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Appearance and colour as indicators for the
evaluation of intrinsic and extrinsic factors driving
consumer preference for fresh meat

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Abstract

The quality of meat derives from a very complex production system that leads to a high variability between fresh meat samples, related to the biological variability of animals, the rearing technique and the slaughtering procedures. These factors affect the quality of meat perceived by consumers. The perception of quality, that includes information, choice of purchase and consumption, defines the overall satisfaction for a product, and the decision of future purchase. Consumers become the jury of the meat quality, so the whole industry wants to meet their needs, in order to induce consumer to buy the products. Understanding the consumer needs is the critical point of meat industry that allows comprehending the meaning of meat quality from the consumer point of view and, thus, the development of a more attractive and high quality product provided with all the information required by the consumers. Appearance and colour are the first aspects that consumers evaluate at the purchase, and they seem to be the main drivers of meat choice. But, since those aspects are subjective it is important to answer those questions: how do consumers perceive appearance and colour? What do appearance and colour communicate to consumers?

Furthermore, colour and appearance seem to be indicators of several intrinsic characteristics of meat, i.e. the correct decrease of pH after slaughtering, the type of animals, the freshness and wholesomeness of meat. So, could consumers appreciate by themselves these properties or should the industry communicate them to consumers? Is it possible to predict the eating quality evaluating appearance and colour of fresh meat? These are the questions, I tried to answer with this work.

The PhD project was developed to identify how appearance and colour could affect the judgment of consumer liking and how appearance and colour could be related and used as predictors of eating properties of meat. Two experiments were conducted to understand consumer behaviour, especially the influence of familiarity on liking. Other two experiments were developed to assess the relationship between appearance and eating quality of meat. A synthesis of each experiment is reported below.

The objective of the first work was to compare consumer liking and perception of beef quality attributes as a function of their familiarity and involvement with fresh meat.

Ninety-three meat consumers were classified on the basis of their familiarity with fresh meats. Socio-demographic differences between the clusters were found to relate to gender and age, and high familiarity (HF) consumers showed higher involvement with meat. HF consumers enjoyed consuming meat, and they associated a symbolic value to it. In addition, their liking ratings were higher than those of low familiarity (LF) consumers for both appearance and taste of three specific types of fresh meat over the course of product shelf-life. The perceived risks associated with meat consumption and product choice were similar between groups. Both consumer segments reported that the most important driver of fresh meat purchase is its appearance, while the role of extrinsic cues differed among the groups. The HF group needed more information when choosing meat. Regardless of familiarity level, liking was consistent with beef appearance as affected by storage, but the prediction of experienced sensory

quality lacked consistency when the perceived intrinsic cue variation was not associated with meat freshness.

The aim of the second study was to define a quality meat grid system based on butcher's appearance judgment as a tool to predict beef eating quality of Italian Simmental (IS) beef.

Longissimus thoracis muscle (LT) of IS steak between the 8th - 9th ribs were evaluated. First, experts developed a grid system for the evaluation of the steaks quality, then the quality of 29 IS steaks was evaluated. A trained panel performed a quantitative descriptive analysis of LT from the same 29 carcasses. The quality index identified two levels of beef quality: standard and high. Results showed that the differences in terms of quality highlighted by experts were also reflected in the cooked meat, when evaluated by a trained panel. It seems that the developed quality index is a helpful tool to valorise the IS meat, guaranteeing the eating quality of beef.

The third experiment aimed at assessing liking and preference for capretto and chevon as a function of consumer familiarity with goat meat. Five meats were produced: traditional milk capretto (MC), heavy summer capretto (HSC), summering, fall and late fall chevon. HSC was the most tender meat, having less cooking losses than both MC and redder chevon types. The instrumental profile corresponded with the appearance and texture attributes perceived by panelists. With aging of kids, meat lost its milk aroma (MC) and sweet taste (HSC) and acquired an increasing intensity of goat flavour and livery notes, partially related to feeding regime and fatty acid profile. Providing heavier carcasses outside the peaks of festival demand is promising for the goat industry, because a niche market preferred chevon over capretto. While the cluster of consumers who were unfamiliar with chevon showed a decrease in pleasantness when tasting chevon, the familiar group reduced their ratings only for meat from the oldest kids.

The aim of the forth experiment was to measure the sensory variability of varying types of cattle meat, in terms of age and gender, and to evaluate the prediction power of visible spectrum analysis in defining the sensory proprieties. 24 lots of cattle meats, veal (V), beef from young bull (B) and heifer (H), were considered. Quantitative descriptive analysis (QDA), due by a trained panel, and reflectance spectra of visible space were recorded. The data set was divided into calibration set (18 samples) and validation set (6 samples) for external validation. PLS-1 was performed for each sensory attribute, in order to estimate the best prediction model, considering the coefficient of prediction Q^2 . In the second step, the performance of the models was evaluated using the validation set, considering R^2p , coefficient of determination of prediction, RMSEP, root mean square error of prediction and SEP, standard error of prediction. The visible spectra showed very good prediction capacity ($Q^2 > 0.7$) for some sensory attributes: colour hue, beef flavour, whey flavour, coarseness. These results were confirmed in the validation phase. Juiciness also was a predictable attribute, but limitations in the validation phase has been detected. As expected, tenderness is not related to the visible spectra. The full Visible light spectrum is needed in order to obtain a good regression model for flavour attributes and coarseness.



Other sensory attributes, as juiciness and colour hue, gave a better prediction model when some specific wavelengths were chosen.

Concluding, the differences in consumers' involvement and familiarity for meat were reflected in their choice, preference and liking, when products with different sensory proprieties were presented. Appearance and colour resulted important attributes that would drive the choice of product. However, more and reliable information are needed by consumer, considering their insecurity at purchase. Information about sensory profile of meat could be a way to differentiate the meat market and could help consumer when they have to buy fresh meat. Expert guide and judgments, as well as visible spectra, are good predictors of the intensity of some sensory attributes.

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I. Introduction

Meat demand and consumption are very high in most developing countries, with an increasing demand by consumers for high quality products with enhanced safety and healthiness (Grunert, 2006). Meat and meat products are an important source of protein in human diets, and their consumption depends on socio-economic factors, ethic or religious beliefs and tradition (Font i Furnols & Guerrero, 2014). Meat purchasing decisions are influenced by colour more than any other quality factor because consumers use discoloration as an indicator of freshness and wholesomeness (Mancini & Hunt, 2005). Nevertheless, meat is a very heterogeneous product since the chemical composition, technological and sensory attributes are highly influenced by pre-slaughter (breed, sex, age, weight and environment) and post-mortem factors (storage time, temperature) (Prieto, Roehe, Lavín, Batten & Andrés, 2009).

1. COLOUR AND APPEARANCE

The visual sensation is the first one that arises from food products. Colour and appearance are used by consumer to define the initial quality of the products, and its acceptability play a major role in the purchase decision, in intent of purchase, especially for fresh food such as vegetables, fruits, fishes and meats. Indeed, it is an important component of quality throughout the agricultural and food industries, because colour is closely associated with factors such as freshness, ripeness, desirability, and food safety (McCaig, 2002). Colour and appearance are the primary indicators of perceived quality and affect the expectations about food taste properties (Girolami, Napolitano, Faraone, Braghieri, 2013; Lawless, & Heymann, 2010). Several studies have shown how colour could affect the perception of other properties, like flavour and taste. Therefore, it is very important that the sensory specialist knows how to ask panellists to evaluate product appearance and colour and how to perform sensory tests to minimize the subjects' colour and appearance biases from affecting the sensory results of other modalities.

