Int. Jrnl. of Soc. of Agr. & Food, Vol. 19, No. 2, pp. 275–288

Meat Safety: A Brief Review on Concerns Common to Science and Consumers

INÊS VIEGAS, JOSÉ MANUEL LIMA SANTOS, ANTÓNIO BARRETO AND MAGDA AGUIAR FONTES

[Paper first received, 15 September 2011; in final form, 27 February 2012]

Abstract. Meat safety is a multidimensional concept, and there are reasons to believe there is an information asymmetry between consumers, producers and safety authorities along the supply chain. Within this framework, this article puts together consumer concerns about meat safety, the current scientific evidence and the existing legal framework in the EU, trying to unveil possible fields for quality differentiating strategies. As such, this article does not add new data to the food safety or consumer issues fields. Rather, it allows a new perspective by associating two different research areas.

Assessing the reported consumer concerns regarding meat, it is not possible to define one specific worry as more prevalent or frequent. Still, the presence of drug residues in meat is a concern often shared by consumers of several types of meat in many different European countries. Interestingly, it is also an open scientific question. Research on the association between the presence of anti-bacterial residues in meat and microbial resistance is frequent. However, there is still no consensus on this subject. Still, even in the absence of such a consensus, it is a relevant issue for meat production, public health and consumer interest.

Regarding the EU legal framework, the food safety legislation has accompanied scientific development, even acting preventively in questions without scientific consensus, as in the case of the use of anti-bacterials as a feed additive. Nevertheless, even if the use of anti-bacterials in food animals is covered by several legal documents, it is still a concern for consumers. This suggests that some consumers may be interested in meat products that relieve their distrust. Therefore, there may be grounds for the development of a differention strategy, aiming at segments willing to pay premiums for meat with increased guarantee of anti-bacterial residue control.

Introduction

Over the last decades within the European Union (EU) consumer concerns about food have slowly shifted from food security to food safety. As food availability is no

Inês Viegas is a Ph.D. Candidate at the Faculdade de Medicina Veterinária, Technical University of Lisbon, Avenida da Universidade Técnica, 1300-477, Lisboa, Portugal.; email: <ines viegas@gmail.com>. José Manuel Lima Santos is at the Instituto Superior de Agronomia, Technical University of Lisbon, Portugal. António Barreto and Magda Aguiar Fontes are at CIISA, Faculdade de Medicina Veterinária, Technical University of Lisbon, Portugal.

ISSN: 0798-1759 This journal is blind refereed.

longer a concern within European borders, consumers became more interested in and alert to the safety and other characteristics of their food. In this context, the last two decades have witnessed impressive changes in consumers' perceptions of food safety in general and meat safety in particular.

However, meat safety is a complex concept, as there are many hazards and challenges to be considered. Hazards include microbial pathogens, resistance to anti-bacterials,[1] food additives, chemical residue and other possible contaminants, to name a few (Knowles et al., 2007). Meat safety challenges involve traceability issues, pathogen and chemical residue detection problems, regulatory issues, addressing consumer concerns, etc. (Sofos, 2008). Moreover, meat safety must be regarded as an increasingly global matter due to the increase of meat consumption around the world, exposing higher numbers of consumers to potential hazards.

In view of such diversity of hazards and challenges there are reasons to believe there is an information asymmetry between consumers, producers and safety authorities along the supply chain (Loader and Hobbs, 1999). Producers, sellers and safety authorities have more and better information about the potential hazards and the dimension of risk associated with the consumption of a given food product. The asymmetry can be associated with the (intentional or not) unavailability of information for consumers, but also with differences between scientific evidence and consumers' perception (Miles et al., 2004; Yeung and Morris, 2001b). This information asymmetry is even more relevant if meat safety is regarded not only as an individual, private matter (the guarantee that a piece of meat will not result in illness) but also a public health matter, as it is when one considers public health issues as those related with drug residues and resistance to anti-bacterials.

Even so, food poisoning in the sense that some food products will make one ill in an individual and immediate sense is no longer a present concern for most consumers. Most of the time, consumers trust their food will not make them ill, and do not even consider the possibility that food available for purchase can have deleterious effects for their health. Scientific developments in the food safety field, together with the evolution of European food safety laws and enforcement as well as food safety communication, have played a role in consumers' ability to gain and maintain such trust.

Nevertheless, food safety concerns have assumed new proportions since the 1980s, as several food scares in Europe have taken unprecedented dimension, particularly when food products of animal origin are considered. One can remember cases like BSE, dioxin residues, E. coli, etc. (Knowles et al., 2007). This increased impact derives not only from (now global) media coverage, but also from the diffuse (and therefore frightening) hazardous effects associated with these issues. For most consumers the health consequences related with these food scares were most certainly hard to fully comprehend. However, regarding that some of these health conditions may be lethal they were always most likely perceived as very severe.

In such context, whatever the attitudes consumers have towards food safety they might have major influence over their consumption options. If food safety concerns are present at the shopping decision moment, consumers may choose to buy a substitute product, as it occurred during the BSE crisis (for data on the substitution of beef consumption for other meats, see Lloyd et al., 2001). If such behaviour becomes generalized it will have obvious consequences for the replaced product market share.

Moreover, consumers are known to make irrational choices and have irrational concerns and preferences under certain circumstances, namely those related with

their safety, over-estimating some risks that are unlikely to occur and under-estimating others. Even when information and transparency are abundant, often consumers seem not to be able, or interested in, processing that information properly (Verbeke et al., 2007). It is therefore an objective of this article to go through the evolution of consumer concerns and perceptions regarding meat and meat products in recent years, and also whether concerns relating to meat consumption actually meet safety hazards mentioned in the scientific literature, or if they represent problems of information asymmetry between consumers and scientific evidence.

