International Journal of Agricultural Policy and Research Vol.6 (9), pp. 144-159, September 2018
Available online at https://www.journalissues.org/IJAPR/
https://doi.org/10.15739/IJAPR.18.017

ISSN 2350-1561

Review

The challenges of aligning consumer preferences and production systems: Analysing the case of a small beef meat exporting country

Received 31 July, 2018 | Revised 17 September, 2018 | Accepted 21 September, 2018 | Published 25 October, 2018

F. Montossi[1*], F. Cazzuli[1], G. Brito[1], C. Realini[2], S. Luzardo[1], P. Rovira[1] and M. Font-i-Furnols[3]

[1] INIA Tacuarembó, Ruta 5 km 386, Tacuarembó, Uruguay.
[2] Grupo de Producción de Rumiantes, Facultad de Ciencias, CENUR Noroeste, Gral. Rivera 1350, Salto, Uruguay.
[3] IRTA-Product Quality, Finca Camps i Armet, E-17121 Monells (Girona), Spain.

*Corresponding Author E-mail: fmontossi@inia.org.uy

Tel. +598 46332407

The beef industry and meat supply chain face several challenges worldwide. These challenges imply increasing overall productivity in order to satisfy a growing population, while keeping a business profitability and product quality and yet minimising its environmental impact. The objective of this paper was to address consumers´ preferences, the effects of production systems on meat characteristics, and national policies and actions developed to improve Uruguayan beef industry competitiveness and exports. To do so, both local and foreign research was reviewed. In this context, sustainability arises as the big issue to be faced by beef production systems and its consideration will affect meat quality characteristics. To match consumers´ preferences and beef production systems will represent a major challenge for the meat industry around the world. Both private initiatives and public policies will be fundamental to achieve this goal.

Key words: consumers, meat quality, sustainability, production systems.

INTRODUCTION

The beef industry and meat supply chain face several challenges around the world, and Uruguay is not an exception. Nonetheless, Uruguay has certain features that make its condition particularly unique.

Among these challenges, sustainable intensification is of paramount importance for the meat sector. The quandary implies increasing overall productivity in order to satisfy a growing population, while keeping a business profitability and yet minimising its environmental impact.

In order to address this issue, this paper aims to focus on consumers´ preferences, considerations on how production systems affect meat characteristics, and national policies and actions in search of improve beef industry competitiveness and exports under a sustainability framework.

World overview

By the year 2050, the agriculture sector will have to increase its production by 60% over current levels to satisfy global food demand. Global meat demand will be expanded considerably during the next decade, at an approximate rate of 1.6%, which means an additional demand of 58 million tons by the year 2023 (FAO, 2014). In this scenario, global meat consumption is expected to grow significantly, considering that it is a source of high quality protein for human diet (Montossi et al., 2013). Adequate intake of high quality protein from animal products (e.g., lean meat and milk) is crucial for optimal growth, development, and health of children, as well as for optimal maintenance, function and health of tissues (including skeletal muscle, brain, heart, kidneys, liver and gut) in adults (Wu, 2016).

The beef industry is constantly adapting itself to meet the requirements of sustainable agriculture and consumer demands for beef quality (Mc Kenna et al., 2002). Thus, several segments of the beef industry are constantly striving to increase product quality,

productivity and economic return (Brito et al., 2014).

Local overview

Uruguay is a small South American country placed in the Southern region of the continent with 3.3 million inhabitants. Livestock production and agriculture have been strategic sectors in Uruguay´s economy, even before it became an independent country. Uruguayan exports stem mainly from the agribusiness (Otero and Bentancur, 2009; Cabrera et al., 2010; Uruguay XXI, 2014; Brito et al., 2014), representing over 70% of national exports, with beef representing one of the main exported products (Uruguay XXI, 2015). This is no surprise considering there are four bovine heads for every Uruguayan inhabitant (Otero and Bentancur, 2009).

In 2005, Uruguay produced enough food to match the demand of 9 million people, in terms of dietary energy supply relative to human dietary energy requirements (MJ/inhabitant/day) (Mondelli, 2014). Nowadays, Uruguay produces food for 28 million people but would have the potential to feed 40 million people.

Uruguayan beef has achieved a recognised international status in world beef trade, placing itself as one of the six largest exporters around the globe (Gorga and Mondelli, 2014; Zurbriggen and Sierra, 2015). Its livestock production has its main customers in more than 100 foreign countries, and many of these customers have highly sophisticated taste and are extremely demanding when choosing meat products. Several issues brought up in the last years concerning consumers´ preferences and purchase behaviour towards food products. The modern meat consumer focuses on its origin, the certification of product and processes, and has a strong environmental awareness about global climate change and the environmental impact of production systems on natural resources. Consumers are also concerned about animal welfare and food safety issues, as well as quality attributes and consistency, differentiation and product availability. Human health aspects have become an increasingly important factor when consumers purchase meat and meat products in addition to ease of preparation and cooking. Finally, aspects involving social responsibility also influence consumers´ food choices (Montossi et al., 2014).

The Uruguayan meat supply chain has been consistently facing challenges during the last 20 years and present conditions are in place for a new productive and competitive leap (Montossi, 2013). In particular, Uruguayan livestock production systems have been intensified in the last 10 years using improved pastures, concentrate feeding and enhanced animal genetics (Brito et al., 2014).

In this new phase, Uruguayan livestock production was marked by a substantial agriculture and forestry growth that have triggered important changes in the productive and commercial structure, boosting prices and increasing farm rents. All these processes came along with a change in land use, major investments within and outside farms and a strong appreciation of labour which is at the same time decreasingly qualified and increasingly scarce. Technology implementation and strategic partnerships among different actors of the meat chain have grown considerably in order to achieve more efficiency in productive and commercial processes. On the other hand, business scale plays a critical role in the competitiveness of the whole system (Montossi, 2013). The scale dimension is of particular importance in Uruguay, in as much small scale farming is usually associated with family businesses which play a key role in absorbing workforce and holding back rural-urban migration (Gómez-Miller et al., 2011).

Uruguay has a temperate climate and an abundance of clean water, which makes it an ideal place to develop outdoor production systems, where livestock graze freely on the open range (Resconi et al., 2008; Montossi, 2014). Actually, the vast majority of Uruguayan livestock production systems are based on native pastures (78% of the area dedicated to livestock farming; MGAP, 2015), even though improved pastures and animal supplementation have been increasingly adopted in recent years (Realini et al., 2004; Brito et al., 2008; del Campo et al., 2008; Brito et al., 2014). Modern Uruguayan livestock production is focused on providing differentiated meat and meat products targeting domestic and mainly foreign consumer demands which are increasingly complex (Montossi, 2013).

The Uruguayan beef industry faces an unprecedented scenario where it is necessary and wise to seize the opportunity to continue growing in line with the expected increase in meat demand, while satisfying consumer preferences and concerns, by taking into account environmental issues in the intensification process. Thus far, Uruguay has been taking a series of multidisciplinary and interinstitutional actions seeking for an ideal balance between intensification and sustainability.

Sustainable intensification

According to Godfray et al. (2010), the introduction of measures to promote sustainability does not necessarily reduce yields or profits. This is where the concept of Sustainable Intensification (SI) begins to take shape.

Baulcombe et al. (2009) and Pretty and Pervez (2014) defined SI as a process whereby yields are increased without adverse environmental impact and without the cultivation of more land. It includes, however, a range of farming practices, from specific agro ecological managements or common practices used in commercial agriculture to the use of biotechnological approaches.

This concept does not articulate or privilege any particular vision or method of agricultural production. It emphasizes ends rather than means, and does not predetermine technologies, species mix or particular design components. The combination of the terms ‘sustainable’ and ‘intensification’ is an attempt to indicate that desirable outcomes could be achieved by a variety of means, yielding both more food and improved environmental goods and services.

Smith and Gregory (2013) suggested that tinkering with the current production systems is unlikely to deliver the food and ecosystems services that are needed in the future and radical changes in production and consumption patterns are likely to be required over the

coming decades.

Sustainable livestock production systems involve systemic and multidisciplinary approaches where social, environmental and economic dimensions are considered.

As to the social dimension, families represent the basic unit of society, and as such, they can be analysed on one hand as an entrepreneurial decision-making core (farmers or food producers), on the other hand as a purchasing decision making nucleus (final consumers). In order to remain competitive and stay on business, the future farmer will need to have an entrepreneurial profile and be familiar with information and communications technologies (ICTs).

As for the environmental dimension, 70% of Uruguayan exports are mainly based on the use of natural resources, being beef one of the most relevant commodities. In the last years, environmental sustainability has become an increasing priority in the government's agenda (Zurbriggen and Sierra, 2015), since attention on the environment has increased in response to market demands. As for the economic dimension, Uruguay has been focusing on becoming more competitive in the world beef market through increasing beef production and improving quality according to market demands, especially in high value markets (Realini et al., 2013).

Sustainable intensification is called to be the great issue that will lead discussions around food production in general and beef production in particular at least in the near future. The ultimate challenge raised is to design beef production systems according to consumer preferences and citizen´s demand trends.

Traditionally, "meat quality" refers to the intrinsic properties of meat, but nowadays it involves environmental, ethical and welfare issues associated with meat production. Consequently, quality became a comprehensive and complex concept, which is influenced by multiple interacting factors including the conditions under which meat is produced (Andersen, et al., 2005).

Extrinsic consumer preferences and demands

According to Font-i-Furnols and Guerrero (2014) having consumers' expectations met at the end of the meat chain, is an important part of their satisfaction and shopping behaviour. Attitudes and beliefs about the characteristics of a certain product and the way it is produced, handled or distributed can influence consumer perception (Claret et al., 2014). Consumers' perception of meat and meat products has a direct effect on the meat industry business. Although consumer behaviour is defined by their needs and what is available to meet their needs, it is strongly influenced by the psychological factor perception. Consumers' perceptions incorporate complex aspects of consumer behaviour such as learning, motivational and contextual factors, and they may change over time (Troy and Kerry, 2010).

Product characteristics are the intrinsic product features but not all product characteristics are important for the consumer, and the product attributes important for the consumer may not be measurable with indicators. Furthermore, these measurable quality characteristics only correlate to a certain extent with the organoleptic quality attributes as perceived by the individual consumer that also relies heavily on extrinsic cues for quality selection (Becker, 2000a).

Jiménez-Colmenero et al. (2001) and Montossi et al. (2013) mentioned animal welfare and environmental sustainability among extrinsic traits of meat that should be considered in order to meet consumer´s expectations.

