traceability document for further processed products
	Identification of detergent and sanitizing products	Accompanying document of medications, detergent and sanitizing products
	Identification of customers and distribution	Accompanying document of products

However the adoption of traceability systems must be possible on a cost basis for both small and big companies. In fact rabbit production chains are sometimes characterised by a high level of fragmentation, low levels of association and lack of structural development in all elements. This could trigger doubts as to the capacity of the rabbit sector to respond to these challenges. So the adoption of a suitable level of organization within the companies involved in the rabbit chain and the development of programmes designed to train and assist small producers with the application of traceability procedures are necessary. Also the Governmental Authorities must organize an efficient system of inspection to control the compliance of traceability systems by the companies and provide sanctions when rules are broken. However the measures to trace rabbits and rabbit products must be based on an assessment of the risks and be scientifically justified, according to the circumstances, and be no more restrictive of trade than required and applied consistently, including between the country imposing the measure and other countries. Measures that are based on international standards are deemed to be necessary. Otherwise traceability can ensure that products can be linked to their sources while protecting products of declared origin (both geographical and production systems).

ACKNOWLEDGEMENTS

The authors would like to thank Valeriano Biguzzi of "Gruppo F.lli Martini & C. S.p.A:" for his precious comments.

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