In this perspective, an overview of recent literature about consumer concerns on meat safety enables the shedding of light on the issues that are more frequent and common throughout European consumers. It should be particularly interesting to verify whether there are concerns common to consumers in different countries, with different backgrounds and consumption habits. An exhaustive literature review was not the authors' objective, and there is no intention to entail any sort of meta-analysis of the research published around this issue. The focus is centered rather on trying to understand whether there are expressed consumer concerns on food safety that have links with the food safety issues addressed by the scientific literature and the existing EU legal framework.

Finally, this article also intends to make an association between consumers' perceptions and concerns about meat safety, the scientific evidence surrounding this food product and the existing legal framework, trying to unveil possible fields for quality differentiating strategies. As such, although the article represents no new contribution or new research on either the food safety field or consumer issues, it aims at putting together two research areas usually not combined. Therefore, the unquestionable speculative character assumed here is nevertheless compensated by the unveiling of the not commonly investigated connections between these two fields. In order to analyse such connections, this article is organized as follows: Section 2 includes a review of European consumer meat-safety concerns; Section 3 is dedicated to an analysis of the scientific evidence supporting consumer concerns about anti-bacterial residues in meat; Section 4 will then examine the EU's specific legal framework on anti-bacterial and other residues in meat; Section 5 concludes by getting together consumer concerns, the European legal framework and potential quality differentiating strategies.

European Consumer Concerns about Meat Safety: A Brief Review

Generally within the EU, public policies have been able to act ahead in preventing food safety hazards (embracing the EU's precautionary principle among other aspects) although there are known cases of reactive (as opposed to preventive) legal acts. BSE is probably the most noticeable example, as the establishing of new regulatory institutions and legislation were triggered by this food scare (Knowles et al., 2007).

Still, in spite of the entire legislative body, and all the European institutions associated with its enforcement, meat safety has been described to be a concern to many European consumers. Many examples of such stated concerns can be found across the literature. Glitsch (2000) and Henson and Northen (2000) report concerns related with beef, poultry and pork safety among German, Irish, Italian, Spanish, Swedish and British consumers; McCarthy (2000) found that 55% of the surveyed Irish consumers were concerned about the safety of meat consumption; Yeung and

Morris (2001a) describe concerns about poultry safety in the UK; Cicia and Colantuoni (2010), in a meta-analysis, detected the increasing importance of meat attributes such as safety among European consumers; Angulo and Gil (2007) found loss of confidence in meat products in Spain, and that beef was considered the most risky food product among the surveyed consumers.

These reported concerns may be a problem for food markets in Europe (de Jonge et al., 2004; Angulo and Gil, 2007; Savadori et al., 2007), as purchase likelihood is strongly correlated with risk perception (de Jonge et al., 2004; Yeung and Morris, 2001b). For example, the beef market instability caused by BSE was strong enough to actually be acknowledged by the EU in Regulation 1760/2000 (*OJ*, L 204, 11 Aug. 2000, pp. 1–10).

Yet, food safety is not a permanently present concern for many consumers, either during food purchasing or consumption. On the contrary, it seems that it is mostly taken for granted as an inherent product attribute that most consider non-negotiable (Angulo and Gil, 2007; Verbeke et al., 2007). Regarding the type of research often done in this field, however, consumer concerns usually emerge upon questioning. Therefore, they may not reflect ideas present while shopping, which can generate inconsistencies between research data and market data. The meat sector has faced periods of great pressure, partly as a consequence of several food scares of recent years such as BSE in beef (Gracia and Albisu, 2001; Beaumond et al., 2006), dioxins in poultry and pigs or Salmonella outbreaks in poultry (Knowles et al., 2007). Additionally, foot and mouth disease and avian influenza also had influence on European consumers' buying behaviour, although they pose no threat to human health (Knowles et al., 2007). One could therefore suspect that concerns about such issues would appear at the top of the European consumers' rankings when asked about food safety risks and concerns.

However, more recent data seem somewhat conflicting, at least when BSE is considered. A *Eurobarometer* report (European Commission, 2006) mentions that 50% of consumers still express some concern about this disease. Similar values were obtained by O'Donovan and McCarthy (2002) in Ireland. On the other hand, there are results showing that the level of concern of BSE was no greater than other safety issues (Henson and Northen, 2000; Verbeke et al., 2010). Perhaps as time goes by following a given food scare, more consumers tend to disregard such occurrence, progressively regaining some trust and recovering old consumption patterns (Knowles et al., 2007).

As such, there are numerous other safety issues regarded as a concern by consumers. Whatever specific hazard is mentioned first depends on the meat product considered, on the relevance food safety issues are having in society (and in media in particular) in that given period, and also on demographic factors, previous experience and risk perception, among others (Buzby, 2001; Gracia and Albisu, 2001 Angulo and Gil, 2007; Sofos, 2008). Nevertheless, apart from the already mentioned concerns about food hazards related specifically with recent scares, there are issues more commonly referred to by consumers without specifying a meat product or geographic region.

One such issue is the presence of drug residues in meat. Veterinary drug residues such as antibiotics are frequently stated as central among the concerns about meat safety expressed by some segments of European consumers (Verbeke et al., 2007).[2] Several specific examples can be quoted from the literature. For example, Henson and Northen (2000) report high levels of concern among consumers from six Euro-

pean countries about antibiotic residues. Such concerns were often ranked second in several of these countries, right after concerns about hormone residues. O'Donovan and McCarthy (2002) found antibiotics to be among the top concerns of Irish meat consumers.

