Review

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

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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 (McCenna 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. Uruguayans export 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 EU 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 (HCA, 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; Wingeeyer 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). Nonetheless, 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 m²/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" (grass-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 GAP). 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 (Chiri 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 (Chiri et al., 2013; Font i Furnols et al., 2011; Garwyn 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 shear 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 prerequisite programs and Hazard Analysis and Critical Control Points (HACCP) plans in place in accordance to importers requirements. Knife trimming of visible
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, 2006; 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; Alberti 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 Sabudo, 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 as: 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 trustness.

Conflict of interests

The authors declare that they have no conflicting interests.

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