1.1 Definitions

Appearance is defined as the information perceived through the eye, including colour, physical form (shape, structure, surface and texture) and temporal aspects, i.e. movement and optical properties colour and relationship with surrounding context (Hutchings, 1999; Girolami et al., 2013). In meat context, visual appearance characteristics refer to colour, fat content, marbling, drip loss (Font i Furnols & Guerrero, 2014). Appearance, as a primary physical characteristic of food, is extensively studied for its relationship with the affective response of food in the area of the sensory evaluation. That is not only because appearance can indicate food quality, such as food defects, freshness, and tastes learned from previous experience, but also because it reminds people of various concepts that may be moral related or others. For instance, it is reported that little meat eating women are likely to feel disgusted and

disappointed toward pictures of meat products, which is interpreted as moral attitude towards the associated image of animal blood and death (Jiang et al., 2014).

Colour is an aspect belonging to the most complex vision phenomena. The term “colour” has different meanings. It is used to denote propriety of an object, it refers to a characteristic of light rays and it specifies a class of sensation (Nassau, 1997). In the present work, colour is the characteristic of an object, whose expression is the contemporaneity of three elements: the light, the viewer and the object (Moëvi, 2006). Colour is the perception in the brain that results from the detection of light after it has interacted with an object. The perceived colour of an object is affected by three entities: the physical and chemical composition of the object, the spectral composition of the light source illuminating the object, and the spectral sensitivity of the viewer’s eye(s). Changing any one of these entities can change the perceived colour of the object (Lawless & Heymann, 2010).

The light that an object reflects is detected by eye(s) and interpreted by the brain, leading to the perception of the colour, after the stimulation of photoreceptors in the retina. Colour arises when an electromagnetic radiation at some wavelengths in the visible spectrum (360-740 nm) interacts with the photoreceptors in the human eyes. The chromatic receptors contain light-sensitive pigments and generate electrical nerve impulses which travel along the optic nerves to the brain. The wavelengths in the visual portion of the electromagnetic spectrum that are not absorbed by the viewed object are seen by the eye and interpreted by the brain as colour. In other words, an object is white when all the energy in the visible spectrum is reflected, while it is black when it is all absorbed (AMSA, 2012).

2. MEAT COLOUR

Meat colour depends of the chemical state of myoglobin (Mb) and its amount. Factors determining the quantity of myoglobin are species, breed, sex, age, type of muscle and training. In general, a high level of muscular activity evokes the elaboration of more myoglobin.

The physical characteristic of meat (i.e. pH, water holding capacity and the light scattering) could affect the colour and apperance of meat. Mb states in fresh meat are Deoxymyoglobin (DeoxyMb), Oxymyoglobin (OxyMb) and Metmyoglobin (MetMb) (Lowrie & Ledward, 2006).

2.1 Myoglobin and its forms

Some heme proteins – hemoglobin, cytochrome C and, especially, myoglobin – are responsible for meat colour. Mb is the major pigment in beef, lamb and pork, where it represent the 70-90% of the heme proteins (Fox, 1987). Myoglobin is a water-soluble protein comprising of 153 amino acids (MW=17800 Da), and containing 8 α -helices (often labelled A-H) linked by short nonhelical sections. Histidine (HIS) plays an important role in the protein’s structure and function. Prosthetic heme group, containing a centrally located iron atom, is positioned in the protein’s hydrophobic core. Of the six bonds associated with this iron atom, four connect iron to the heme ring, the 5th attaches to the proximal histidine-63,



and the 6th site is available to reversibly bind ligands, including diatomic oxygen, carbon monoxide, water, and nitric oxide (Mancini & Hunts, 2005). The ligand present at the 6th coordination site and the valence state of iron determine meat colour via four chemical forms of myoglobin: deoxymyoglobin (DMb), oxymyoglobin (OMb), carboxymyoglobin (COMb), and metmyoglobin (MMb) (AMSA, 2012).

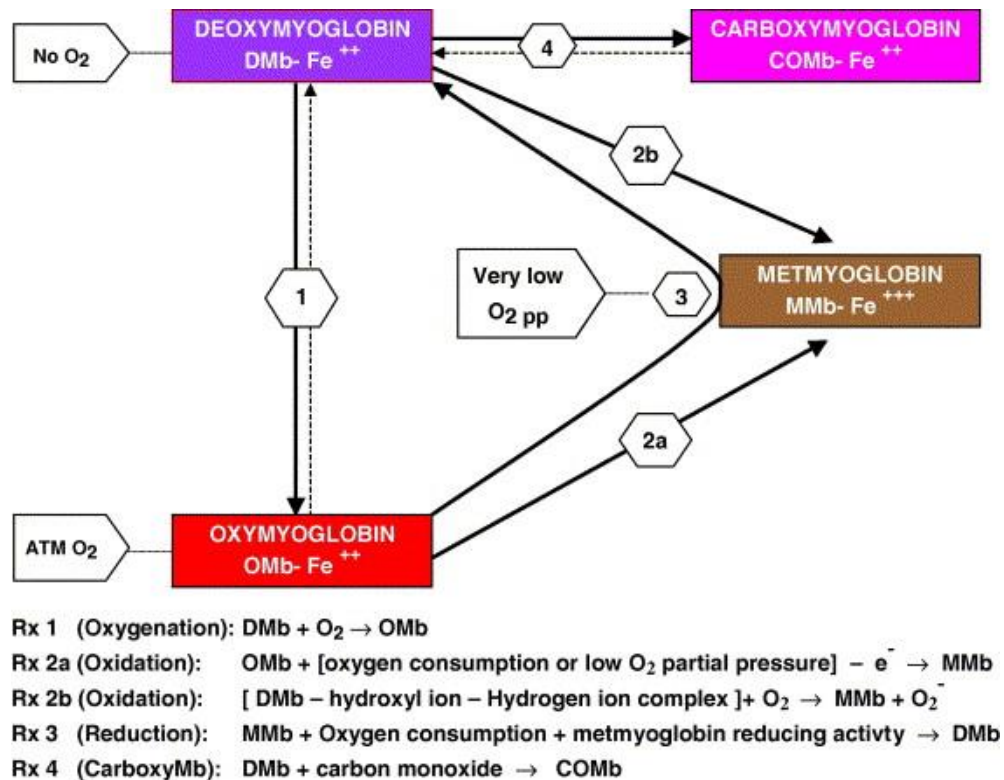


Fig. 1 Visible myoglobin redox interconversion on the surface of meat (Mancini & Hunt, 2005)

Deoxymyoglobin occurs when no ligand is present at the 6th coordination site and the heme iron is ferrous (Fe^{2+}). The colour of meat is defined as purplish-red or purplish-pink, the colour of muscle immediately after cutting or of meat vacuum-packaged, because the maintenance of this state of myoglobin requires a very low oxygen tension. The oxygenation or blooming depends on time, temperature, pH and competition for oxygen by mitochondria (reaction 1 in fig.1). When the oxygenation occurs, there is no change in iron's valence, although the 6th coordination site is occupied by diatomic oxygen (blooming). The colour of oxymyoglobin (Fe^{2+}), the oxygenated form of myoglobin, is described as bright cherry-red colour, which is appreciated by consumers. The thickness of the oxymyoglobin layer depends mostly on the oxygen partial pressure and the competition for oxygen by other respiratory processes (Mancini & Hunt, 2005). The oxidation of both ferrous myoglobin forms deoxy- and oxy-myoglobin causes to discoloration, generating the metmyoglobin form (reaction 2a & 2b, Fig.1). This autoxidation leads the conversion to the ferric state (Fe^{3+}). The conversion in metmyoglobin depends on numerous factors including oxygen partial pressure, temperature, pH, meat's reducing activity and microbial growth (Gorelik & Kanner, 2001).