Verbeke and Vackier (2004) found several segments of Belgian consumers to be worried about antibiotics in fresh meat, and those concerns were ranked first when compared to other meat safety risks (namely dioxins, BSE and harmful bacteria). Miles et al. (2004) found more than 50% of the surveyed UK consumers to be extremely worried about the use of antibiotics in animal production. Krystallis and Arvanitoyannis (2006) describe a cluster of Greek consumers particularly concerned about meat chemical safety (i.e. its content in antibiotics and hormones).

Concerns about this specific chemical hazard are also mentioned in reports about consumer's perceptions about poultry meat (Glitsch, 2000; Yeung and Morris, 2001) and pork meat (Glitsch, 2000). Mørkbak et al. (2010) estimated a positive willingness to pay among Danish consumers for pork produced under tighter rules regarding the use of antibiotics. Finally, a European survey points out the same conclusion, stating that 68% of European consumers are 'very worried' or 'fairly worried' about 'residues in meat like antibiotics or hormones' (European Commission, 2006).

In Portugal, during focus groups conducted in 2009 aiming at proper scenario design for a stated preference survey (Viegas et al., 2011), antibiotic residues in meat were often spontaneously referred to as a beef safety concern for many participants. The same reactions were also found in a series of focus group meetings in Spain (Carlos et al., 2005) and in research in the UK (Miles and Frewer, 2001).

As mentioned above, hormone residues are also a concern for some segments of European consumers (O'Donovan and McCarthy, 2002; Miles et al., 2004; Tonsor et al., 2005; European Commission, 2006; Knowles et al., 2007), which may seem contradictory considering that the use of substances with hormonal action in farm animals is prohibited within the EU (with legally defined exceptions, see Council Directive 96/22/EC, *OJ*, L 7, 10 Jan. 1996, p. 9) (Reig and Toldrá, 2008). These concerns about chemical hazards such as the presence of antibiotics or hormones in meat may be justified by the 'unknown' factor, i.e. consumers have less knowledge about such hazards and consider them to be more unnatural and unfamiliar to them, thus attributing them a higher risk (Yeung and Morris, 2001; Miles et al., 2004).

Another meat safety issue of concern to consumers is microbiological safety. More specific references are related to the presence of pathogenic micro-organisms like Salmonella or *Escherichia coli* (namely VTEC O157:H7) (Miles and Frewer, 2001; O'Donovan and McCarthy, 2002; Beaumond et al., 2006). These microbiological risks are more commonly associated with poultry meat, where in fact Salmonella and Campylobacter are the commonest food-borne bacteria (Glitsch, 2000; Yeung and Morris, 2001), and with pork meat (Glitsch, 2000).

However, there seems to be a somewhat lower level of concern about microbiological risks, even if these are considered the main food hazards for the public among the scientific community (Miles et al., 2004). Low concern about this issue may have several sources. First, there have been no recent widespread food scares related with microbiological hazards in meat. Furthermore, most meat poisoning situations due to pathogenic micro-organisms that do occur are localized (in the sense that they affect few people in a given location) and somewhat benign, and do not reach the media as a problem for society in general.

Also emerging in the literature about food safety concerns are GMOs. There are several reports of a very strong mistrust from European consumers about food products that include GMOs (Bredahl, 2003; Burton et al., 2001; Costa-Font et al., 2008; for a meta-analysis on this subject, see Dannenberg, 2009). However, this is not an issue arising very often when meat safety is considered. It is possible that feeding cattle with GMOs is something most consumers do not consider or even have much knowledge about.

Going through the reviewed information related to meat consumers' concerns, it is not possible to define one specific concern as absolutely more prevalent or frequent. The main concerns manifested by consumers depend, for example, on the type of meat under survey. Nevertheless, a safety issue that often emerges as one of the top worries for European consumers is the presence of drug residues such as antibiotics in meat. This particular hazard shows up as a concern shared by consumers of several types of meat and in many different European countries. Therefore, the following section analyses some of the scientific literature on why this issue is relevant in terms of meat production, public and animal health.

Are Anti-bacterial Residues in Meat a Concern?

Meat safety faces uncountable challenges in today's globalized markets. Sofos (2008) and Nørrung and Buncic (2008) elect Campylobacter and Salmonella as the most common pathogens affecting meat safety. Besides these and other microbiological hazards, technological hazards (those related with genetic modification) or contaminant-related hazards (pesticides and drugs) (Yeung and Morris, 2001; Knowles et al., 200) are widely described and debated in the literature concerning meat safety. Within this broad spectrum of hazards and challenges, it is only comprehensible that consumers are uncertain and concerned about meat safety.

Nevertheless, the presence of drug residues such as anti-bacterials in meat does emerge as a somewhat consistent and persistent concern in the literature on consumer perceptions, referred across different countries and regarding different types of meat. At the same time, research on anti-bacterial residues in meat and meat products and microbial resistance is frequent when literature on food safety, veterinary medicine, environmental safety or public health is reviewed. Moreover, as it will be seen further ahead, this issue has been subject to extensive legal regulation.

This problem is multi-faceted not only in terms of its origin, but also concerning the consequences, as it has implications for public health, animal health, the environment, biodiversity, and also for global markets, societies and policy-makers. As will be described, the emergence of bacterial resistance to anti-bacterials has great implications for the availability of efficient tools to fight human infections on a global level. Also, the environmental consequences go far beyond the local consequences of pollution due to animal production. Finally, economic and social aspects should be taken into consideration, namely those related to livestock producers, the pharmaceutical industry, international trade, and consumers. This means that whatever regulatory measures are taken (based or not in scientific evidence), there are many (and potentially conflicting) points of view to be considered.