Traceability

Traceability is usually implicitly associated with ensuring food safety and delivering quality assurances (Hobbs et al., 2005). Full traceability is mandatory in the European Union (EU) - one of Uruguay´s main beef markets - since 2000, and even though consumers appear not to be interested in traceability label cues per se, it is necessary for legal purposes. The value of full traceability could be in the speed of product recall or recovery of food safety problems (Verbeke and Ward, 2006).

Uruguay has a group traceability system since 1974. However, since 2010 Uruguay can only enter the UE market (specifically the "Hilton quota") with individually traced animals, from their birthplace to the slaughterhouse (Osorio, 2009). Nowadays, every livestock unit in the country has two individual ear tags, one visual and one electronic. Uruguay became the first country in the world with a traceability system with these characteristics (Gorga and Mondelli, 2014; Zurbriggen and Sierra, 2015). In fact, the government has implemented a National Livestock Information System (SNIG) to guarantee the individual and group traceability of bovine cattle, from the slaughterhouse to the farm of origin, as well as, an Electronic Information System of the Meat Industry (SEIIC) also known as "Black Boxes". The SEIIC is a system consisting on scales, industrial computers, printers, scanners and communication devices installed along the slaughter, deboning and dispatch lines in each slaughterhouse duly authorized for bovine cattle slaughtering (IICA, 2009).

For Uruguay to be able to develop its full traceability all the way from the farm to the consumer, several actions were taken. For instance, joint actions of the public sector, the implemented national regulations and the applied innovations developed by the private sector. This successful system transcended into the international beef market and this country is recognised currently as a benchmark in the traceability processes (Toro, 2009). The number of markets that Uruguayan beef has reached continues to grow, and so does the profits originated from this business. Full traceability grants the Uruguayan beef supply chain a competitive advantage that can hardly be matched in a medium term basis by any other beef producer or exporter country (Almeida, 2009; Pastoriza, 2013; Montossi et al., 2013).

Environmental sustainability

In recent years, business has begun to recognise the shift in consumer preferences toward products that are less harmful to the environment (Green, 2012). Meat production systems affect the environment and quality of

life for humans, which constitute the environmental or ecological component of sustainability (Verbeke et al., 2010). Consumers are becoming more interested in environmental sustainability (Glitsch, 2000; Brito et al., 2008).

When considering environmental issues related to beef production at the farm level, Uruguay tackled three separate matters: soil conservation, rangeland biodiversity enhancement and climate change mitigation.

Since 1980 Uruguay set to work on the adaptation and validation of the Universal Soil Loss Equation (USLE) (Wischmeier and Smith, 1978), followed by its revised version (RUSLE) (Renard et al., 1997). Even before that, contrasting land uses were evaluated in the earliest long-term rotations trial of Latin America. The information generated from this trial in combination with the aforementioned foreign research, was used as the basis to outline a public policy that was later regulated and resulted in the compulsory presentation of Land Use Management Plans (Hill et al., 2008; MGAP, 2013; Wingeyer et al., 2015). The information derived from the long-term trial highlights the synergy in terms of soil erosion control and organic carbon conservation between the crop phase and the pasture phase of a crop-pasture rotation (Terra et al., 2006; García-Préchac et al., 2004; Montossi et al., 2008; Salvo et al., 2010; Gabriella et al., 2012; Díaz and Quincke, 2013; Franzluebbers et al., 2014; Salvo et al., 2014). In the same way, but in spite of being unusual around the world, crop-pasture rotations have been the predominant cropping system in Uruguay since the 1960s (García-Préchac et al., 2004).

Uruguayan main agricultural activity in terms of land use can be described as extensive animal production (beef and wool) based on direct grazed rangelands. Natural grasslands in Uruguay present the lowest estimate of annual erosion rates compared with any other pasture-crop rotation scheme (García-Préchac and Durán, 2001). The Pampas and Campos biome grasslands represent the largest agro-ecosystem, provide valuable agronomic and ecosystem services (Overbeck et al., 2007; Modernel et al., 2016), and present unique biodiversity values with over three thousand temperate and subtropical species (Bilenca and Miñarro, 2004). Furthermore, there is evidence that in the Centre-Southern Uruguayan region, grazing promotes an increase in species abundance (Rodríguez et al., 2003; Altesor et al., 2005; Altesor et al., 2006).

As for Uruguay attempts to tackle the issue of rangeland biodiversity conservation, one of the instruments utilized by the government, was the offering of non-refundable loans to family farmers aiming to take actions in order to adapt and mitigate the negative effects of climate change, among which, proper management of natural pastures was considered (MGAP/CNFR, 2011).

Great interest is shown in the popular media concerning greenhouse gas (GHG) emission intensity from food production (Pelletier et al., 2010). The environmental effects of meat production were one of the most important reasons why these consumers would change their meat consumption (Latvala et al., 2012). Consumers often perceive that the modern beef production system has environmental impact far greater than historical systems, with improved production efficiency being achieved at the expense of GHG (Capper, 2011). Product carbon footprints are beginning to be reported publicly and this includes product labelling in some jurisdictions (Ridoutt et al., 2011). Livestock industries face an ongoing challenge in producing sufficient food to fulfil consumer demand, while reducing resource use and GHG emissions per unit of food (Capper, 2011).

Understanding the behaviour of GHG emissions and technologies to mitigate their impact is critical because of the eventual restrictions that may be imposed in order to have access to certain international markets (Clariget et al., 2015). Recently, the first Carbon Footprint study was published describing the three main Uruguayan agro export supply chains, being the beef industry one of them. This study showed that the national carbon footprint of beef is strongly influenced by methane and nitrous oxide emissions, accounting for 60-65% and 30-35%, respectively, of total emissions. Carbon dioxide would represent 5-10% of total emissions and would be related to the use of fossil energy (fuel) due to the use of machinery, vehicles or energy production, or indirectly outside the farms, for example for feedstuff and cattle transportation. Emissions assigned to the production process up to the port of arrival of the merchandise, account for 95% of the global carbon footprint of the beef chain (Becoña and Oyhançabal, 2013). Further studies in this area should be encouraged and given appropriate priority in the research agenda, considering that the most demanding international markets increasingly value information regarding environmental sustainability, therefore this would forestall eventual non-tariff barriers that could arise in the future (Pravia et al., 2014a). Moreover, these latter authors as well as Navajas et al. (2014) suggested giving priority to initiatives in which genomics are incorporated as a genetic progress booster towards an increase in animal feed conversion efficiency, since one of the expected results of these studies is the GHG emission reduction for every kilogram of meat produced as indicated further in this article.

Animal welfare

People as citizens express animal welfare-related concerns in relation to meat consumption (Guerrero et al., 2013), even though they are not well channelled into choices that people make as consumers (Guerrero et al., 2000; Latvala et al., 2012). Nontheless, Latvala et al. (2012) suggested that more citizen-oriented perspectives are gradually gaining strength regarding meat consumption. This statement agrees with Schnettler et al. (2009), Troy and Kerry (2010), Guerrero et al. (2013) and Montossi et al. (2013), who support the idea that industrialised countries pay increasing attention to animal welfare issues and animal life quality.

Beef Supply Chain Quality Audits are carried out in Uruguay every five years since 2002, by the joint efforts of the National Meat Institute (INAC) and the National Agricultural Research Institute (INIA). These Audits were initially carried out in collaboration with Colorado State University (CSU) from United States. Many interesting

results were obtained from these studies. For instance, bruising has been identified as a major source of economic loss given that these carcass alterations need to be removed, and when these bruises affect high value areas of the carcasses, they become particularly relevant. Improper animal handling is closely related to the presence of carcass bruises (Brito et al., 2011).

Further animal welfare issues have been studied in the last 10 years in Uruguay. Del Campo et al. (2008) demonstrated that animal welfare is negatively affected when cattle is fed in areas with less than 8 m^2/animal. These same authors reported that grazing behaviour patterns are not affected when animals are supplemented to the level of 1.2% LW or lower, on swards with adequate availability and quality. This is of specific relevance considering that the great majority of Uruguayan livestock production is performed on these extensive or semi-extensive production systems.

Local research has also shed light on optimum pre-slaughter lairage time in terms of animal welfare and meat quality, which it may differ between countries and therefore optimum lairage time should be adjusted considering production systems´ particularities (del Campo et al., 2014). On the other hand, it has also been established that individual temperament directly affects meat quality, resulting in lower shear force values in meat from calmer animals (del Campo, 2008; del Campo et al., 2010). Animal handling affects their behaviour, in particular excitable individuals, and therefore special action must be taken in these cases in order to contribute to animal welfare. As for the effects of painful procedures applied to beef cattle, such as castrations, national research has shown that the sooner the procedure is performed in the animal´s life, the lower are the stress and pain signs observed (del Campo et al., 2014).

Genetic improvement/genomics and feed conversion efficiency

It is clear that improving productivity is key to reducing the environmental impact of beef production (Capper, 2011). On the other hand, providing feed for cattle is the single largest input cost in most livestock production enterprises (Arthur et al., 2004). Cattle feeding may represent up to 50% of production costs of livestock farmers (Navajas et al., 2014).

Local research recommends emphasising the selection of animals with less dry matter intakes per carcass unit produced (Pravia et al., 2014b). In 2014, an inter institutional public-private agreement was signed between the Society of Hereford Breeders (SCHU), the Uruguayan Rural Association (ARU), INAC, the Clemente Estable Biology Research Institute (IIBCE), the Ministry of Livestock, Agriculture and Fisheries (MGAP), the National Research and Innovation Agency (ANII) and INIA, to carry out a project in which the main objective was to improve the beef supply chain competitiveness through the integrated use of livestock information systems (traceability and "black boxes" installed in every slaughterhouse), combined with genomics and classical animal breeding that would allow a faster and more precise way to achieve the pursued goal of improving animal feed conversion efficiency (Pravia et al., 2014b).

Any improvement in efficiency of feed utilization will go a long way in reducing the cost of production (Arthur et al., 2004). Additionally, GHG emissions per kg of meat produced are expected to decrease as a consequence of the improvement of animal conversion efficiency (Navajas et al., 2014).

In recent years, carcass and meat quality characteristics have been emphasised in genetic improvement programmes such as ribeye area, subcutaneous fat thickness, retail cuts yield, tenderness and intramuscular fat content. Researchers and breeders found in genomic selection a feasible tool to improve these economically relevant traits (Navajas et al., 2014).