Enzyme activity and NADH pool availability decrease with increasing post-mortem time. These two elements are crucial to maintain the colour of meat. Before the conversion of oxymyoglobin in deoxymyoglobin (reaction 3, Fig.1), it forms the ferric redox state at low oxygen partial pressures. Endogenous removal of oxygen to achieve low oxygen partial pressures occurs via oxygen consumption, which results in oxidation of OMb and MMb. At this point, the formation of DMb depends on the muscle's reducing capacity, plus further reduction in oxygen tension. Carboxymyoglobin forms when carbon monoxide binds to the 6th position of DMb (reaction 4, Fig.1). It causes a very bright-red colour that is relatively stable and appreciated by consumers (AMSA, 2012). The development of COMb reached a great importance because of the new packaging systems with low levels of carbon monoxide (Hunt et al., 2004).

2.2 Factors affecting meat colour

The pigment concentration varies greatly among different meats. The factors that mainly contribute to the amount of pigments are: species (e.g. beef contains much more myoglobin than pork), breed, age (pigment concentration increases with age), gender (meat from male animals usually contains more pigment than that from female animals) and muscle function. In fact, the function of myoglobin is the oxygen storage. Therefore, muscles that do more work contain more myoglobin, e.g. leg muscles (Ranked, 2000). Other factors affecting meat colour are pH, temperature, light, bacteria, freezing conditions and type of packaging.

The variation in ultimate pH is the most known colour-affecting factor. The abnormal appearance of pale, soft, exudative pork (PSE pork) and of dark, firm, dry (DFD) can be explained in biochemical and biophysical terms. PSE pork is pale for several reasons. Firstly, while the muscles are warm, the rapid fall in muscle pH causes denaturation of muscle proteins that increase reflectivity beyond the normal reflectivity of myofibrillar proteins in rigor. Secondly, the excessive drip takes myoglobin with it. Finally, PSE conditions are more common in pig breeds whose muscles have a low myoglobin concentration, and are thus predisposed to lighter coloured meat. Dark-cutting meat is dark red for roughly the opposite reasons. Relatively non-denatured proteins are unreflective, so the meat appears darker due to absorption of light. Muscle which is deficient in glycogen because of exercise or stress prior to slaughter produces dark, firm, dry (DFD) meat. Such meat is characterized by a high ultimate pH (>6.0) and deficiencies in glucose and glycolytic intermediates. The water binding capacity of dark-cutting meat is high, so no myoglobin is lost through drip (Young & West, 2001). Moreover in superficial muscles such as the *Longissimus*, which cool rapidly on the carcass, stimulation will have a minimal effect on colour stability. In deep muscles, like the *Semimembranosus*, for which cooling occurs slowly during chilling, low pH values and high temperatures often coexist, leading to a more exudative and paler meat.

The oxygen concentration in packaging could modify the colour of meat. The absence of oxygen maintain the reduce form of myoglobin giving a purple colour of meat. The modified atmosphere

packaging (MAP) is the most used and appreciated method, because the presence of oxygen develops the bright-red colour and carbon dioxide gas is added to suppress bacterial growth (McMillin, 2008).

Aerobic bacteria consume oxygen, thus reduce the oxygen concentration causing browning. This is particularly important in minced meat, which has a large surface area. Some bacteria produce hydrogen sulphide (H_2S); this combines with myoglobin to form green sulphmyoglobin. That is the cause of 'greening' in non-eviscerated poultry and in some over-aged vacuum-packed meats. Other bacteria are responsible of colour modification: some *Pseudomonas* species cause blue and green variation and some *Sarcina* or *Micrococcus* species cause red discoloration (Ranked, 2000).

The temperature of the chilling condition modifies the rate of oxidation of the pigment to MMb. MMb concentration increases with increasing temperature. Red colour is therefore more stable at lower temperatures, because the solubility of oxygen is greater and oxygen-consuming reactions are slowed down.

Rapid freezing results in the formation of small ice crystals which cause severe light scattering, giving the meat a pale, opaque appearance. Slowly frozen meat contains large ice crystals, which causes less light scattering, so that the meat has a dark, translucent appearance. These colour changes disappear on thawing out. Meat has a better frozen colour when allowed to 'bloom' in air before freezing (Zhou, Xu, & Liu, 2010).

Light has little direct effect on the colour of fresh meat at chill temperatures but care should be taken in a way that high illumination does not cause a rise in temperature due to a 'greenhouse' effect in the package. Even in a chill cabinet, light energy absorbed through the transparent film may cause the product temperature increase, above the ambient air, and the meat may therefore become warm. Ultra-violet light causes protein denaturation, which will result in browning in the longer term. In frozen meat, light accelerates discoloration. Products should therefore be covered during frozen storage, to protect them against the normal lighting in the cold store (Ranked, 2000).

2.3 Colour measurements

The Munsell system was invented by the American artist A. H. Munsell around 1900, prior to the advent of instrumental techniques. The Munsell system had three attributes: hue (H), value (V), and Chroma (C). A specific colour was described as a point in the three dimensional space. In 1931, the Commission Internationale de l'Eclairage (CIE) developed the tristimulus values XYZ. The reason why the CIE $L^*a^*b^*$ system was developed in 1976 is that the XYZ colorimetric distances between the individual colours do not correspond to perceived colour differences (Lawless, & Heymann, 2010). In 1976 the three-dimensional Lab colour space (or CIELAB colour space) was developed. In this system, the colour differences one perceives correspond to distances, when measured colorimetrically (Sharma, 2003). Perceptible colour has hue, lightness, and saturation properties. Hue is the colour description as we communicate it in language (red, yellow, green, blue, etc.). Hue is developed by the specific wavelengths reflected from a meat surface back to the detector. Lightness describes the brightness or darkness of



the colour. Saturation refers to how vivid or dull the colour is (Pérez-Alvarez & Fernández-López, 2009). Many methods have been established that measure or describe colour (Gilchrist & Nobbs, 1999). The development of the CIE $L^*a^*b^*$ colour space allowed colour to be expressed in a three dimensional space (Fig.2). The combination with optic response of the human eye and the calculation of L^* , a^* , b^* values establish a three dimensional colour space (CIE, 1986). In the agricultural and food industries, CIELAB system is the most popular numerical colour-space system (McCaig, 2002). For the colour space, a^* values are represented on the X axis, b^* values on the Y axis and L^* values on the Z axis (Fig.2). In the centre of the colour space is neutral grey. Along the a^* axis (X axis), a positive a^* represents the red, and a negative a^* represents the green (scale from red to green). Along the Y axis, a positive b^* represents the yellow, and a negative b^* represents the blue (scale from yellow to blue). The third dimension L^* is represented numerically where 100 is white, and 0 is black. For this colour space, the a^* and b^* values can be plotted to establish the colour or hue of a meat sample (AMSA, 2012).