An exhaustive description of the occurrence of anti-bacterial residue, of the mechanisms of microbial resistance or of control measures is beyond the scope of this review. The main focus will be on exposing why this issue is important in terms of meat production, public health and consumer interest.

In livestock production, anti-bacterials can be used for three purposes: therapeutics, prophylaxis and growth promotion (Sarmah et al., 2006; Azevedo et al., 2010). Growth promotion effects are generally obtained through the application of sub-therapeutic doses of anti-bacterials as feed additives (Doyle and Erickson, 2006; Silbergeld et al., 2008) and it is more frequent in poultry and pig production than in beef production. It can be said that the use of such anti-bacterials is beneficial as it improves the conversion rate (among other possible effects), thus improving profitability (Azevedo et al., 2010).

Whatever the application purposes, anti-bacterial residues reach the environment. The most common paths include animal product residues, waste disposal, soil, water and food crop contamination, etc. Environmental contamination occurs mainly because animals excrete high proportions of active forms of the supplied anti-bacterials, which is an effect also present when sub-therapeutic doses are used (Sarmah et al., 2006; Silbergeld et al., 2008). Finally, consumers can have direct contact with these residues either through environmental exposure or through the ingestion of contaminated food products. Exposure can translate into direct effects at an individual level, such as allergic reactions, carcinogenic effects, digestive problems, etc. (Reig and Toldrá, 2008; Azevedo et al., 2010).

Even more significant, however, are the indirect consequences of anti-bacterial residues, which raise important public health issues. The World Health Organization (WHO) and the European Food Safety Agency (EFSA), as well as many research reports, consider that microbial resistance to anti-bacterials is one of the more serious and emerging problems in public health across the world (Doyle and Erickson, 2006; Reig and Toldrá, 2008; Hugas and Liebana, 2009).

The most serious consequence of microbial resistance is the decrease in the useful life of anti-bacterials for combating human or animal diseases (Silbergeld et al., 2008; Sofos, 2008). This can be verified through increased frequencies of treatment failures and increased severity of infections, as well as the occurrence of infections that would not have occurred otherwise (Angulo et al., 2004). This becomes even more serious when it is remembered that no new molecules have been developed recently. There are therefore no new alternatives to those already subject to microbial resistance (Acar and Moulin, 2006; Azevedo et al., 2010).

Resistance can be acquired through a long evolutionary process of responding to environmental pressures that cannot be avoided (intrinsic resistance) (Doyle and Erickson, 2006). Microbial agents can also develop cross-resistance mechanisms, meaning they can become resistant to several antibacterials (especially, but not only, if these agents have similar actions) (Acar and Moulin, 2006).

However, besides the development of intrinsic resistance, there is a more concerning phenomenon of acquired resistance. These acquired resistance mechanisms are developed much faster than the intrinsic resistance phenomenon, and the exposure of bacteria to sub-lethal (or sub-therapeutic) concentrations of anti-bacterials is a particularly effective way of selecting resistant strains (Silbergeld et al., 2008).

Several sources claim that the usage of anti-bacterials in livestock is a major driving force for the selection of resistant micro-organisms, as well as the transmission of zoonotic and commensal microbial agents from animal populations to humans (Angulo et al., 2004; Silbergeld et al., 2008; Azevedo et al., 2010). The livestock sector is the largest user of anti-bacterials worldwide (Sarmah et al., 2006; Silbergeld et al., 2008) potentiating the transmission of genes and mechanisms associated with resistance (Phillips et al., 2004; Sarmah et al., 2006).

Selective pressure often interacts within the environment, animal and human populations, amplifying the resistance phenomenon and the spreading through different species, with the help of fast and efficient bacterial reproduction (Acar and Moulin, 2006). It is not possible to measure the impact of these selective mechanisms on resistant microbial species in human populations, but there is undoubtedly a catalytic effect, potentiated by the intensity of livestock production and the consequent intensive use of anti-bacterials (Silbergeld et al., 2008; Azevedo et al., 2010).

Multiple research claims to have established a causal relationship between (subtherapeutic or other) anti-bacterial administration in livestock and the growing incidence of anti-bacterial resistance in human medicine (Angulo et al., 2004). For example, Silbergeld et al. (2008) refer to consistent temporal relationships between the introduction of anti-bacterials into livestock production use and increases in the prevalence of resistant microorganisms, among other evidence.

However, other authors claim that insufficient evidence has been found to prove that relationship beyond doubt (Phillips et al., 2004; Smith et al., 2005; Presi et al., 2009). Similarly, some authors argue that meat and meat products can act as a vehicle for the spread of bacterial resistance to various anti-bacterials, besides spreading anti-bacterial residues, although there is also no consensus on this subject (Phillips et al., 2004; Presi et al., 2009). Finally, it must also be remembered that incorrect use of anti-bacterials is as serious in human medicine as in livestock production, which cannot therefore be the only sector to blame for resistance emergence (Sarmah et al., 2006; Azevedo et al., 2010).

Measures such as a worldwide ban of non-therapeutic use of anti-bacterials (Silbergeld et al., 2008) or the establishment of precise guidelines for the prudent use of anti-bacterials in veterinary medicine as defined by the World Organisation for Animal Health (OIE) (Acar and Moulin, 2006) have been suggested, but not without controversy (Smith et al., 2005). The WHO also has a global strategy for the containment of anti-bacterial resistance (WHO, 2001). The application or evaluation of such measures and guidelines are nevertheless beyond the scope of this article. However, the specific regulatory measures that have been put in place to deal with this issue in the European Union are worth analysing. This will be done in the following section.