Production systems

Pomar et al. (2007) pointed out that intensive meat production often generates large volumes of waste with detrimental effects on the environment. The interest in grass-based production systems is growing since they are perceived as low-input systems with reduced feed costs (Realini et al., 2013) and safer meat from the microbiological contamination standpoint (Russell et al., 2000).

In a focus group study lead by Verbeke et al. (2010) about European consumers' attitudes and preferences regarding beef, healthy beef was associated with the production system, more specifically with grass-fed beef. Moreover, a healthy cut of meat was expected to be natural and without additives and hormones that could affect human health. The use of hormones and growth promoting technologies are banned in Uruguay (MGAP, 2015), a policy that is strongly supported by the Uruguayan beef industry (Brito et al., 2011).

For a certain segment of European consumers, the feeding system is the most important factor taken into account in beef and lamb purchasing decisions, being meat from grass-fed animals the most preferred (Font i Furnols et al., 2011; Realini et al., 2013). However, some segments of consumers when taste the meat, preferred those fed concentrated or a combination of concentrate and grass (Font i Furnols et al., 2009; Realini et al., 2009).

Uruguayan research work has been focused on studying the differences in meat quality between typical extensive or semi-extensive beef production systems and intensive feeding systems. Brito et al. (2008) indicated that feeding systems affect meat quality, mainly muscle colour and intramuscular fat content and composition. del Campo et al. (2008) conducted a trial where Hereford steers were fed on pastures with concentrate supplementation rates of 0% LW, 0.6% LW and 1.2% LW or steers fed ad libitum concentrate only. Although average daily gain was higher with increasing levels of energy in the diet and thus meat production was improved, concentrate supplementation up to 1.2% LW had minimal effects on meat quality characteristics. Results showed that European consumers rated higher acceptability scores for Uruguayan beef from grass-fed animals and supplemented animals on grass, than animals fed on concentrate only (Realini et al., 2009).

Realini et al. (2004) compared grass-fed with high

concentrate diets on Hereford steers. Carcasses from cattle finished on concentrate were heavier than those finished on pasture which resulted in an improved carcass conformation.

Branding, certification and promotion campaigns

Consumer concern regarding the way food products are generated has increased during the last 10-15 years in most European countries (Grunert et al., 2004). International beef trade has gone through several changes and reshaping over the last years (Gorga and Mondelli, 2014) causing the demand to be more segment-orientated and requiring product differentiation (Bisang et al., 2009). The world´s largest meat wholesalers are increasingly requiring highly detailed and strict specifications about the type and quality of the traded product (Sturgeon, 2013).

Becker (2000b), Mesias et al. (2010), Font i Furnols et al. (2011), and Realini et al. (2013) state that "Country of Origin" is one cue, among other extrinsic cues, on which consumers base their quality perception of the food product. Verbeke et al. (2009) indicated that origin or quality labels, among others, were cues or attributes perceived to signal safe beef although would depend if the consumers faith in the institutions responsible to provide the certifications (Schleenbecker and Hamm, 2013). According to Verbeke and Ward (2006), the value consumers place in some label cues can be changed through information campaigns. Specifically, these campaigns can have measurable positive impact on consumer´s attention and importance of cues such as country of origin. Indication of origin may become a valued quality signal if the source or origin is associated with higher food safety or food quality perceptions (Loureiro and Umberger, 2007).

Much of the information that consumers receive regarding meat and meat quality is provided through adverts, information campaigns, labels or brands (Font-i-Furnols and Guerrero, 2014) and this high amount of information is indicative of the complexity of the consumer decision about beef purchasing. There is widespread agreement among many actors in the food sector that competitiveness on developed food markets is linked to the ability to work up new, differentiated products which are able to exploit the fact that consumer preferences differ among consumer segments, increase consumer loyalty and move competition away from the purely cost and price-based competition which characterises commodity type markets. Any form for improved or differentiated meat quality attribute requires new ways to signal the quality to the consumer, being branding the most obvious way to do so (Grunert et al., 2004). Meat quality expectations are often based on a few cues, principally labelling (Glitsch, 2000; Grunert et al., 2004).

Certification is an important tool that can affect consumer preferences in one way or the other, depending on the country (Font i Furnols and Guerrero, 2014). In this sense, Montossi et al. (2013) stated that meat products should reach retail stores with clear identification about the country of origin, as well as the product´s nutrition facts. Montossi and Sañudo (2007), Font i Furnols et al. (2011) and Realini et al. (2013) identified an opportunity to add value to Uruguayan beef by promoting “Uruguay Brand" premium brands in markets for high net worth individuals. Gorga and Mondelli (2014) asserted that Uruguay is succeeding in the quest of establishing a reliable "Uruguay brand". Furthermore, some of the high quality meat wholesalers are not satisfied with buying beef from any slaughterhouse of a certain multinational company, but rather demand on a specific country of origin. Realini et al. (2013) also highlighted that foreign country promotion is fundamental for marketing beef in Europe, as well as the development of different marketing strategies to satisfy each clearly identified consumer segment.

The access to the "481 Quota" (grain-fed animals) is an example of the achievements of the Uruguayan beef supply chain, and so is the "Hilton Quota" (grass-fed animals), both directed to the EU. The "481 Quota" demands a specific product with novel traits above traditional Uruguayan beef: cattle under 30 months of age and grain-fed for the last 100 days before slaughter (Gorga and Mondelli, 2014).

Concerning certification, Uruguay has a "Certified Natural Meat Program” (USDA Process Verified Program including the “Never-ever 3” protocol, and Global G.AP.). Similar certification programmes are "Uruguayan Hereford Beef", "Uruguayan Angus Beef" (Almeida, 2009), "Grasslands Alliance", "Uruguay Open Range Beef" (Gorga and Mondelli, 2014), among others. Even though Font i Furnols et al. (2009) evaluated lamb and not beef, these authors stated that it is important to consider the differences between consumer preferences within a certain country or between countries, and it should be considered when developing demand driven orientated marketing strategies. Oliver et al. (2006) and Realini et al. (2013) suggested that individual preferences would lead to the concept of market segmentation based on eating quality (e.g. taste preferences).

Life quality of farmers and maximizing the use of workforce

The integration of meat production with social priorities forms the social component of sustainability and is needed to legitimate the sector in eyes of society and government (Verbeke et al., 2010).

After 2000, there was a broad adoption of self-feeding supplementation for grazing cattle in Uruguay, as a response to the decrease in available workforce, due in part to the expansion of alternative economic rural activities (Rovira and Velazco, 2012; Lagomarsino et al., 2014). Thus, national researchers focused on studying this technology, concluding that self-feeding supplementation would be a valid alternative to decrease time and workforce costs associated to daily supply of feed (Rovira, 2012; Quintans, 2013). In the same line of thought, infrequent supplementation was also evaluated by Lagomarsino et al. (2014) and Luzardo et al. (2014), who demonstrated that the application of this technology can be very effective in beef grazing systems, given that

no negative effects were found when compared to supplementation in a daily basis in terms of animal performance.

Intrinsic consumer preferences and demands

A recent review of consumers' perspectives on beef quality attributes considers colour as the most important intrinsic attributes, tenderness, and flavour as the most important eating quality attributes (Henchion et al., 2017; Maltin et al., 2003). Furthermore, taste and nutritional value are also an important meat quality attributes for most consumers (Nuernberg et al., 2005; del Campo et al., 2008; Brito et al., 2014).). In addition meat should be healthy and safe (Becker, 2000a; Jiménez-Colmenero et al., 2001). Verbeke and Ward (2006) support that traceability as such - being an extrinsic quality trait - has little marketing potential unless it is accompanied by trustworthy indicators of quality.

Meat quality characteristics

Fat, which includes intramuscular fat and intermuscular fat, are appearance attributes that can affect at the consumers' preferences. Generally, consumers preferred meat with low fat content (Ngapo et al., 2017; Ngapo and Dransfield, 2006) although in some studies they show a preference for beef with slightly fat content (Bello Acebrón and Calvo Dopico, 2000; Realini et al., 2014; Lucherk et al., 2016). Fat content might affect the palatability and tenderness of beef (O'Quinn et al., 2012) although not always this association was reported (Chriki et al., 2013).

Colour is a very important attribute for the consumers since it is related to the wholesomeness of the meat (Mancini, 2009). Nevertheless, preferences for colour varied between consumers, depending on cultural aspects (Prescott et al., 2004). Thus, for some consumers dark beef is preferred, and for some others pale red or dark red (Bello Acebrón and Calvo Dopico, 2000; Realini et al., 2014; Killinger et al., 2014a).

Tenderness is a very important eating quality attribute in meat. In fact, Koohmaraie (1995) pointed out that the problem of consumer dissatisfaction will be solved only if we resolve the problem of unacceptable variation in meat tenderness. Tenderness depends on the muscle, genetic and feeding (Chriki et al., 2013; Font i Furnols et al., 2011; Garmyn et al., 2011) and is also highly dependent on the post mortem factors which affect the tenderization (Colle et al., 2015; Lucherk et al., 2016; Gruber et al., 2006).

Animal genetic and feeding system affect meat flavour since they affect the intramuscular fat level and the fatty acid profile (Font-i-Furnols and Guerrero, 2014). Intramuscular fat content affects flavour, juiciness and tenderness, and it is positively related to overall palatability (Realini et al., 2009). Fatty acid composition and consequently nutritional quality are closely related to the feeding being very different in pasture and concentrate fed animals (Díaz et al., 2005). Extensive production systems based mainly on pastures have been conventionally associated with inferior meat quality characteristics, such as tenderness or colour, since meat is darker and fat yellower (Duckett et al., 2013; Realini et al., 2004) and some studies showed a decrease in tenderness (Sitz et al., 2005; Mezgebo et al., 2017).

However, del Campo et al. (2008) reported that meat quality characteristics were not only almost unaffected in grass-fed with supplementation systems, but also pasture based diets increased meat tenderness. Similarly, Moloney et al. (2011) found no differences in sensory traits (tenderness, juiciness, firmness and chewiness) of Irish steers being finished on pasture compared with those fed indoors. Brito et al. (2008) and del Campo et al. (2007 and 2008) did not find an effect on meat shear force of concentrate supplementation at 1 – 1.2% LW of grass-fed cattle. In fact, del Campo et al. (2008) found that meat of animals fed exclusively on grain-fed had higher shear force values than grass-fed steers. Realini et al. (2004) found that meat shear force values 24 h post-mortem did not differ between pasture and grain-fed cattle (4.7 vs 4.5 kg, respectively), but beef from grass-fed animals showed a greater rate of post-mortem tenderization during aging (lower meat hear force values at day 7 and 14 of aging) than beef from grain-fed steers. Resconi et al. (2008) concluded that finishing diet systems resulted in differences in sensory quality. Meat from pasture-fed steers was tenderer than concentrate-fed animals and sensory panellists preferred beef from grass-fed animals with grain supplementation than beef from animals fed concentrate only.