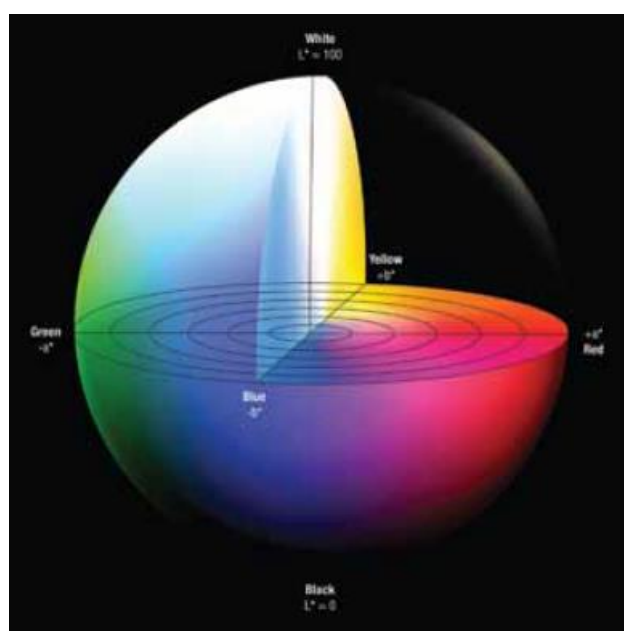


Fig.2 Representation of colour solid for CIE $L^*a^*b^*$ colour space (Konica Minolta Sensing Americas, AMSA, 2012).

Optical methods have the advantage of being non-destructive, fast, inexpensive, and are considered suitable for online measurement. The colour of foods can be studied in two main ways: by chemically analysing the presence of pigments, or by physically measuring the interaction of light. Meat colour is measured for many reasons, including grading, matching customer specifications, measuring consumer response to colour, measuring colour changes (e.g. during shelf-life) and determining the causes of discoloration. Meat mainly reflects light in a diffuse way from the surface. However, there is some spectral reflectance from the glossy surface of wet meat, and since meat is partially translucent, a portion of the incident light is transmitted below the surface and reflected internally. When the reflected colour of meat is assessed or measured, samples must be sufficiently thick to ensure that no

light is reflected from the background. Above all, the measurement of meat colour demands a systematic approach to data collection, whether colour is scored by a sensory panel or instrumentally measured (Young & West, 2001).

2.3.1 Instrumental analysis

The total light energy emitted from a source or falling on a surface can be measured. This total energy can cover a portion of the spectrum including ultraviolet and infrared energy. Energy at an individual wavelength or over a range of wavelengths can be measured (Minolta, 2014). Instrument packages come in two major classes capable of measuring colour: the colorimeter and the spectrophotometer (AMSA, 2012). Colour-measurement instruments are widely used throughout the food and agricultural industries to monitor colour of products such as meat (Wulf & Wise, 1999), coffee (Ortola, Londono, Gutierrez, & Chiralt, 1998), tea (Joubert, 1995) and cheese (Drake, Chen, Gerard, & Gurkin, 1998). However, the prediction of meat quality using spectroscopy is more accurate and efficient than working only with colour values (Xing et al., 2007).

Colorimeter is the instrument that is used to assess the colour of samples, based on the three-dimensional space (CIELAB systems). The tristimulus method uses a light source that illuminates the sample and it is then reflected through red, green, and blue filters onto photo-detectors (MacDougall, 2002). The results expressed by these instruments consist in three numbers on a display that needs to be interpreted by experts in order to define the chromatic profile of meat (Joshi & Brimelow, 2002). Some advantages of these instruments are that they are portable, economic and non-destructive on samples or on carcasses. The descriptions of colour differences between samples are often reported as values of the L^* , a^* , b^* coordinates. Reflectance spectroscopy is the major remote-sensing technique used to study the chemical composition and microstructure of various light-scattering media. The reflected light spectrum is measured and used to decode the relevant information with respect to the inherent properties of a food layer in the framework of the radiative transfer theory (Pérez-Alvarez, & Fernández-López, 2009). The reflection spectra represent the spatial distribution of radiation bands separating the monochromatic components, thus permit the composition of the whole band to be understood. A spectrophotometer grating is an optical component with a periodic structure, which splits and diffracts light into several beams travelling in different directions. The grating separates different colours of light much more than a prism. Even a single wavelength of light can be further diffracted. The resolution of spectrophotometers can vary from 2 to 10 nm. Several studies suggested that starting from the analysis of visible space, it is possible to determine the concentration of the three forms of myoglobin and their percentage. Indeed, several isobestic points were found in beef, poultry and pork (Pérez-Alvarez, & Fernández-López, 2009). However, Khatri and colleagues demonstrated that several regions in the whole spectra from 400 to 1100 nm (VIS-NIR spectrum) contribute to the predictive ability for the three states of myoglobin (Khatri et al., 2012). NIR spectroscopy is one of the techniques that

utilise the vibrational energy transitions of molecules. In the near-infrared reflectance (NIR) region of the electromagnetic spectrum, which is defined from 780 to 2,500 nm, molecular vibrations that are overtones and combinations of the fundamental vibrations of the mid-infrared (IR) spectral region are found. The vibrational frequencies depend on the force constant of the molecular bond and the masses of the two molecules constituting the bond. Thus, NIR analysis provides complete information about the molecular bonds and chemical constituents. This method can be useful for quality control and it has recently been used to predict meat quality, in terms of chemical composition, physical properties and sensory attributes (Prieto et al., 2009).

Computer vision has the ability to inspect samples and to analyse differences among samples or regions within a sample. Although originated in the 1960s (Baxes, 1994), computer vision is a relatively new technology for food industry. The development of computer vision is based on the hardware and learning algorithms, and the technique can be used to extract and to analyse useful information from agri-food products to perform detection, recognition, and classification. Computer vision is capable of estimating shape, size, and position consistently and rapidly. With developments of new algorithms and the improvement of computer hardware, the sensitivity and ranges have been widened for samples of larger size and more complicated shape. Therefore, computer vision has been extensively applied for food quality assessment, including meat and meat products (Antequera et al. 2007; Chmiel et al. 2011). The basic image processing procedure of a computer vision system is mainly composed of image acquisition, pre-processing, segmentation and recognition, among which segmentation is the most important step for extracting the region of interest. The technology of computer vision can be developed further to combine with other techniques such as spectroscopy (hyper spectral imaging) (Ma et al., 2014).

2.3.2 *Sensory analysis*

Appearance attributes clearly affect perceived colour, so appearance and colour are both important characteristics to consider during the sensory evaluation. Physical appearance characteristics can easily be measured through sensory techniques (Lowless & Heymann, 2010). Three types of sensory panels could be used to judge colour and appearance of food, including meat and meat products. The objective evaluation is performed by a trained panel. Trained panelists undergo rigorous screening and training to obtain quantitative ratings of samples on anchored scales. These panelists should not be asked to rate personal preferences or acceptability of the samples they evaluate. Standard descriptive techniques can quantify size, shape, and visual surface textures using simple intensity scale. The colour assessment should be standardised and controlled for several parameters, such as the background colour in the viewing area and the light source (Moëvi, 2006).