European Union Legal Framework on Anti-bacterial and Other Residues in Meat

Quality management systems for food safety are based in public legislation and in private standards, both having the Codex Alimentarius as background. Although it is not the objective of this article to thoroughly describe any of these private quality systems, brief reference should be made.

Private quality management systems have been developed mostly by the food distribution sector and generally include the food safety legal requirements, while trying to complement them. Some examples within the EU include GLOBALG.A.P. (G.A.P. – Good Agricultural Practice; formerly EUREPGAP – Euro-Retailer Produce Working Group), BRC (British Retail Consortium), IFS (International Food Standard), EFSIS (European Food Safety Inspection Service) and GFSI (Global Food Safety Initiative). These systems are business-to-business management systems that can include one or several standards, such as good agricultural practices, HACCP, ISO, etc. Therefore, they are not directly visible to consumers.

Regarding the public legislation, the EU has an impressive body of legal documents that relate to food safety. In broad terms, there is general food safety legisla-

tion, applicable to all kinds of food, and there is more specific legislation directed towards specific products. Specific food and feed law covers (among many other subjects) food residues and contaminants.

To fully understand and explain the implications of such legal and institutional framework would be an overwhelming task. Thus, to make an exhaustive review of all the legal documents concerning this issue is not the goal of this article. Moreover, no technical legal analysis is pretended, as it would exceed the authors' specific competences.

The objective is therefore to simply list the legal documents that regulate and control the use of antibacterial drugs in meat production as well as the presence of drug residues in meat products throughout the EU. This food safety issue was recognized by the EU, the WHO and the Codex Alimentarius as a growing (but still non-consensual) concern, because of the possible existence of a link between antibacterial residues in meat and the development of microbial resistance, therefore justifying the need for proper regulation.

The review aims not so much at technical legal aspects, but at trying to present an organized and summarized version of the most relevant legislation (Table 1). More importantly, this review intends to understand if there are links between these documents and consumer confidence or concerns.

Table 1. Most relevant legislation regulating and controlling the use of anti-bacterial drugs in meat production, as well as the presence of drug residues in meat products throughout the EU.

Regulation (EC) No. 470/2009	• Describes the procedures to evaluate the safety of residues of pharmacologically active substances in accordance with human safety requirements. • Establishes a maximum residue level (MRL) for pharmacologically active substances used in veterinary medicinal products for each relevant food product (eggs, meat, milk, etc.) for each relevant species. • Annexes include all the pharmacologically active substances with marketing authorization used in veterinary medicinal products, according to their MRL status. • The administration of veterinary medicinal products containing pharmacologically active substances included in Annex IV (such as nitrofurans) to food producing animals is prohibited within the EU.
Council Directive 96/22/EC	• Prohibits the use of beta-agonists and other substances with hormonal or thyrostatic action in livestock farming, once it is acknowledged that their action may be dangerous for consumers and may also affect the quality of food-stuffs of animal origin. In no case can an animal to which one of these substances has been applied enter the food chain.
Council Directive 96/23/EC	• Establishes the measures that EU Member States should take to monitor substances and their residues in both live animals and animal products. • Defines measures to monitor the substances and groups of residues such as substances with anabolic effect and unauthorized substances, veterinary drugs and contaminants.
Directive 2001/82/EC	• Regulates the prescription and distribution of veterinary medicinal products intended for use in food-producing animals. • Defines the withdrawal period as the period necessary to protect public health, between the last administration of a veterinary medical product to animals and the production of food-stuffs from such animals.

Sources: Regulation (EC) No. 470/2009, *OJ*, L 152, 16 June 2009, pp. 11–22; Council Directive 96/22/EC, *OJ*, L 125, 23 May 1996, p. 3–9; Council Directive 96/23/EC, *OJ*, L 125, 23 May 1996, pp. 10–32; Directive 2001/82/EC, *OJ*, L 311, 28 Nov. 2001, pp. 1–66.

It can be suggested that this link between consumers and the legal framework surrounding food products is intended by the EU, as the general food law (Regulation (EC) No. 178/2002, *OJ*, L 31, 1 Feb. 2002, pp. 1–24) establishes objectives for the protection of consumer interests and tries to ensure that consumer confidence is secured. Therefore, it could be expected that the following legal documents go towards addressing consumer worries.

With regard to the particular subject of this article, it can also be said that food safety legislation has accompanied closely the scientific development in the food safety area. Even in questions still not subject to scientific consensus, the EU has acted preventively, based on the precautionary principle, as in the case of the use of anti-bacterials as a feed additive.

Taking now the consumer point of view, the above-described legal framework might also have been implemented in order to address public perceptions, concerns and fears. The control of the use of anti-bacterials and hormones in food animals is covered extensively by several legal documents. Moreover, this ensures complete transparency of all the implemented mechanisms and procedures.

However, as the review shows, this is still very much a present concern for meat consumers across Europe. The difficulty inherent in the effective communication of such a complex technical issue may be a reason for such concerns to exist in spite of a seemingly transparent regulatory framework. Furthermore, the existence of asymmetric information implies that consumers have inferior knowledge compared to retailers, producers and authorities regarding the safety of the meat they are consuming. It can be suggested that consumer consciousness regarding this asymmetry is a reason for their stated concerns.