Brito et al. (2014), showed that beef from grain-finished cattle result in whiter fat colour scores than beef fat from grass-fed animals. Realini et al. (2004) registered greater yellowness values in subcutaneous fat from pasture-finished steers when compared with concentrate-fed animals; this may have been since fat colour is largely dependent on its carotenoid content derived from plants. Data of the *Longissimus* muscle showed greater redness and yellowness values for pasture-fed beef compared with concentrate-fed beef.

Meat safety

Certain aspects have caused a lack of confidence in the perception of meat as a safe food. Examples of these were the outbreaks of bovine spongiform encephalopathy (BSE) and *Salmonella* spp. in chicken (Jiménez-Colmenero et al., 2001). Food safety and food quality have increasingly come to the forefront of consumer concerns, industry strategies and government policy initiatives (Hobbs et al., 2005). The relevance of meat as a source of zoonotic pathogens is considerable in terms of the resultant public health and economic burden (Troy and Kerry, 2010). *Escherichia coli* O157:H7 has been sporadically isolated from Uruguayan cattle, sheep, and ground beef (Rovira, 2010; Varela et al., 2008; Rovira et al., 2014). This is not surprising as the gastrointestinal tract of ruminants is the main reservoir of *E. coli* O157:H7 (Ferens and Hovde, 2011) and microbiological contamination is likely to occur during beef slaughtering and processing. Most Uruguayan meat plants have pre-requisite programs and Hazard Analysis and Critical Control Points (HACCP) plans in place in accordance to importers requirements. Knife trimming of visible

contamination, steam vacuuming and water wash are the most common post-slaughter interventions to minimise the risk of microbiological contamination in Uruguayan carcasses. Recently, acid spray of carcasses has become more common as the European Union, one of the most important destinations of Uruguayan meat, has authorized the use of lactic acid for decontamination of bovine carcasses (Regulation EU No. 101/2013). From a conceptual standpoint, the assurance of Uruguay meat safety relies more on good hygienic practices and prevention of contamination (e.g. slow speed chain) rather than on specific carcass interventions to reduce microbial loads.

Glitsch (2000) reported that "freshness" was identified as the most important meat trait that reflected safety for consumers. They also stated that in nearly every European country where the survey took place, most consumers expressed that they were very concerned about BSE, hormones and antibiotics when buying beef. Uruguay is recognized as having a negligible BSE risk by the World Organization for Animal Health (OIE, 2017) and the use of hormones and antibiotics for growth promotion in cattle is prohibited by law in Uruguay (IMPO, 2011). Nowadays, using antibiotics in livestock production systems is a concern not only because of the risk of chemical residues in meat but also for the potential effect on developing antimicrobial resistant bacteria that can reach human populations (Woolhouse and Ward, 2013). The extensive and pastoral livestock systems in Uruguay determine a low usage of antibiotics in production animals, without compromising animal health and welfare, and decreasing the selective pressure for emergence of antimicrobial resistance in zoonotic bacteria.

Nowadays, Uruguay has an information platform previously mentioned in this article (SNIG and SEIIC) which makes it possible to enhance animal health and food safety surveillance programs. (Zurbriggen and Sierra, 2015), and hence it is responding to the market demands in terms of beef safety. These platforms do not assure food safety by itself but enable a prompt and effective national response in case of eventual meat-associated outbreaks or recalls. One of the main challenges is how to handle the process and interpret information from those platforms ('big data') to answer applied marketing and research questions.

Currently, public and private institutions in Uruguay carry out key beef safety projects to fill in the research gaps. The main concern is that the intensification of Uruguayan beef production systems (e.g. increase in the proportion of slaughtered cattle coming from feedlots) may have unintended negative effects on food safety issues either in the final product or in the production process. A proactive and science-based approach to identify weaknesses and strengths along the Uruguayan red meat chain will promote and prove sustainable system intensification without compromising beef safety.

Meat and health

Consumers are becoming more aware of the effect of food on their health (Siró et al., 2008) and thus, health concerns are becoming a relevant determinant factor in food consumption. Latvala et al. (2012) highlighted that Finnish consumers identified healthiness as the most important reason for changing consumption habits. This idea was also supported by Font-i-Furnols and Guerrero (2014). Jiménez-Colmenero et al. (2001) stated that in rich societies, one of the aspects that most affects the image and hence the consumption of meat is whether it is perceived as healthy. Verbeke et al. (2010) indicated that European consumers acknowledge that meat is one of the components of a healthy diet, being aware of its nutritional role as a source of protein and iron; and most consumers considered lean beef to be the healthiest type. However, according to Troy and Kerry (2010), meat can be viewed as having a double mirror image with respect to composition and nutrition. While meat is a complex and nutritionally important component in the diet providing high biological value protein, essential fatty acids, vitamins and minerals, beef fat is a significant source of saturated fatty acids because red meat has a relatively high ratio of saturated to unsaturated lipids (Barahona et al., 2016). These fatty acids have been associated with an increase in blood cholesterol and risk of cardiovascular diseases, which are the main cause of death in developed countries (Scollan et al., 2006). Consequently, increasing attention has been focused on modifying the fat content and the fatty acid composition of beef (Realini et al., 2004; del Campo et al., 2008; Brito et al., 2014).

Omega-3 (n-3) fatty acids play a major role in human health and are involved in the development of brain and retinal tissues, as well as in the progression and prevention of human diseases, including heart disease and some cancers (Simopoulos, 1999; Connor, 2000). Conjugated linoleic acid (CLA) naturally produced by ruminant animals has the potential to reduce the risk of cancer, cardiovascular diseases, diabetes, and obesity, as well as to boost the immune system (Khanal, 2004; O´Shea et al., 2004; Pariza, 2004; Wahle et al., 2004; Wang and Jones, 2004; Schmid et al., 2006). Thus, animal feeding strategies have been successfully used to significantly increase polyunsaturated fatty acids, omega-3 and CLA in meat (Realini et al., 2004, 2009; Mach et al., 2006; Morales et al., 2012; Gillis et al., 2004; Albertí et al., 2013; Realini et al., 2015).

Studies conducted in Uruguay have focused on the evaluation of the effect of diet on the fat content and fatty acid composition of beef (Realini et al., 2016). Grass-fed beef resulted in improved fatty acid profile of intramuscular fat including n-3 and CLA fatty acids and more favourable P:S and n-6:n-3 fatty acid ratios from a human health standpoint than concentrate-fed beef (Realini et al., 2004). In addition, beef from grazing animals showed vitamin E contents in muscle (3.9 μg/g) above the recommended levels to extend meat shelf-life (Faustman et al., 1989). Grass-fed Uruguayan beef was compared with typical beef from United Kingdom (supplemented grass-fed animals), Spain and Germany (both concentrate-fed animals) (Montossi and Sañudo, 2007). Uruguayan beef showed higher levels of n-3 fatty acids resulting in more favourable fatty acid ratios (n-6:n-

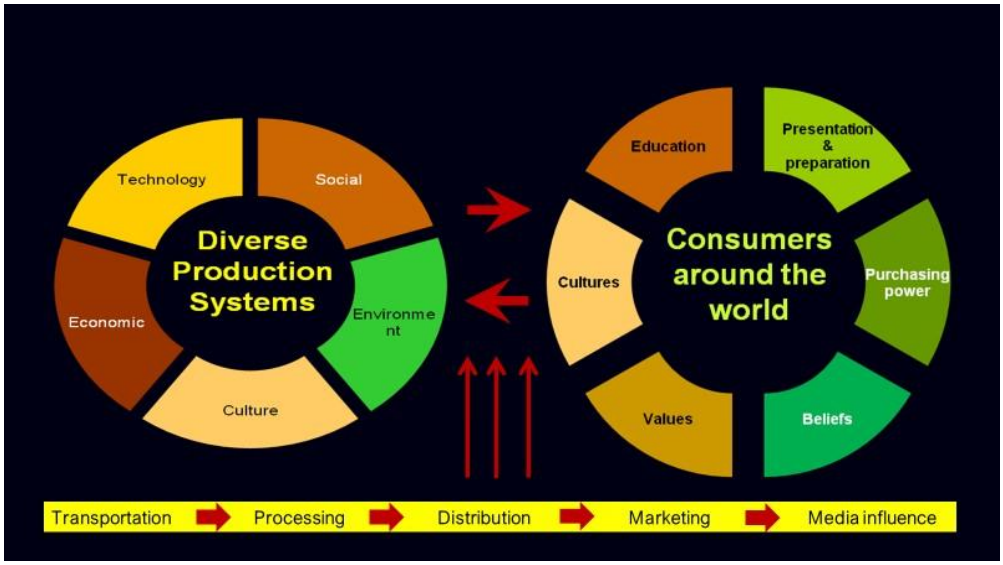

Figure 1: The design of meat production systems and supply value chain according to consumer's characteristics

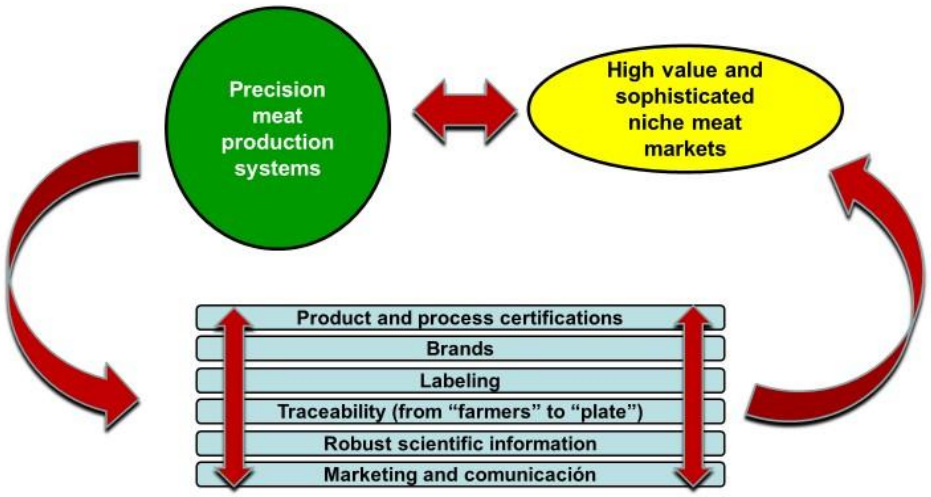

Figure 2: Tools for the alignment of consumer's demands and meat productions systems and supply value chain

3 and P:S) than beef from United Kingdom, Spain and Germany.