Consumer panelists, on the other hand, are used for providing information using hedonic scales of their preferences and the acceptability of the product's attributes. They are not trained, their judgement is subjective and qualitative.



An expert is defined by the American Society of Testing Materials as someone (often operating alone) with extensive experience in a product category who performs perceptual evaluations to draw conclusions about the effects of variations in raw materials, processing, storage, aging, and so on (ASTM, 2005). The expert panel has been employed in several studies, in meat research as well as in other food items, e.g. beer (Valentin et al., 2007) and wine (Gawel & Godden, 2008; Ballester et al., 2008). In the meat sector, several classification and grading schemes have been developed and applied in the quality assessment of fresh meat. These aspects will be further discussed in paragraph 2.4.

The particular research question determines which type of panel can provide the right answer. Type of scale and standard could not be generalized, but is defined based on the experiment's goals. Colour guidelines provided by AMSA (2012), reported several standard and scale to score colour and appearance characteristics as well as hedonic scale for consumer panel.

2.4 Meat standard and grading

Meat standards and grading systems are globally applied to meet consumers' needs and for a more accurate value-based payments framework. The development of carcass classifications and grading schemes evolved from a necessity to describe the carcass using standard terms to facilitate trading. The growth in the world trade of meat and meat products and the transition from trading carcasses to individual meal portions raise the need for an international language that can service contemporary needs (Polkinghorne, & Thompson, 2010). Early grading systems only described intact carcasses with various traits such as carcass weight, age or maturity of the animal, gender, fatness and fat. Marbling and lean colour have been added as quality traits. Those schemes with a yield component are used to predict the saleable meat. Several countries developed their own standard and carcass grading schemes. In their review, Polkinghorne and Thompson (2010) summarised the carcasses evaluation systems that have been developed around the world, such as in Canada, Europe, Japan, South Korea, The Republic of South Africa, USA and Australia. Recently, a growing awareness to predict quality assurance for consumers has been developed in several countries. The USA beef industry developed some critical control point planes, in order to guarantee a total managing approach that led to the assurance of meat palatability (Simth et al., 2008). The most consumer driven system is the one adopted by Australia. The MSA system classifies individual beef muscles into eating quality grades, taking into account the cooked methods as well. On the other hand, reliable systems guaranteeing eating quality at the consumer level are still lacking, in spite of numerous private and official quality marks exist at the consumer level (e.g. "Label Rouge" in France or "Celtic Pride Beef" in Wales).

3. CONSUMER PERCEPTION ABOUT MEAT

Consumer's demand is addressed to high-quality products with enhanced safety and healthiness and to food product systems with sustainable agricultural practices (Grunert, 2006; Verbeke et al., 2010).



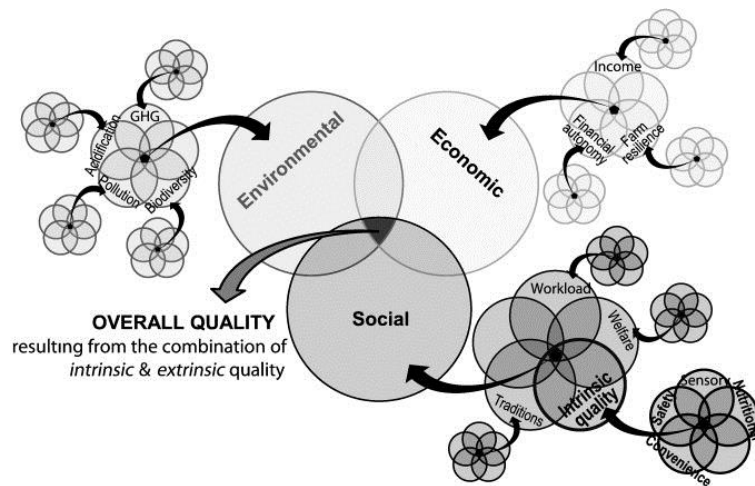


Fig.3 From intrinsic to extrinsic quality of beef (Botreau, personal communication: in Houquette et al., 2012)

Food quality is a complex concept that is frequently measured using objective indices related to the nutritional, microbiological or physicochemical characteristics of the food, or in terms of the opinions of designated experts. Consumer's perception of meat and meat products is a critical issue for the meat industry because it directly impacts its profitability. Many studies have concluded that consumer perception is both complex and dynamic therefore difficult to define. Various models of food quality have been proposed (Grunert et al., 1996; Peri, 2006). Peri (2006) divided the concept of product as a food (i.e. safety nutrition, sensory and ethical) and as an object of trade (certification, traceability, convenience and price). The quality model represented by Grunert et al. (1996) distinguished the quality characteristic of product, before and after the purchase. At the purchase, consumer evaluated costs, intrinsic and extrinsic quality cues, while the quality traits after purchase evaluated by consumers are meat preparation, experienced quality and sensory characteristics. In all models, quality cues are taken into account and contribute to the function of beliefs and, therefore, to the purchase choice. Recently, a model built to explain the overall quality of beef was reported by Houquette and collaborators (2012). The model that summarises the role of intrinsic and extrinsic quality traits is reported in Fig. 3. Quality in this scheme is considered as a convergence between end user's wishes and needs on the one hand, and the quality attributes of fresh beef and beef products on the other hand (Houquette et al., 2012). However, some, although not all, the quality attributes can be evaluated by the consumer at the moment of purchase.

The main factors affecting the consumer behaviour at purchase are schematised in Fig.4. Consumers are the last step in the production chain, and the match or mismatch between expectation and experience lead to consumer satisfaction or dissatisfaction and willingness to purchase the product again (Houquette et al., 2014). Thus, it is important to understand which factors affecting the consumer behaviour. Three main factors interact with each other to form the consumers' behaviour: psychological (individual factor), sensory (product-specific factor) and marketing (environmental factor). The weights that consumers associated to each factors depend on the subject, the context, the culture and so on.

Understanding individual differences in expectations is critical for segmenting the consumer population into specific target audiences. The product developer should strive to be aware of these individual differences and how they influence the perception and/or processing of product information. In such a way, marketing communications about the product can be tailored to specific consumer segments, thereby maximizing expectations and their impact on purchase behaviour (Cardello & MacFie, 2007).