Hence, consumers may also face difficulties trusting the existing enforcement mechanisms in situations so distant from their daily livelihood. Also, as most consumers do not have contact with animal and food production, their natural ignorance may also be translated into distrust and legitimate concern.

This article's conclusions will therefore attempt at pulling together consumer concerns, scientific evidence and the European legal framework. The existence of such concerns in spite of all the legal and institutional mechanisms suggests that consumers may therefore be willing to choose meat products that relieve their distrust, thus representing a possibility for the development of the quality differentiating strategies that will also be suggested.

Conclusions

European consumer concern about beef safety has changed over the last two decades. Such changes are due not only to transformations in Western societies in terms of food availability, ethical awareness and health concerns, but also more recently to some food scares of previously unseen proportions. The growing media coverage and globalization of food markets have influenced the dimension and impact of these scares.

Some of the major food scares that occurred in Europe since the 1980s were related to different types of meat, namely BSE in beef, dioxins in pork and poultry, etc. Consumers therefore express concerns about meat safety (such as BSE, anti-bacterial and hormone residues, GMOs, etc.) although they are often discordant in subject and proportion with scientific evidence or legal impositions. For example, the concerns about the presence of hormone residues in meat seem somewhat disproportionate,

as the use within the EU of substances with hormonal action is prohibited in farm animals. Also, the same legal criteria apply to products originating in third countries and there have been no scares related to this issue. It is therefore not easy to reason the origin of consumer concerns on this issue. But wherever they come from, they represent at least a miscommunication issue for the EU.

Moreover, although several sources argue that some of the most serious meat safety issues involve microbial agents (such as Campylobacter, Salmonella spp. and verocytotoxigenic E. coli infections) (for a detailed review on this issue, see Nørrung and Buncic, 2008), consumers do not seem to have the same perception (Miles and Frewer, 2001).

This different perception may emerge from several facts already described, namely the absence of significant or widespread food scares relating to meat and microbial agents. Moreover, the legal framework in place has no doubt a major role in guaranteeing as far as possible the microbiological safety of meat products throughout the entire chain, contributing to the absence of such outbreaks.

There is, however, an issue where evidence and worries expressed by the scientific community may be more closely related to consumer concerns: anti-bacterial residues in meat. This potential hazard is mentioned by many consumers in several European countries as being part of their preoccupations about meat safety. Moreover, it is probably one of the few hazards mentioned in association with different types of meat, be it beef, poultry or pork.

It is very interesting to verify that one of the concerns consumers state about meat safety is actually an open scientific question pointed out in the literature as a real problem, even if the real scientific reasoning and proof on this issue is beyond the knowledge or comprehension of most consumers. In addition, the safety guarantees of anti-bacterial residues control may be a field where the European legal and institutional framework has not met consumer concern, whether by technical, legal or communicational reasons.

As such, anti-bacterial residues in meat seem to be an area where consumer concern, scientific evidence and legal framework seem to share common grounds in the need to establish new strategies. However, it can be suggested that the unsolved scientific questions around this issue will probably remain open for quite some time, as it represents a complex scientific issue, due to difficulties related with establishing causal relationships. Moreover, it can also be noted that the legal framework for meat production is already extensive, and that new legislation on issues still to gather scientific consensus would probably raise many conflicts.

Within this context, a market strategy could be proposed in the shape of a user-oriented quality differentiating strategy for meat, aiming at consumer segments willing to pay premiums for meat with increased guarantees concerning anti-bacterial residue control. It is known that some consumer segments are already willing to pay for differentiated meat with characteristics associated with increased safety.

Preferences for beef with quality labels such as Protected Designation of Origin (PDO) or other guaranteed origin schemes are often mentioned as being related to a perception of increased meat safety (Gracia and Albisu, 2001; Verbeke et al., 2007). This can be verified, for example, in Portugal, where Aguiar Fontes et al. (2008) found that consumers seem to associate PDO beef to safer beef. Free-range or organic meat and other meat products with certified production methods are also associated with safety guarantees (Henson and Northen, 2000; Yeung and Morris, 2001; O'Donovan

and McCarthy, 2002; Krystallis and Arvanitoyannis, 2006) although there is no evidence that organic food is safer than conventional products (Sofos, 2008).

Quality strategies involving guaranteed traceability are also among those preferred by consumers when it comes to additional safety guarantees (Krystallis and Arvanitoyannis, 2006; Verbeke et al., 2007). Quality differentiating strategies may therefore be a potential route for assessing very specific consumer concerns (such as those manifested for anti-bacterial residues in meat) and thus explore new niche markets.

Thus, efforts can be suggested in order to promote preventive health and animal-welfare management in meat production systems. These should allow a more efficient and rational use of anti-bacterials, which is a characteristic consumers associate with safer and higher quality meat.

Technical specifications of such quality differentiating strategies are not part of the objectives of this article and the limits to such differentiation strategy must be recognized. However, preventive plans applied together with certification schemes guaranteeing a sound usage of anti-bacterials could create a market niche for such meat products, providing producers with incentives to supply meat according to standards above those legally imposed by the EU.

There may be an attractive market for such meat products because they would supply an instrument to extract the implied value of food safety related to control of anti-bacterial residues. However, it must be stressed that such certification schemes must be associated with higher production costs, which represents necessarily higher prices for consumers. These higher prices, together with well-known income effects on demand often translate into small niche market shares.

As such, the expected quantities produced and consumed would always be small. From a public health perspective, the effect would therefore be negligible. Thus, if a global public health problem is assumed to be associated with the usage of anti-bacterials in meat production, it must also be assumed that there are no sufficient incentives for the market to be a solution. This issue would most likely need to be considered a public affair and the competent authorities would need to take the matter into their own hands.