Although Uruguayan beef production is based on native grassland, more intensive production systems have been implemented during the last 10 years by using improved pastures and/or concentrate supplementation on pasture (Brito et al., 2014). Thus, Montossi and Sañudo (2007) evaluated beef quality from production systems differing in the extent of intensification involving increasing levels of concentrate in the diet (pasture only, concentrate supplementation on pasture at two levels: 0.6 and 1.2% LW, and concentrate only). Beef from grazing animals showed an improved fatty acid profile relative to the other treatments (higher n-3 and CLA and lower n-6:n-3 ratio). However, these differences were not significant and vitamin E content was similar between beef from an exclusively grazing system and beef from animals fed low levels of supplementation (0.6% LW) (Alvarez et al., 2007). Finally, Brito et al. (2009) indicated that feeding concentrate during the last 40 days of beef finishing would not modify significantly the beef fatty acid composition of intramuscular fat.

Research progress is focusing on the impact of forage diversity on beef fatty acid composition, minimizing fat composition changes in beef from intensive finishing systems preceded by pasture grazing, and the potential benefits of genetic strategies on improving the fatty profile in beef (Realini et al., 2016). Uruguay has a broad range of forage diversity, from native pastures, forage crops and improved pastures. Previous studies indicated

that the type of pasture can modify the fatty acid composition of beef (Duckett et al., 2013; Noci et al., 2007). Moreover, Scollan et al. (2014) highlighted the increased interest in beef production from botanically diverse pastures and the scarcity of scientific information in this research area. Finishing grass-fed cattle on intensive feeding systems during the last 40 days may increase fat levels without significant changes on its composition. These production systems are interesting given that the higher intramuscular fat levels may result in higher sensory ratings, but a similar fatty acid profile of meat from animals fed exclusively on pastures. Although animal genetic factors have lower impact than nutritional aspects on the fatty composition of beef (De Smet et al., 2004), genetic progress can be achieved in the nutritional quality of meat by crossbreeding, genetic selection within breeds (Kelly et al., 2013), and genomics or marker assisted selection. Preliminary studies in Uruguay (Branda et al., 2014) identified eight SNPs that were significantly linked to marbling and the percentage of saturated and polyunsaturated fatty acids.

Cabrera and Saadoun (2014) reviewed the nutritional value of beef and lamb from grazing systems in the southern countries of South America, highlighting the role of meat in supplying essential nutrients such as heme iron, zinc, fatty acids, PUFA, CLA, and health-critical vitamins in a healthy and complete diet. Cabrera et al. (2010) determined the mineral content of seven meat cuts from Hereford and Braford steers fed pasture in Uruguay indicating that iron, heme iron, selenium and zinc in bioavailable forms are largely present, covering the requirements for children, pregnant women and teenagers (Cabrera and Saadoun, 2014).

Conclusions

Beef from Uruguay show competitive advantages in the market place based on fully traceable grazing systems and high safety, quality and ethical production and industry standards. Nonetheless, it has been clearly established that the Uruguayan beef supply chain must continue working to keep up with the most exigent high value foreign markets. This is not only a matter of merely increasing beef production, but also to understand the key meat intrinsic and extrinsic factors most valued by consumers. There are clear challenges to design beef production systems and setting up the whole supply value chain to align them to consumers´ characteristics, such us: beliefs, cultural background, values, education, age, purchasing power, food presentation and preparation, etc. (Figure 1).

The Uruguayan meat supply chain is committed in supporting the required concerted research, production, products and processes certification, traceability from "consumer to plate" and marketing and communication efforts to achieve timely responses to consumer demands in the ever-changing meat market landscape (Figure 2).

Notwithstanding, needs and expectations of consumers in terms of intrinsic and extrinsic meat quality attributes may modify profoundly and Uruguay should respond quickly to these disruptive changes. Sustainability seen as a multidimensional issue (economic, social and environmental) is one of the current challenges and is seen as a paramount opportunity that must be faced with priority, and will possibly succeed only through the combination of public and private efforts, where the use of robust scientific information will play an increasing key role, particularly at the level of consumer trustiness.

Conflict of interests

The authors declare that they have no conflicting interests.

REFERENCES

Albertí P, Gómez I, Mendizabal JA, Ripoll G, Barahona M, Sarriés V, Insausti MJ, Beriarin MJ, Purroy A, Realini C (2013). Effect of whole linseed and rumen-protected conjugated linoleic acid enriched diets on feedlot performance, carcass characteristics, and adipose tissue development in young Holstein bulls. Meat Sci., 94(2): 208–214.

Almeida P (2009). Uruguay país productor de carnes de calidad programas de certificación y trazabilidad, atributos esenciales para los mercados de alto valor. Revista Colombiana de Ciencias Pecuarias, 22(3): 346–351.

Altesor A, Oesterheld M, Leoni E, Lezama F, Rodríguez C (2005). Effect of grazing on community structure and productivity of a Uruguayan grassland. Plant Ecol., 179: 83–91.

Altesor A, Pineiro G, Lezama F, Jackson RB, Sarasola M, Paruelo JM (2006). Ecosystem changes associated with grazing in subhumid South American grasslands. J. Veg. Sci., 17: 323–332.

Alvarez I, De la Fuente J, Díaz MT, Cañeque V (2007). Composición en ácidos grasos y vitamina E de la carne de novillos alimentados con niveles diferentes de concentrado. In: Montossi F, Sañudo C (Eds.), Cooperación Hispano-Uruguaya: Diferenciación y Valorización de la Carne Ovina y Bovina del Uruguay en Europa: Influencia de Sistemas de Producción sobre Aceptabilidad y Percepción de Consumidores y Salud Humana (pp. 61 - 66). Tacuarembó: INIA. Serie Técnica N° 168.

Andersen HJ, Oksbjerg N, Young JF, Therkildsen M (2005). Feeding and meat quality - A future approach. Meat Sci., 70: 543–554.

Arthur PF, Archer JA, Herd RM (2004) Feed intake and efficiency in beef cattle: overview of recent Australian research and challenges for the future. Aust. J. Exp. Agr., 44: 361.

Barahona M, Olleta JL, Sanudo C, Alberti P, Panea B, Perez-Juan M, Realini CE, Campo MM (2016). Effects of whole linseed and rumen-protected conjugated linoleic acid enriched diets on beef quality. Animal, 10(4): 709–717.

Baulcombe D, Crute I, Davies B, Dunwell J, Gale M, Jones J, Pretty J, Sutherland W, Toulmin C (2009). Reaping the benefits: science and the sustainable intensification of global agriculture. Report. The Royal Society. London,

UK. (pp 72).
Becker T (2000a). Consumer perception of fresh meat quality: a framework for analysis.B. F. J., 102(3): 158-176.
Becker T (2000b). "Country of Origin" as a cue for quality and safety of fresh meat. 67th EAAE Seminar "The socioeconomics of origin labelled products in agrifood supply chains: spatial, intitutional and co-ordination aspects". Le Mans, France (pp. 187–208).
Becoña G, Oyhançabal W (2013). Primer estudio de la huella de carbono de tres cadenas agroexportadoras del Uruguay: Carne vacuna, lácteos y arroz. Montevideo.
Bello Acebrón L, Calvo Dopico D (2000). The importance of intrinsic and extrinsic cues to expected and experienced quality: An empirical application for beef. Food Qual. Prefer., 11: 229–238.
Bilenca D, Miñarro F (2004). Identificación de áreas valiosas de pastizal (AVPs) en las Pampas y Campos de Argentina, Uruguay y Sur de Brasil. Buenos Aires: Fundación Vida Silvestre.
Bisang R, Anlló G, Campi M, Albornoz I (2009). Cadenas de valor en la agroindustria. In: Kosacoff B., Mercado R (Eds.), La Argentina ante la nueva internacionalización de la producción: crisis y oportunidades Buenos Aires. (pp. 219–276).
Branda A, Ravagnolo O, Brito G, Baldi F, LaManna A, Banchero G, Navajas E, Rincón G, Medrano JF (2014). Evaluación de panel SNP en genes candidatos de vías metabólicas para carne en Hereford. Arch. Zootec., 63(241): 73–84.
Brito G, Chalkling D, Simeone A, Franco J, Beretta V, Beriau E, Iriarte JM, Tucci D, Montossi F (2009). Effect of finishing systems on meat quality and fatty acid composition of Uruguayan steers. In: 55th International Congress of Meat Science and Technology. Copenhague, Denmark.
Brito G, Lagomarsino X, Olivera J, Trindade G, Arrieta G, Pittaluga O, del Campo M, Soares de Lima JM, San Julián R, Luzardo S, Montossi F (2008). Effect of different feeding systems (pasture and supplementation) on carcass and meat quality of Hereford and Braford steers in Uruguay. In: 54 th International Congress of Meat Science and Technology. Cape Town, South Africa.
Brito G, San Julián R, Lagomarsino X (2011). Segunda auditoría de calidad de carne vacuna del Uruguay. Tacuarembo: INIA. Serie Técnica N° 185.
Brito G, San Julián R, La Manna A, del Campo M, Montossi F, Banchero G, Chalkling D, Soares de Lima J M (2014). Growth, carcass traits and palatability: Can the influence of the feeding regimes explain the variability found on those attributes in different Uruguayan genotypes? Meat Sci., 98(3): 533–538.
Cabrera MC, Saadoun A (2014). An overview of the nutritional value of beef and lamb meat from South America. Meat Sci., 98(3): 435-444.
Cabrera MC, Ramos A, Saadoun A, Brito G (2010). Selenium, copper, zinc, iron and manganese content of seven meat cuts from Hereford and Braford steers fed pasture in Uruguay. Meat Sci., 84(3): 518–528.
Capper JL (2011). The environmental impact of beef production in the United States: 1977 compared with 2007. J. Anim. Sci., 89: 4249–4261.
Chriki S, Renand G, Picard B, Micol D, Journaux L, Hocquette JF (2013). Meta-analysis of the relationship between beef tenderness and muscle characteristics. Livest. Sci., 155: 424-434.
Claret A, Guerrero L, Ginés R, Grau A, Hernández MD, Aguirre E, Peleteiro JB, Fernández-Pato C, Rodríguez-Rodríguez C. (2014). Consumer beliefs regarding farmed versus wild fish. Appetite, 79: 25–31.
Clariget J, Montossi F, Ciganda V, La Manna A (2015). Emisiones de CO_2 en la ganadería de Uruguay: Evolución e impacto de estrategias tecnológicas de mitigación. Revista INIA, 40: 57–60.
Colle MJ, Richard R P, Killinger KM, Bohlscheid JC, Gray AR, Loucks WI, Day RN, Cochran AS, Nasados JA Doumit ME (2015). Influence of extended aging on beef quality characteristics and sensory perception of steaks from the *gluteus medius* and *longissimus lumborum* Meat Sci., 110: 32-39
Connor WE (2000). Importance of n 3 fatty acids in health and disease 1 – 3. Am. J. Clin. Nutr., 71(3): 171–175.
De Smet S, Raes K, Demeyer D (2004). Meat fatty acid composition as affected by fatness and genetic factors: a review. Animal Research, 53(2): 81–98.
del Campo M (2008). El Bienestar Animal y la Calidad de Carne de novillos en Uruguay con diferentes sistemas de terminación y manejo previo a la faena. Universidad Politécnica de Valencia.
del Campo M, Brito G, Montossi F, Soares de Lima JM, San Julián R (2014). Animal welfare and meat quality: The perspective of Uruguay, a "small" exporter country. Meat Sci., 98(3): 470–476.
del Campo M, Brito G, Soares de Lima J, Hernández P, Montossi F (2010). Finishing diet, temperament and lairage time effects on carcass and meat quality traits in steers. Meat Sci., 86(4): 908–914.
del Campo M, Brito G, Soares de Lima J, Vaz Martins D, Sañudo C,SanJulián RS, Hernández P, Montossi F (2008). Effects of feeding strategies including different proportion of pasture and concentrate, on carcass and meat quality traits in Uruguayan steers. Meat Sci., 80: 753–760.
del Campo MG Brito CP Hernandez JM, Soares de Lima D, Vaz Martins R, San Julián Montossi F, Sañudo C (2007). Effect of different diets on carcass traits and meat quality in Uruguayan steers. In: 53rd International Congress of Meat Science and Technology. Beijing, China.
Díaz MT, Alvarez I, De la Fuente J, Sañudo C, Campo MM, Oliver MA, Font i Furnols M, Montossi F, San Julián R, Nute GR, Cañeque V (2005). Fatty acid composition of meat from typical lamb production systems of Spain, United Kingdom, Germany and Uruguay. Meat Sci., 7: 256–263
Díaz R, Quincke A (2013). Rotaciones agrícola-ganaderas: el experimento más antiguo de Latinoamérica cumplió 50 años. Revista INIA, 34: 57–59.
Duckett SK, Neel JPS, Lewis RM, Fontenot JP, Clapham WM (2013). Effects of forage species or concentrate finishing on animal performance, carcass and meat quality 1,2. J. Anim. Sci., 91: 1454–1467.
Faustman C, Cassens RG, Schaeffer DM, Buege DR,