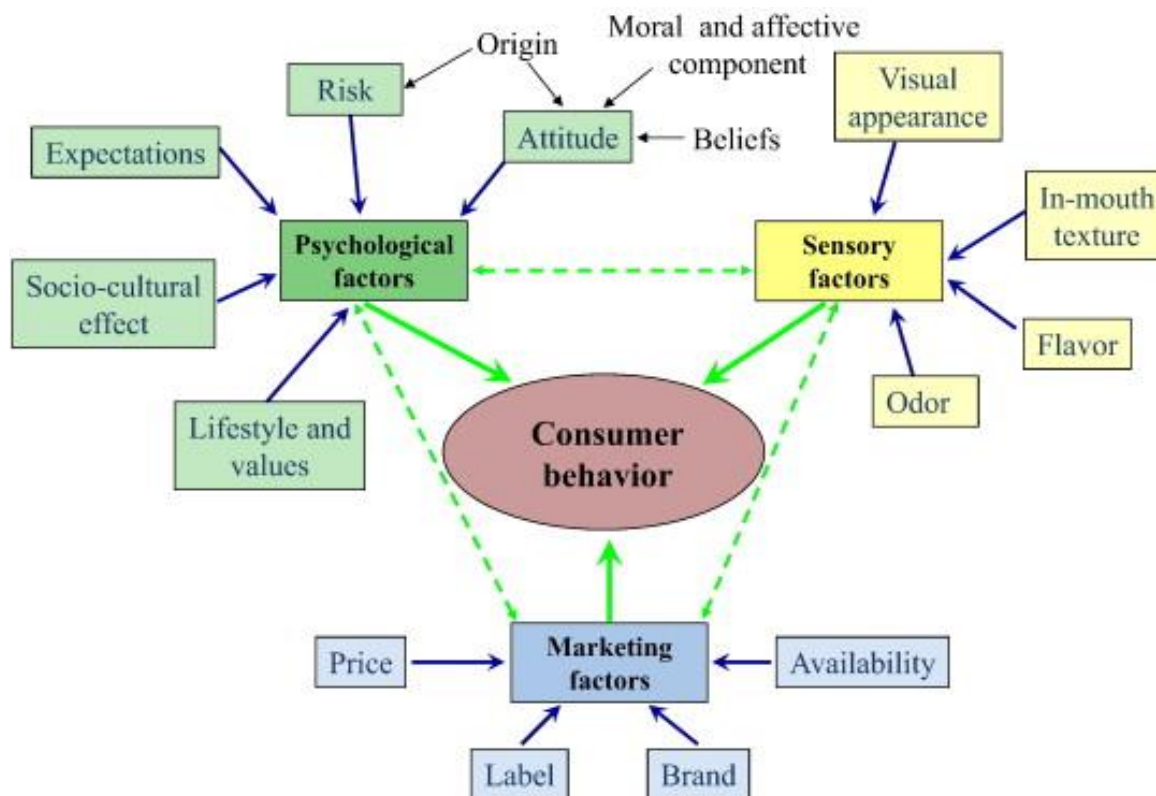


Fig.4 Multidisciplinary model of the main factors affecting consumer behaviour in food domain (Font i Furnols & Guerrero, 2014)

3.1 Psychological factors

Individual beliefs, attitudes and expectations, as well as personality traits, have plenty of potential to interact with the acceptance of foods. Their importance grows in the wealthy Western countries, in which the supply of food is large and abundant product information is available (Tuorila, & MacFie, 2007). Thus, consumers are segmented based on their values, attitudes, personality traits and other mental constructs. Beliefs represent an individual's perception of the relationship between the given object, action or event and the particular attribute associated with it (Smith et al., 2012). Beliefs information is a dynamic process that can be developed during a whole lifetime by direct observation and experience, by external information and by inference (the connections between previous knowledge and experience). Attitudes refer to a person's feelings toward and evaluation of an object, person, issue or event. The distinctive nature of an attitude is its affective /evaluative nature (Font i Furnols & Guerrero, 2014). Expectation could be defined as a group of feelings and/or beliefs inherent to humans and concerning the likelihood that something will happen in certain way or that a product will have certain characteristics. Expectation implies anticipation and some degree of rational thinking,

and they thus include the evaluation of similar or related past experiences and available information. They are, therefore, subjective (Cardello, 1995; Font i Furnols & Guerrero, 2014).

Nowadays, the consumer's decision to eat meat is gradually becoming more influenced by nutrition and health consideration than by safety concern (Verbeke et al., 2010). Meat is a rich source of proteins and vitamins, but it is often associated to a number of unfavourable health conditions, such as chronic diseases and some types of cancer. The recommendations suggest that moderate consumption of fresh red meat is desirable for the prevention of colorectal cancers (Demeyer et al., 2008).

Sustainability, animal welfare, ecological component and preservation of biodiversity are growing interest among the consumers (European commission, 2006). Intensive livestock affect the environment, generating large volumes of waste. Therefore, there is a growing interest toward organic production, extensive production systems and the valorisation of traditional breeding (Troy & Kerry, 2010; Franzluebbers et al., 2014).

Important variables to product expectation are familiarity and involvement. Consumers and food products could be classified in "Familiar" – individuals who had prior experience with a particular product – and "Not Familiar" – individuals who had never experienced a particular product. A positive correlation between familiarity and consumer acceptance has been observed in previous studies (Tuorila et al. 2008; Lawless et al., 2013). Familiarity is influenced not only by similarity in food culture, but also by information, degree of exposure and personal attitudes, such as neophobia or variety seeking (Chung et al. 2012). It is well established that eating patterns are different among different cultures (Lee et al., 2010). Acceptability for specific foods or types of food can be different among countries and cultures, but it can also vary within one culture. For example, the preferences of consumers from various countries differed for beef (Thompson et al. 2008) and lamb meat (Font i Furnols et al. 2006).

A general definition of consumer involvement refers to the level of perceived personal importance, interest or relevance evoked by a stimulus or stimuli, which are linked by the consumer to enduring or situation-specific goals. In general, when product involvement is low, consumers may not be motivated to critically think about information regarding the product, resulting in greater effectiveness of the persuasive elements in an information message (Deliza & MacFie, 1996). Involvement in fresh meat is shown to be a multidimensional construct, including the dimensions "pleasure value", "symbolic value", "risk probability" and "risk importance" (Verbeke, & Vackier, 2004).

Researches have focused on several aspects of consumer's attitude and behaviour, developing several verbal scales as tools to measure it. The most used scales are the food neophobia scale, the food choice questionnaire, the health and taste attitude scale and the involvement scale (Tuorila, 2007).

Consumers' quality expectation for meat and meat products is very difficult to form, especially for fresh meat, for which little information is provided. The formation of quality expectation for fresh meat is based on labelling and appearance. The uncertainty that consumers show when they have to choose



meat, explains the importance of the butcher's role and its advice. That's why consumers prefer to delegate the purchase decision to an expert, who is supposed to be more competent at predicting the quality of products (Grunert et al., 2004).

3.2 Sensory properties of meat

All sensory modalities are involved with the perception of food. Visual perception or olfactory signals are often the first to provide information about the quality of food. Other sensory modalities come into play when the food is touched, tasted or eaten, and later inputs complement or revise the early visual and olfactory information. These five modalities act in a multimodal manner. Thus, several modalities participate in the observation or identification of food, supporting each other's perceptual outcome (Tuorila, 2007). Starting from that standpoint, visual appearance, odour, flavour and texture of meat play the same role in the sensory enjoyment. However, the preference for the sensory characteristic is not homogenous among consumers.

The colour and appearance of meat are the first signal at the purchase and are related with consumers' expectation about meat quality (Banović et al., 2012; Troy & Kerry, 2010), although colour is not always related to eating satisfaction (Carpenter et al., 2001). As meat acceptability depends on psychological factors, preference and liking for colour vary between and within countries (Prescott et al., 2004).