Nevertheless, there are certification schemes across Europe that include food safety specifications (namely those already related to HACCP), which represent an increased benefit to producers and retailers. As some consumers may be willing to pay more for such meat products, they may provide some support to specific meat production sectors. Therefore, there may be market segments to be explored and opportunities to be seized for different product variants associated with higher levels of food safety related to anti-bacterial residues.

Notes

1. It should also be noted that the reference to anti-bacterials includes antibiotics, sulphonamides and quinolones, and that this chosen definition is in accordance with the one used across the legal documents currently in force within the EU. It is also important to stress that, for the EU, the definition of residue includes not only substances with pharmacological effects, but also their metabolites or other substances transmitted to animal products that are likely to be harmful to human health.
2. In the context of consumer concern, the term antibiotic is more often applied instead of anti-bacterial, which is probably more accurate in a scientific context. Nevertheless, the term antibiotic will be used whenever it is applied in the referred literature.
3. Codex Alimentarius is a code of practice based on scientific evidence, established by the Food and Agriculture Organisation of the United Nations (FAO) and the WHO. Its goals are to protect consumers

and to facilitate international trade. It has no mandatory aspects, but it does act as a basis for many legal standards, including European ones.

References

Acar, F. and Moulin, G. (2006) Antimicrobial resistance at farm level, *Revue scientifique et technique*, 25, pp. 775–792.

Aguiar Fontes, M., Lemos, J.P.C., Banovic, M., Monteiro, A.C.G., Lúcio, C., Duarte, F., Fraústo da Silva, M. and Barreira, M.M. (2008) Is beef differentiation a real source of competitiveness? A combination of procedures to achieve an answer, in: R. Fanfani, E. Ball, L. Gutierrez and E. Ricci Maccarini (eds) *Competitiveness in Agriculture and Food Industry: US and EU Perspectives*. Bologna: BUP.

Angulo, A.M. and Gil, J.M. (2007) Risk perception and consumer willingness to pay for certified beef in Spain, *Food Quality and Preference*, 18, pp. 1106–1117.

Angulo, F.J., Nargund, V.N. and Chiller, T.C. (2004) Evidence of an association between use of anti-microbial agents in food animals and anti-microbial resistance among bacteria isolated from humans and the human health consequences of such resistance, *Journal of Veterinary Medicine*, 51, pp. 374–379.

Azevedo, C., Maia, I. and Tavares, N. (2010) Antibioterapia em bovinos: princípios de utilização e suas implicações na saúde pública, *Veterinary Medicine*, 12, pp. 41–54.

Beaumond, N., Orenga, L., Sans, P. and Brugère, H. (2006) Quality requirements for meat production at the farm level, in: H. Navetat and F. Schelcher (eds) *Proceedings of the XXIV World Buiatrics Congress, October 15th–19th, Nice, France*. Ithaca, NY: IVIS.

Bredahl, L. (2003) Cue utilisation and quality perception with regard to branded beef, *Food Quality and Preference*, 15, pp. 65–75.

Burton, M., Rigby, D., Young, T. and James, S. (2001) Consumer attitudes to genetically modified organisms in food in the UK, *European Review of Agricultural Economics*, 28, pp. 479–498.

Buzby, J.C. (2001) Effects of food-safety perceptions on food demand and global trade, in: A. Regmi (ed.) *Changing Structure of Global Food Consumption and Trade*. Washington DC: Diane Publishing, pp. 55–66.

Carlos, P. de, García, M., de Felipe, I., Briz, J. and Morais, F. (2005) *Analysis of Consumer Perceptions on Quality and Food Safety in the Spanish Beef Market: A Future Application in New Product Development*. Paper presented at the XIth European Association of Agricultural Economics Congress 'The Future of Rural Europe in the Global Agri-Food System, Copenhagen, 24–27 August.

Cicia, G. and Colantuoni, F. (2010) Willingness to pay for traceable meat attributes: a meta-analysis, *International Journal of Food System Dynamics*, 3, pp. 252–263.

Costa-Font, M., Gil, J.M. and Traill, W.B. (2008) Consumer acceptance, valuation of and attitudes towards genetically modified food: review and implications for food policy, *Food Policy*, 33, pp. 99–111.

Dannenberg, A. (2009) The dispersion and development of consumer preferences for genetically modified food: a meta-analysis, *Ecological Economics*, 68, pp. 2182–2192.

Doyle, M.P. and Erickson, M.C. (2006) Emerging microbiological food safety issues related to meat, *Meat Science*, 74, pp. 98–112.

European Commission (2006) Risk issues, *Special Eurobarometer*, 238/Wave 64.1.

Glitsch, K. (2000) Consumer perceptions of fresh meat quality: cross-national comparison, *British Food Journal*, 102(3), pp. 177–194.

Gracia, A. and Albisu, L.M. (2001) Food consumption in the European Union: main determinants and country differences, *Agribusiness*, 17, pp. 469–488.

Henson, S. and Northen, J. (2000) Consumer assessment of the safety of beef at the point of purchase: a Pan-European study, *Journal of Agricultural Economics*, 51, pp. 90–105.

Hugas, M. and Liebana, E. (2009) European Food Safety Authority (EFSA) perspectives on microbial safety of beef, in: G. Duffy and G.J. Nychas (eds) *Advancing Beef Safety through Research and Innovation*. Dublin: Teagasc.