Williams SN, Scheller K (1989). Improvement of Pigment and Lipid Stability in Holstein Steer Beef by Dietary Supplementation with Vitamin E. J.Food Sci., 54(4): 858–862.

Ferens WA, Hovde CJ (2011). *Escherichia coli* O157:H7: animal reservoir and sources of human infection. Food borne Pathog. Dis., 8: 465-487.

Font-i-Furnols M, Guerrero L (2014). Consumer preference, behavior and perception about meat and meat products: An overview. Meat Sci., 98(3): 361–371.

Font-i-Furnols M, Realini C, Montossi F, Sañudo C, Campo MM, Oliver MA, Nute GR, Guerrero L (2011). Consumer's purchasing intention for lamb meat affected by country of origin, feeding system and meat price: A conjoint study in Spain, France and United Kingdom. Food Qual. Prefer., 22: 443–451.

Font-i-Furnols M, Realini CE, Guerrero L, Oliver MA, Sañudo C, Campo MM, Nute GR, Cañeque V, Álvarez I, San Julián R, Luzardo S, Brito G, Montossi F (2009). Acceptability of lamb fed on pasture, concentrate or combinations of both systems by European consumers. Meat Sci., 81: 196–202.

Food and Agriculture Organization of the United Nations (FAO). (2014). Food and Nutrition in Numbers. Rome: UN.

Franzluebbers AJ, Sawchik J, Taboada M A (2014). Agronomic and environmental impacts of pasture-crop rotations in temperate North and South America. Agric. Ecosyst.Environ., 190: 18–26.

Gabriella J, Pérez Bidegain M, Terra J, Sawchik J (2012). WEPP as a tool for enabling a more comprehensive analysis of the environmental impacts of soil erosion. Agrociencia Uruguay, 16: 268–273.

García-Préchac F, Durán A (2001). Estimating Soil Productivity Loss Due to Erosion in Uruguay in Terms of Beef and Wool Production on Natural Pastures. In: Stott D, Mohtar R, Steinhardt G (Eds.), Sustaining the Global Farm - Selected papers from the 10th International Soil Conservation Organization Meeting Pardue. (pp. 40–45).

García-Préchac F, Ernst O, Siri-Prieto G, Terra J A (2004). Integrating no-till into crop-pasture rotations in Uruguay. Soil Tillage Res., 77: 1–13.

Garmyn A J, Hilton GG, Mateescu RG, Morgan JB, Reecy JM, Tait Jr RG, Beitz DC, Duan Q, Schoonmaker JP, Mayes MS, Drewnoski ME, Liu Q, VanOverbeke DL (2011). Estimation of relationships between mineral concentration and fatty acid composition of *longissimus* muscle and beef palatability traits. J.Anim. Sci., 89: 2849–2858.

Gillis MH, Duckett S K, Sackmann JR (2004). Effects of supplemental rumen-protected conjugated linoleic acid or corn oil on fatty acid composition of adipose tissues in beef cattle. J. Anim. Sci., 82: 1419–1427.

Glitsch K (2000). Consumer perceptions of fresh meat quality: cross-national comparison. B. F. J, 102(3): 177–194.

Godfray H, Beddington J, Crute I, Haddad L, Lawrence D, Muir J, Pretty J, Robinson S, Thomas S, Toulmin C (2010). Food Security: The Challenge of. Sience, 327(February): 812–818.

Gómez-Miller R, Ferreira G, Albin A (2011). Caracterización de los sistemas de producción familiar en el área de alrededores de Tacuarembó. In: Gómez-Miller R, Ferreira G, Albin A (Eds.), Caracterización de los sistemas de producción familiar en el área de alrededores de Tacuarembó. Serie Técnica 195. (p. 76). Tacuarembó: INIA. Serie Técnica N° 195.

Gorga L, Mondelli M (2014). ¿La carne uruguaya ha escalado en las cadenas globales de alto valor? Anuario OPYPA/MGAP, 617–636.

Green G (2012). Rural jobs: making a living in the countryside. In: Kulcsár L, Curtis, K (Eds.), International handbook of rural demography Netherlands: Pringer (pp. 307–317).

Gruber SL, Tatum JD, Scanga JA, Chapman PL, Smith GC,Belk KE (2006). Effects of post mortem ageing and USDA quality grade on Warner-Bratzler shear force of seventeen individual beef muscles. J. Anim. Sci., 84: 3387-3396.

Grunert KG, Bredahl L, Brunsø K (2004). Consumer perception of meat quality and implications for product development in the meat sector—a review. Meat Sci., 66: 259–272.

Guerrero L, Claret A, Hernández F, Dalmau A (2013). Creencias, actitud y expectativas de los consumidores españoles frente al bienestar animal porcino y a la castración (quirurgica e inmunocastración). In: World Congress of Dry-Dured Ham Ourique, Portugal: VII WCDDH. (pp. 2–7).

Guerrero L, Colomer Y, Guàrdia M, Xicola J, Clotet R (2000). Consumer attitude towards store brands. Food Qual. Prefer., 11: 387–395.

Henchion MM, McCarthy M, Resconi VC (2017). Beef quality attributes: A systematic review of consumer perspectives. Meat Sci., 128: 1-7

Hill M, García Préchac F, Terra JA, Sawchik J (2008). Incorporación del efecto del contenido de agua en el suelo en el modelo USLE / RUSLE para estimar erosión en Uruguay Soil water content effect in the USLE / RUSLE model to estimate erosion in Uruguay. Agrociencia, 12: 57–67.

Hobbs J E, Bailey D, Dickinson D L, Haghiri M (2005). Traceability in the Canadian Red Meat Sector: Do Consumers Care? C. J. A. E., 53 (March): 47–65.

IMPO (2011). Registro Nacional de Leyes y Decretos, Tomo 1, Semestre 1, p. 461. Retrieved

Inter-American Institute for Cooperation on Agriculture (IICA). (2009). Cooperation node: Uruguay´s experience in beef cattle traceability. Montevideo: IICA. 56 p.

Jiménez-Colmenero F, Carballo J, Cofrades S (2001). Healthier meat and meat products: Their role as functional foods. Meat Sci., 59: 5–13.

Kelly M, Tume R, Newman S, Thompson J (2013). Genetic variation in fatty acid composition of subcutaneous fat in cattle. Anim. Prod. Sci., 53: 129–133.

Khanal R (2004). Potential health benefits of conjugated linoleic acid (CLA): A review. Asian-Australas. J. Anim.Sci., 17(9): 1315–1328.

Killinger K M, Calkins C R, Umberger W J, Feuz D M, Eskridge K M (2004a). Consumer visual preference and value for beef steaks differing in marbling level and color. J. Anim. Sci., 82: 3288–3293.

Koohmaraie M (1995). Biochemical factors regulating the

toughening and tenderization process of meat. Meat Sci., 43(S): 193–201.

Lagomarsino X, Luzardo S, Montossi F (2014). ¿Cómo producir terneros con más de 300 kg con edades menores a los 15 meses en sistemas ganaderos de Basalto? In Estrategias de intensificación ganadera Treinta y Tres: INIA. Serie Actividades Difusión N° 734. (pp. 31–36).

Latvala T, Niva M, Mäkelä J, Pouta E, Heikkilä J, Kotro J, Forsman-Hugg S (2012). Diversifying meat consumption patterns: Consumers' self-reported past behaviour and intentions for change. Meat Sci., 92(1): 71–77.

Loureiro M L, Umberger W J (2007). A choice experiment model for beef : What US consumer responses tell us about relative preferences for food safety, country-of-origin labeling and traceability. Food Policy, 32: 496–514.