The importance of fresh meat colour as a quality trait should be seen in the context of the overall appearance, considering the influence of other factors such as fat and marbling (Troy & Kerry, 2010). Fat colour, fat content and marbling are strongly related to the acceptability of meat. Consumers are negatively influenced by the presence of fat cover or marbling, because of its unhealthy proprieties (Font i Furnols & Guerrero, 2014). The lean meat is generally preferred to fatty meat, although in some countries, such as Japan or South Korea, fatty pork is preferred over lean pork (Ngapo et al., 2007). On the other hand, the positive effect of marbling or intramuscular fat in eating quality and palatability has been established. Indeed, fat and marbling are related to flavour, tenderness and juiciness, and thus likely to increase palatability (Miller, 2002). Additionally, fat colour could vary from white to yellow-orange – according to the type of feeding (forage vs. concentrate) and the biological ability of the animal to convert fat-soluble compounds as carotenoids – to other forms almost colourless (Kauffman & Marsh, 1987).

The quality experienced by consumers involves the flavour and texture perceptions of meat. The flavour of raw meat is bland, slightly metallic and bloody like. The development of complex meat flavours occurs only after thermic treatment. Several reactions take place during cooking that involve non-volatile compounds of the lean and fatty tissue. Lipid degradation and Maillard reactions lead to several flavour compounds that could react between each other and generate thousands of volatile compounds (Mottram, 1998). Meat flavour is characteristic of species, so beef, pork and lamb meats are clearly distinguished after cooking. As for fat colour, the feeding regimen affects the meat flavour. In fact, grass-fed lamb is characterised by a more intense mutton odour and flavour, as compared to meat



obtained from grain-fed animals (Sañudo et al., 2007). Moreover, the older an animal is, the higher the intensity of the species-specific odour or flavour becomes; the difference between Capretto and Chevron is well explained by Dhanda et al. (1999), which describes some changes that occur in meat at different stages of the animal growth.

In general, the main determinants of meat tenderness are the extent of proteolysis on key structural proteins and the degree of shortening of the muscle fibres. Most evidence points to the calpains as the main proteomes involved in post-mortem tenderisation (Dransfield, 1993). Tenderness and juiciness are positive quality proprieties that affect eating satisfaction (Thompson et al., 2005). In a recent study, Ngapo et al. (2013) found that aging time positively affects the perception of tenderness by consumers. With the increasing of aging in pork, the liking scores of tenderness increase. Moreover, a gender factor affected the tender scores, indicating that castrated males provide harder meat than gilts do. Consumer tenderness scores were higher also in more aged cows (Vitale et al., 2013), while the tenderness of light and concentrate-fed lambs was preferred to heavy and grass-fed lambs (Font i Furnols et al., 2009). Moreover, tenderness and juiciness are positively correlated with intramuscular fat content and type (O'Quinn et al., 2012).

3.3 Marketing factors

Information about meat and meat quality provided to the consumers come from adverts, labels, brand and information campaigns. These information are used by consumers, along with other previously described factors, to create quality expectations. Expectations affect choice of the product, purchasing decision and willingness to pay (Font i Furnols & Guerreo, 2014). Price is an important quality cue related with consumers' purchase decision. In fact, low price is often associated to low quality product. High prices generate high expectations of quality in terms of taste, environment and safety. The willingness of consumers to spend more or less for meat products is highly related to demographic characteristics (gender, age and income). In fact, a lower price is preferred by consumers with a low purchase power or those for whom the meat type is not an important issue (Font i Furnols, et al., 2011). Consumers may willingly pay a premium for products with more appreciable texture (i.e. tender and juicy meat) (Verbeke et al., 2010) or derived from organic production (Napolitano et al., 2010).

Among the quality labels and certification due by governments, branding origin indications are the most appreciated aspects by consumers, who used this information to infer expected beef quality (Verbeke & Ward, 2006). The development of quality labels in Europe was initially motivated by the desire to protect famous geographical names, by providing higher/typical quality form consumers' standpoint and by the need of sustainable agriculture. Thus, Europe promotes and encourages the development of rural areas and national regions. This promotion is aimed at the preservation of biodiversity and the maintenance of landscape variety and natural resources, as well as the maintenance of rural areas dynamics (Houquette et al., 2012). Starting from this point, three schemes were defined to promote and protect the names of quality agricultural products and foodstuffs: PDO (protected designation of origin),

PGI (protected geographical indication) and TSG (traditional speciality guaranteed). These quality labels positively influence consumers' intention of purchasing meat and meat products (Mesías et al., 2005, Sepúlveda et al., 2010).

The effect of the origin country on the consumer preferences has been widely studied, showing a higher interest for local meat products. This preference is probably related to perception of freshness, taste and high quality (Schnettler et al., 2009).

Organic production is related to food safety, nutrition, ethics, health management and environmental aspects, and thus increases consumers' preferences (Napolitano et al., 2010). Some consumers had higher expectations on eating quality for meat labelled as "organic" rather than those labelled as "conventional". However, these expectations are sometimes confirmed, and the eating quality for organic meat is higher (Napolitano et al., 2010), but some other times they are disconfirmed, and the eating quality is thus lower than expected (Verbeke et al., 2010). Usually, animals for organic production are raised on pasture and use outdoor areas. The pasture affects the taste of meat in terms of flavour and texture. So, some consumers appreciated that and other consumers could dislike it (Font i Furnols et al., 2011).

Finally, the interest for halal meat is increasing in the Western countries, because of the growing numbers of Muslim consumers. Especially, young and female Muslim consumers are in favour of a label not only as a guarantee for meat wholesomeness, but also as an assurance of the halal status of meat. They also showed their interest in willingness to pay a premium for certified halal labelled meat (Verbeke et al., 2013).

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II. Aim

Appearance and colour of fresh meat are the key points of this work. They are the main intrinsic cues that consumer evaluates at the purchase. Starting from the visual analysis of the product, consumers generate expectation for the eating quality of meat by using their own previous experiences. They make their choice, linking their experiences to their knowledge, credence, believes and attitudes. However, the low degree of differentiation in the meat market let consumer confused and disoriented. Consumers need more information about products and their eating quality. Indeed, both expected and experienced quality affect product acceptance that vary with the consumers' degree of product-related experience. The consumer's perception of overall quality generates the future decision of product purchase.

Thus, the aim of this work was the study of meat appearance and colour: how they affect consumer liking and preferences, and how they could be used to predict sensory eating proprieties. In particular the study was divided in four experiments, where:

1. It has been investigated the involvement profile of fresh meat consumers, their familiarity with meat product and the importance of several extrinsic and intrinsic product quality cues. In addition, we investigate how different levels of product familiarity influence consumers' cattle meat liking.
2. It has been developed a quality meat grid system based on appearance of meat guaranteeing beef eating quality.
3. It has been evaluated the most important properties of representative types of goat meat and investigated the variability and structure of liking for goat meat by consumers, considering the differences in familiarity with the product.
4. It has been measured if sensory proprieties could be predicted starting from visible spectrum in different cattle meat.