Jonge, J. de, Frewer, L., Trijp, H. van, Renes, R.J., Wit, W. de and Timmers, J. (2004) Monitoring consumer confidence in food safety: an exploratory study, *British Food Journal*, 106(10–11), pp. 837–849.

Knowles, T., Moody, R. and McEachern, M.G. (2007) European food scares and their impact on EU food policy, *British Food Journal*, 109(1), pp. 43–67.

Krystallis, A. and Arvanitoyannis, J.S. (2006) Investigating the concept of meat quality from the consumers' perspective: the case of Greece, *Meat Science*, 72, pp. 164–176.

Lloyd, T., McCorriston, S., Morgan, C.W. and Rayner, A.J. (2001) *The Impact of Food Scares on Beef and Interrelated Meat Markets*. Paper presented at 2001 American Agricultural Economics Association Annual Meeting, Chicago, IL, 5–8 August.

Loader, R. and Hobbs, J.E. (1999) Strategic responses to food safety legislation, *Food Policy*, 24(6), pp. 685–706.

McCarthy, M. (2000) *An Investigation into Consumer Perceptions of Meat Hazards*, Department of Food Economics Discussion Paper Series No. 26, Department of Food Economics, University College Cork, Cork.
Miles, S. and Frewer, L.J. (2001) Investigating specific contents about different food hazards, *Food Quality and Preference*, 12, pp. 47–61.
Miles, S., Brennan, M., Kuznesof, S., Ness, M., Ritson, C. and Frewer, L. (2004) Public worry about specific food safety issues, *British Food Journal*, 106(1), pp. 9–22.
Mørkbak, M.R. and Christensen, B.J. (2010) Consumer preferences for safety characteristics in pork, *British Food Journal*, 112(7), pp. 775–791.
Nørrung, B. and Buncic, S. (2008) Microbiological safety of meat in the European Union, *Meat Science*, 78, pp. 14–24.
O'Donovan, P. and McCarthy, M. (2002) Irish consumer preference for organic meat, *British Food Journal*, 104, pp. 353–370.
Phillips, I., Casewell, M., Cox, T., de Groot, B., Friis, C., Jones, R., Nightingale, C., Preston, R. and Waddell, J. (2004) Does the use of antibiotics in food animals pose a risk to human health? A critical review of published data, *Journal of Antimicrobial Chemotherapy*, 53, pp. 28–52.
Presi, P., Stärk, K.D.C., Stephan, R., Breidenbach, E., Frey, J. and Regula, G. (2009) Risk scoring for setting priorities in a monitoring of antimicrobial resistance in meat and meat products, *International Journal of Food Microbiology*, 130, pp. 94–100.
Reig, M. and Toldrá, F. (2008) Veterinary residues in meat: concerns and rapid methods for detection, *Meat Science*, 78, pp. 60–67.
Sarmah, A.K., Meyer, M.T. and Boxall, A.B.A. (2006) A global perspective on the use, sales, exposure pathways, occurrence, fate and effects of veterinary antibiotics (VAs) in the environment, *Chemosphere*, 65, pp. 725–759.
Savadori, L. Graffeo, M., Bonini, N., Lombardi, L., Tentori, K. and Rumiati, R. (2007) Rebuilding consumer trust in the context of a food crisis, in: M. Siegrist, T.C. Earle and H. Gutscher (eds) *Trust in Risk Management: Uncertainty and Scepticism in the Public Mind*. London: Earthscan, pp. 178–190.
Silbergeld, E.K., Graham, J. and Price, L.B. (2008) Industrial food animal production, antimicrobial resistance, and human health, *Annual Review of Public Health*, 29, pp. 151–169.
Smith, D.L., Dushoff, J. and Morris, J.G. Jr. (2005) Agricultural antibiotics and human health, *PLos Medicine*, 2, pp. 731–735.
Sofos, J.N. (2008) Challenges to meat safety in the 21st century, *Meat Science*, 78, pp. 3–13.
Tonsor, G.T., Schroeder, T.C., Fox, J.A. and Brie, A. (2005) European preferences for beef steak attributes, *Journal of Agricultural and Resource Economics*, 30, pp. 367–380.
Verbeke, W. and Vackier, I. (2004) Profile and effects of consumer involvement in fresh meat, *Meat Science*, 67, pp. 159–168.
Verbeke, W., Frewer, L.J., Scholderer, J. and De Brabander, H.F. (2007) Why consumers behave as they do with respect to food safety and risk information, *Analytica Chimica Acta*, 586, pp. 2–7.
Verbeke, W., Wezemael, L.V., de Barcellos, M.D., Küger, J. and Grunert, K.G. (2010) Consumer perception of beef safety, in: G. Duffy and G.J. Nychas (eds) *Advancing Beef Safety through Research and Innovation*. Dublin: Teagasc.
Viegas, I., Santos, J.L. and Fontes, M.A. (2011) *Joint Production of Safer, Cleaner and Animal Friendlier Beef: Do Consumers Join It Too? Insights from Focus Groups*. Paper presented at 2011 EAAE International Congress 'Change and Uncertainty', Zurich, 30 August–2 September.
WHO (World Health Organization) (2001) *WHO Global Strategy for Containment of Antimicrobial Resistance*. Geneva: WHO.
Yeung, R.M.W. and Morris, J. (2001a) Consumer perception of food risk in chicken meat, *Nutrition and Food Science*, 31(6), pp. 270–278.
Yeung, R.M.W. and Morris, J. (2001b) Food safety risk: consumer perception and purchase behaviour, *British Food Journal*, 103(3), pp. 170–186.