Lucherk LW, O'Quinn TG, Legako JF, Rathmann RJ, Brooks JC, Miller MF (2016). Consumer and trained panel evaluation of beef strip steaks of varying marbling and enhancement levels cooked to three degreesof doneness. Meat Sci., 112: 145-154.

Luzardo S, Cuadro R, Lagomarsino X, Montossi F, Brito G, La Manna A (2014). Tecnologías para la intensificación de la recría bovina en el Basalto - suplementación infrecuente sobre campo natural y pasturas mejoradas en Basalto. In: Berretta E, . Montossi F, Brito G (Eds.), Alternativas tecnológicas para los sistemas ganaderos del Basalto Tacuarembó: INIA. Serie Técnica N° 217. (pp. 93–125).

Mach N, Devant M, Bach A, Díaz I, Font-Furnols M, Oliver MA, García JA (2006) Increasing the amount of omega-3 fatty acid of meat from intensively-fed young Holstein bulls through nutrition. J. Anim. Sci., 84: 3039-3048

Maltin C, Balcerzak D, Tilley R, Delday M (2003). Determinants of meat quality: tenderness. Proceedings of the Nutrition Society, 62: 337-347.

Mancini RA (2009). Meat color. In: Kerry JR, Ledward D (Eds.), Improving the sensory and nutritional quality of fresh meat CRC Press: Woodhead Publishing Limited. (pp. 89–110).

Mc Kenna D, Roeber D, Bates P, Schmidt T, Hale D, Griffin D, Savell J W, Brooks J C, Morgan J B, Montgomery T H, Belk K E, Smith C (2002). National Beef Quality Audit 2000: Survey of targeted cattle and carcass characteristics related to quality, quantity, and value of fed steers and heifers. J. Anim. Sci., 80: 1212–1222.

Mesias F, Gaspar P, Escribano M, Pulido F (2010). The role of protected designation of origin in consumer preference for Iberian dry-cured ham in Spain. I. J. F. Sci., 22(4): 367–376.

Mezgebo GB, Moloney AP, O'Riordan E,G, McGee M, Richardson RI, Monahan FJ (2017). Comparison of organoleptic quality and composition of beef from suckler Bulls from different production systems. Animal, 11: 538-546.

Ministry of Livestock, Agriculture and Fisheries of Uruguay (MGAP) National Commission for Rural Development (CNFR) (2011). Sistemas agropecuarios del Uruguay Adaptación y mitigación al cambio climático en sistemas agropecuarios del Uruguay. Montevideo.

Ministry of Livestock, Agriculture and Fisheries of Uruguay (MGAP). Resolución Ministerial Planes de Uso de Suelo (2013). Montevideo: Ministerio de Ganaderia, Agricultura y Pesca (MGAP). Retrieved August 30, 2017, from http://www.cebra.com.uy/renare/media/Resolución-Ministerial-Planes-de-Uso.pdf

Ministry of Livestock, Agriculture and Fisheries of Uruguay (MGAP). (2015). Marco Legal. Programa Nacional de Residuos Biologicos. Retrieved August 30, 2017, from http://www.mgap.gub.uy/dgsg/PNRB/PNRB_MarcoLegal.htm

Modernel P, Rossing W A H, Corbeels M, Dogliotti S, Picasso V, Tittonell P (2016). Land use change and ecosystem service provision in Pampas and Campos grasslands of southern South America. Environ.l Res. Lett., 11: 113002.

Moloney A P, Mooney M T, Troy D J, Keane M G (2011). Finishing cattle at pasture at 30 months of age or indoors at 25 months of age: Effects on selected carcass and meat quality characteristics. Livest. Sci., 141: 17–23.

Mondelli M (2014). 2º Foro Cooperativo Agropecuario CAF 2014 Panel I: El agro uruguayo al 2020. Lineamientos Estratégicos Para El Desarrollo Competitivo Agroexportador. Retrieved August 30, 2017, from http://www.caf.org.uy/IMG/pdf/5-Mondelli.pdf

Montossi F (2013). Innovación e invernada de precisión para el Uruguay. In F. Montossi (Ed.), Invernada de precisión: pasturas, calidad de carne, genética, gestión empresarial e impacto ambiental (GIPROCAR II). Tacuarembó: INIA. Serie Técnica N° 211. (pp. 1–6).

Montossi F (2014). 60th International Congress of Meat Science and Technology, August 17th-22nd, 2014, Punta del Este, Uruguay. Meat Science, Sustainability and Innovation. Meat Sci., 98(3): 321.

Montossi F, Ayala W, Díaz R (2008). The challenges of Cropping and Forestry intensification on Grasslands Livestock Production Systems: The Uruguayan case. In Multifunctional grasslands in a changing world, Volume II: XXI International Grassland Congress and VIII International Rangeland Congress. Hohhot, China. (pp. 5–13).

Montossi F, Font-i-Furnols M, del Campo M, San Julián R, Brito G, Sañudo C (2013). Sustainable sheep production and consumer preference trends: Compatibilities, contradictions, and unresolved dilemmas. Meat Sci., 95(4): 772–789.

Montossi F, Sañudo C (2007). Cooperación Hispano-Urugaya: Diferenciación y Valorización de la Carne Ovina y Bovina del Uruguay en Europa: Influencia de Sistemas de Producción sobre Aceptabilidad y Percepción de Consumidores y Salud Humana. Tacuarembó: INIA. Serie Técnica N° 168.

Montossi F, Soares de Lima J, Brito G, Berretta E. (2014). Impacto en lo productivo y económico de las diferentes orientaciones productivas y tecnologías propuestas para la región de Basalto. In: Berretta E, Montossi F, Brito G (Eds.), Alternativas tecnológicas para los

sistemas ganaderos de Basalto. Tacuarembó: INIA. Serie Técnica N° 217. (pp. 557–568).

Morales R, Folch C, Iraira S, Teuber N, Realini C E (2012). Nutritional Quality of Beef Produced in Chile from Different Production Systems. Chilean Journal of Agricultural Research, 72(1), 80–86.

Navajas, E, Pravia, I, Lema, M, Ravagnolo, O, Clarieget, J, Dalla Rizza, M, Montossi, F (2014). Selección genómica en eficiencia de conversión y calidad de canal de la raza Hereford en Uruguay. Anuario Hereford Del Uruguay, 160–176.

Ngapo T M, Dransfield E (2006). British consumers preferred fatness levels in beef: Surveys from 1955, 1982 and 2002. Food Qual. Prefer., 17: 412–417.

Ngapo TM, Braña Varela D, Rubio Lozano MS (2017). Mexican consumers at the point of meat purchase. Beef choice. Meat Sci., 134: 34-43.

Noci F, French P, Monahan F J, Moloney A P (2007). The fatty acid composition of muscle fat and subcutaneous adipose tissue of grazing heifers supplemented with plant oil-enriched concentrates. J. Anim. Sci., 85(4): 1062–1073.

November 1st, 2017, from https://www.impo.com.uy/bases/decretos/98-2011.

Nuernberg K, Dannenberger D, Nuernberg G, Ender K, Voigt J, Scollan N D, Wood J D, Nute R I, Richardson R I (2005). Effect of a grass-based and a concentrate feeding system on meat quality characteristics and fatty acid composition of longissimus muscle in different cattle breeds. Livest. Prod. Sci., 94: 137–147.

O´Shea M, Bassaganya-Riera J, Mohede I C M (2004). Immunomodulatory properties of conjugated linoleic acid 1 – 3. Am. J. Clin. Nutr., 79: 1199–1206.

O'Quinn TG, Brooks JC, Polkinghorne RJ, Garmyn AJ, Johnson BJ, Starkey JE, Rathmann RJ, Miller MF (2012). Consumer assessment of beef strip loin steaks of varying fat levels. J. Anim. Sci., 90: 626–634.

OIE (2017). Resolution No. 26. Recognition of the Bovine Spongiform Encephalopathy Risk

Oliver M, Nute G, Font-i-Furnols M, San Julián R, Campo M M, Sañudo C, Cañeque V, Guerrero L, Alvarez I, Díaz M T, Branscheid W, Wicke M, Montossi F (2006). Eating quality of beef, from different production systems, assessed by German, Spanish and British consumers. Meat Sci., 74: 435–442.

Osorio G (2009). Trazabilidad individual a campo. In: Un nodo de cooperación sobre la experiencia de Uruguay en trazabilidad bovina Montevideo: IICA. (pp. 33–37).

Otero M, Bentancur A (2009). 1. Uruguay: país ganadero. In: Un nodo de cooperación sobre la experiencia de Uruguay en trazabilidad bovina (pp. 11–23).

Overbeck G, Müller S, Fidelis A, Pfadenhauer J, Pillar V, Blanco CC, Boldrini II, Both R, Forneck E (2007). Brazil's neglected biome: The South Brazilian Campos. Perspect. Plant Ecol. Syst., 9: 101–116.

Pariza MW (2004). Perspective on the safety and effectiveness of conjugated linoleic acid 1-4. Am. J. Clin. Nutr., 79(6): 1132S–1136S.

Pastoriza J (2013). La trazabilidad en Uruguay: de las marcas a fuego a la identificación individual electrónica. (H. Durán-Marrtínez, Ed.). Montevideo.

Pelletier N, Pirog R, Rasmussen R (2010). Comparative life cycle environmental impacts of three beef production strategies in the Upper Midwestern United States. Agric. Syst., 103(6): 380–389.

Pomar C, Dubeau F, Létourneau-Montminy M P, Boucher C, Julien P O (2007). Reducing phosphorus concentration in pig diets by adding an environmental objective to the traditional feed formulation algorithm. Livest. Sci., 111: 16–27.

Pravia I, Navajas E, Lema M, Aguilar I, Ravagnolo O, Brito G, Clariget J, Peraza P- de los Santos J, Dalla Rizza M, Montossi F (2014a). Mejoramiento genético en eficiencia de conversión de alimento y características de canal: oportunidades a través del uso de la genómica. In: V Congreso de la Asociación Uruguaya de Producción Animal (AUPA) Montevideo: AUPA. (pp. 2–3).

Pravia MI, Ravagnolo O, Urioste JI, Garrick D J (2014b). Identification of breeding objectives using a bioeconomic model for a beef cattle production system in Uruguay. Livest. Sci., 160: 21–28.

Prescott J, Young O, Zhan, S, Cummings T (2004). Effects of added "flavour principles" on liking and familiarity of a sheepmeat product: a comparison of Singaporean and New Zealand consumers. Food Qual. Prefer., 15(2): 187-194.

Pretty J,Pervez Z (2014). Sustainable intensification in agricultural systems. Ann. Bot., 114(1911): 1571–1596.

Quintans G, Echeverria J, Scarsi A, Rovira P (2013). Efecto del suministro de ración en comederos de autoconsumo en terneros destetados precozmente. In: Quintans G, Scarsi A (Eds.), Seminario de actualización técnica: cría vacuna Treinta y Tres: INIA. Serie Técnica N° 208: 207–218.

Realini C E, Duckett S K, Brito G W, Dalla Rizza M, De Mattos D (2004). Effect of pasture vs. concentrate feeding with or without antioxidants on carcass characteristics, fatty acid composition, and quality of Uruguayan beef. Meat Sci., 66: 567–577.

Realini C E, Font-i-Furnols M, Guerrero L, Montossi F, Campo M M, Sañudo C, Nute G R, Alvarez I, Cañeque V, Brito G, Oliver M A (2009). Effect of finishing diet on consumer acceptability of Uruguayan beef in the European market. Meat Sci., 81(3): 499–506.

Realini C E, Font-i-Furnols M, Sañudo C, Montossi F, Oliver M A, Guerrero L (2013). Spanish, French and British consumers' acceptability of Uruguayan beef, and consumers' beef choice associated with country of origin, finishing diet and meat price. Meat Sci., 95: 14–21.

Realini C E, Guardia M D, Díaz I, García-Regueiro J A, Arnau J (2015). Effects of acerola fruit extract on sensory and shelf-life of salted beef patties from grinds differing in fatty acid composition. Meat Sci., 99: 18–24.

Realini C, Brito G, Montossi F (2016). Investigación para el desarrollo de estrategias nutricionales y genéticas que optimicen el contenido y el perfil de ácidos grasos de la carne vacuna uruguaya. Revisión. In: Archivos Latinoamericano de Producción Animal (Vol. 24, pp. 189–201).

Realini CE, Kallas Z, Pérez-Juan M, Gómez I, Olleta JL, Beriain MJ, Albertí P, Sañudo C (2014). Relative importance of cues underlying Spanish consumers' beef

choice and segmentation, and consumer liking of beef enriched with n-3 and CLA fatty acids. Food Qual. Prefer., 33: 74-85.

Renard K, Foster G, Weesies D, Mc Cool D, Yoder D (1997). Predicting Soil Erosion by Water: A guide to Conservation Planning with the Revised Universal Soil Loss Equation (RUSLE). USDA Agriculture Handbook (Vol. 537). Maryland: USDA.

Resconi V C, Campo M M, Font-i-Furnols M, Oliver M, Luzardo S, San Julián R, Brito G, Montossi F, Sañudo C (2008). Effect of different feeding systems in the sensory quality of Uruguayan beef. In: 54 th International Congress of Meat Science and Technology Cape Town, South Africa. (pp. 4–6).

Ridoutt B G, Sanguansri P, Harper G S (2011). Comparing carbon and water footprints for beef cattle production in Southern Australia. Sustainability, 3, 2443–2455.

Rodríguez C, Leoni E, Lezama F, Altesor A (2003). Temporal trends in species composition and plant traits in natural grasslands of Uruguay. J. Veg. Sci., 14: 433–440.

Rovira P (2010). Inocuidad en sistemas de producción con énfasis en *Escherichia coli* O157:H7. In: Seminario de Actualización Técnica en Calidad de Carnes, 20-21st September 2010, Tacuarembó, Uruguay.

Rovira P, Brito G Montossi F (2014). Presence of *Escherichia coli* O157:H7 in feces of grazing lambs ready for slaughter in Uruguay. In: Proceedings of the 60th International Congress on Meat Science and Technology, Punta del Este, Uruguay.

Rovira P, Velazco J (2012). Suplementación de bovinos en pastoreo: autoconsumo. Rovira P, Velazco J (Eds.). Treinta y Tres: INIA. Serie Técnica N° 199.

Rovira PJ (2012). Desempeño productivo de novillos sobre pasturas templadas con suplementación energética en autoconsumo. Revista Veterinaria, 23(1), 3–7.

Russell J B, Diez-Gonzalez F, Jarvis G N (2000). Potential effect of cattle diets on the transmission of pathogenic *Escherichia coli* to humans. Microb. Infect., 2: 45–53.

Salvo L, Hernández J, Ernst O (2014). Soil organic carbon dynamics under different tillage systems in rotations with perennial pastures. Soil Till. Res., 135: 41–48.

Salvo L, Hernández, J, Ernst, O (2010). Distribution of soil organic carbon in different size fractions, under pasture and crop rotations with conventional tillage and no-till systems. Soil Till. Res., 109: 116–122.

Schleenbecker R, Hamm U (2013). Consumers' perception of organic product characteristics: A review. Appetite, 71: 420–429.

Schmid A, Collomb M, Sieber R, Bee G (2006). Conjugated linoleic acid in meat and meat products: A review. Meat Sci., 73(1): 29–41.

Schnettler B, Vidal R, Silva R, Vallejos L, Sepúlveda N (2009). Consumer willingness to pay for beef meat in a developing country: The effect of information regarding country of origin, price and animal handling prior to slaughter. Food Qual. Prefer., 20: 156–165.

Scollan N D, Dannenberger D, Nuernberg K, Richardson I, MacKintosh S, Hocquette J F, Moloney A P (2014). Enhancing the nutritional and health value of beef lipids and their relationship with meat quality. Meat Sci., 97(3): 384–394.

Scollan N, Hocquette J F, Nuernberg K, Dannenberge, D, Richardson I, Moloney A (2006). Innovations in beef production systems that enhance the nutritional and health value of beef lipids and their relationship with meat quality. Meat Sci., 74(1): 17-33.

Simopoulos A (1999). Evolutionary aspects of omega-3 fatty acids in the food supply. Prostaglandins Leukot. Essent. Fatty Acids, 60(5-6): 421–429.

Siró I, Kápolna E, Kápolna B, Lugasi A (2008). Functional food. Product development, marketing and consumer acceptance-A review. Appetite, 51: 456–467.

Sitz BM, Calkins C R, Feuz DM, Umberger W J, Eskridge KM (2005). Consumer sensory acceptance and value of domestic, Canadian, and Australian grass-fed beef steaks. J. Anim.Sci., 83: 2863–2868.

Smith P, Gregory P J (2013). Climate change and sustainable food production. The Proceedings of the Nutrition Society, 72(November 2012): 21–8.

Status of Member Countries. Retrieved November 1st, 2017, from http://www.oie.int/fileadmin/Home/eng/Animal_Health_in_the_World/docs/pdf/Resolutions/2017/A26_RESO_2017_BSE.pdf.

Sturgeon T (2013). Global Value Chains and Economic Globalization: Towards a New Measurement Framework. Industrial Performance Centre, Massachusetts Institute of Technology (MIT).

Terra J A, García Préchac F, Salvo L, Hernández J (2006). Soil use intensity impacts on total and particulate soil organic matter in no-till crop-pasture rotations under direct grazing. Advances in Geoecology, 38: 233-241.

Toro G (2009). Presentación. In: Un nodo de cooperación sobre la experiencia de Uruguay en trazabilidad bovina Montevideo: IICA. (p. 3).

Troy D J, Kerry J P (2010). Consumer perception and the role of science in the meat industry. Meat Sci., 86: 214–226.

Uruguay XXI (2014). Ambiente para los negocios: guía del inversor. Montevideo: Uruguay XXI. Promoción de inversiones y exportaciones. Retrieved January 8, 2018, from http://www.uruguayxxi.gub.uy/guia/ambiente-negocios.html.

Uruguay XXI (2015). Informe de Comercio Exterior: exportaciones e importaciones de Uruguay. Montevideo: Uruguay XXI. Promoción de inversiones y exportaciones. Retrieved August 30, 2017, from http://www.inv.gov.ar/PDF/ComercioExterior/InformeEstadiEcuador.pdf

Varela G, I Chinen P Gadea E Miliwebsky MI Mota S González G González MJ, Gugliada CC Carbonari G Algorta M Bernadá R Sabelli L Pardo M Rivas Schelotto F (2008). Detección y caracterización de *Escherichia coli* productor de toxina Shiga a partir de casos clínicos y alimentos en Uruguay. Rev. Argent. Microbiol., 40: 93-100.

Verbeke W, Ward R W (2006). Consumer interest in information cues denoting quality, traceability and origin: An application of ordered probit models to beef labels. Food Qual. Prefer., 17: 453–467.

Verbeke W, Pérez-Cueto FJA, Barcellos MD De, Krystallis A, Grunert KG (2010). European citizen and consumer

attitudes and preferences regarding beef and pork. Meat Sci., 84(2): 284–292.
Verbeke W, Van Wezemael L, de Barcellos M, Kugler J, Grunert G (2009). Advancing Beef Safety through Research and Innovation Proceedings of a meeting at Ashtown Food Research Conference Centre, Teagasc, Dublin, Ireland Editors. In: . Duffy G, Nychas G (Eds.), Advancing Beef Safety through Research and Innovation Proceedings of a meeting at Ashtown Food Research Conference Centre, Teagasc, Dublin, Ireland. Dublin: ProSafeBeef. (pp. 8–10).
Wahle KWJ, Heys SD, Rotondo D (2004). Conjugated linoleic acids: Are they beneficial or detrimental to health? Prog. Lipid Res., 43(6): 553–587.
Wang YW, Jones PJ (2004). Conjugated linoleic acid and obesity control: efficacy and mechanisms. Int. J.Obes., 28: 941–955.
Wingeyer A, Amado T, Pérez-Bidegain M, Studdert G, Varela C, Garcia F, Karlen D (2015). Soil Quality Impacts of Current South American Agricultural Practices. Sustainability, 7: 2213–2242.
Wischmeier WH, Smith DD (1978). Predicting rainfall erosion losses, a guide to conservation planning. USDA Agricultural Handbook (Vol. 537). Maryland: USDA.
Woolhouse ME, Ward MJ (2013). Sources of antimicrobial resistance. Science, 341: 1460-1461.
Wu G (2016). Dietary protein intake and human health. Food Funct., 7(3): 1251–1265.
Zurbriggen C, Sierra M (2015). Redes colaborativas de conocimiento en el agro uruguayo: avances y desafios pendientes. Corporación de Estudios para Latinoamérica (CIEPLAN). CAF Banco de Desarrollo para América Latina.