III. Experiment 1

THE ROLE OF PRODUCT FAMILIARITY AND CONSUMER INVOLVEMENT ON LIKING AND PERCEPTIONS OF FRESH MEAT

1. INTRODUCTION

Familiarity is one of the most important drivers of preference for food products, because it reduces product uncertainty and leads to a more likely match between expectations and product characteristics (Deliza & MacFie, 1996; Tuorila, Meiselman, Bell, Cardello, & Johnson, 1994). Familiarity may change consumers' risk perception, lowering concern about possible negative effects of the products and reducing consumer scepticism (Verbeke, Scholderer, & Lahteenmaki, 2009). Consumers' familiarity and expertise with a product category are a key moderator of the role played by extrinsic cues in the choice utility function (Chocarro, Cortiñas, & Elorz, 2009). For example, Bancović and collaborators (2012) segmented consumers on the basis of their familiarity with specific meat cuts, finding differences in their use of intrinsic and extrinsic cues in beef quality perception (Bancović, Aguiar Fontes, Barreira, & Grunert, 2012). On the other hand, habitual behaviour in purchase decisions are often made with little or no conscious effort (Alba & Hutchinson, 1987). To assess the degree to which consumers are habitual or more thoughtful in their decision-making, food involvement scales have been developed by which it is possible to assess the interest of consumers in specific foods or food categories (Laurent & Kapferer, 1985). Consumer involvement is defined as "the level of perceived personal importance, interest or relevance evoked by a stimulus or stimuli, which are linked by the consumer to enduring, situation-specific goals" (Verbeke & Vackier, 2004). Verbeke and Vackier (2004) classified consumers on the basis of their involvement with fresh meats, a multidimensional construct that includes pleasure value, symbolic value, risk importance and risk probability. Differences in the involvement profile can lead to differences in consumer attitudes toward meat, i.e. extensiveness of the decision-making process, impact and trust in information sources, levels of concern etc. Moreover, different levels of involvement with food have been related to different consumer profiles, allowing the identification of specific target consumer profiles, enabling food companies to develop specific marketing programs for these different consumer groups and to focus marketing activities on specific market segments (Drichoutis, Lazaridis, & Nayga, 2006). For example, Australian consumers, classified in terms of their fish consumption, were found to have different levels of food involvement. Higher consumption of fish was associated with higher levels of hedonic and symbolic value and a greater product importance than lower consumption (Brich & Laweley, 2014).

The objective of the present work was to investigate the involvement profile of fresh meat consumers and to evaluate the importance of several extrinsic and intrinsic product quality cues for consumers with

either high or low meat familiarity. In addition, we investigate how different levels of product familiarity influence consumers' beef quality evaluations and, particularly, the liking for fresh meat appearance and taste. While appearance, especially colour, is the most important intrinsic quality cue related to consumers' quality expectation of meat, taste is related to consumers' post-consumption quality experience. Both expected and experienced quality affect product acceptance and vary with the consumers' degree of product-related experience (Banović et al., 2012).

2. MATERIALS AND METHODS

2.1 Meat types and experimental design

In order to take into account meats with different appearance, three categories of cattle meat, veal (V), beef from young bull (B) and heifer (H), were considered and evaluated during their commercial shelf life at three predetermined intervals after packaging: 1, 3 and 6 days. The nine meat types were produced and packaged on different days, to be evaluated simultaneously on the same day. This experimental design was replicated three times during three consecutive weeks, using three different complete lots of samples. The supplier guaranteed the standardization of the feeding regime, the slaughtering of animals, and the processing procedures of meat, within and between lots, during the experiment. The cuts of meat were those available on the Italian market and were randomly presented among experimental groups. The top (also known as the inside) round cut, containing primarily the semimembranosus, sartorius, adductor, gracilis and pectineus muscles, was sliced into steaks (2.54 cm thickness) that were placed in polystyrene/ethylvinylalcohol/polyethylene trays and packaged by modified atmosphere technology. Trays were flushed with 80% O₂:20% CO₂.

2.2 Selection of consumer panelists

The consumers were recruited from a mailing list of workers and students at the University of Udine, Italy. They were selected according to two major criteria: eating meat regularly and having responsibility for home food purchases. Respondents were interviewed by phone about their frequency of consumption of 11 types of fresh meat (7-point category scale: 1 = never; 2 = once a month or less; 3 = two–three times a month; 4 = once a week; 5 = two–three times a week; 6 = once a day 7 = more than once a day) and whether they usually purchase food for the home (I usually buy food, I sometimes buy food, I never buy food). Consumers who reported to eat fresh meat at least two/three times a month and who also were responsible for home food purchases were selected for further participation (Dinnella, Torri, Caporale, & Monteleone, 2014). This frequency of consumption, lower than those recommended by World Cancer Research Fund and American Institute for Cancer Research (2007), was chosen in order to engage consumers aware of fresh meat. Ninety-three consumers of meat, 31 each week, were assigned to participate in the hedonic tests. Participants were 40% male and 60% female with an average age of 36 years old (range = 21 to 65).



2.3 Consumer test

Consumer testing was performed at the University of Udine, in a laboratory built according to the UNI-ISO 8589:1990 standard. Consumers evaluated samples in individual booths under white incandescent light. They were compensated with some samples of meat (depending on the number of family members). The test was performed very close to lunch and/or dinner time, between 12.00-15.00 p.m. and 18.00-20.00 p.m., according to the availability of consumers.

Each consumer was first asked to indicate his/her liking for the appearance of the raw meat steaks using the LAM (Labelled Affective Magnitude) scale. The scaled range from +100 to -100 (anchored with “greatest imaginable like/dislike”) (Schutz & Cardello, 2001). The samples of the nine meat types were presented in a blind condition, monadically, and randomized between panelists and sessions. Appearance evaluation was carried out on raw meat steak samples. Each slice was taken out of refrigerated storage, unpacked and placed on a white tray with a three-digit numeric code. Consumers, randomly divided in groups of eight, evaluated the same slice of meat. The taste of meat samples was evaluated after portioning (sample size = 4x3 cm) and cooking, without added condiments or dressing. The firing was done in a convection oven at 230°C with humidity control, until the sample reached 70 °C at the centre of the product. Consumers ate unsalted crackers and drank mineral water to rinse their palate between samples. After every 3 samples, panellists were provided with a 5 minute break. Each sample was placed in a white cup with a three-digit numeric code. The codes of raw and cooked samples were different, in order to avoid any association between appearance and taste. The data were collected using Fizz Acquisition software (2.46A, Biosystemes, Couternon, France).

2.4 Measures of consumer familiarity and involvement with fresh meat

At the end of the hedonic test, consumers were asked to complete a questionnaire concerning their familiarity with fresh meat. Consumers were asked to report their familiarity with 11 commercial classes of meat: poultry, beef, pork, turkey, veal, rabbit, game, barnyard animals, sheep, goat, heifer and other. Consumers scored their familiarity on a 5 point-scale, where 1 = I do not recognize the product; 2 = I recognize the product, but I have not tasted it; 3 = I have tasted, but I do not use the product; 4 = I occasionally eat the product; 5 = I regularly eat the product (Bäckström, Pirttilä-Backman, & Tuorila, 2004).

The involvement of consumers was measured using a 15-item scale comprised of 5 sub-dimensions developed by Laurent and Kapferer (1985). Each item was scored on a seven-point Likert (interval) scale, ranging from 1=totally disagree to 7= fully agree. The level of importance that consumers ascribe to different product cues that influence purchasing motives was assessed using a 5-pt scale, in which 1 = none or very little importance, 2 = little importance, 3 = average importance 4 = quite a lot of importance and 5 = great importance (Sepúlveda, Maza, & Mantecón, 2008). The specific cues were down-selected from the literature, considering both intrinsic and extrinsic cues. Appearance, marbling, leanness and sensory property expectations were the intrinsic traits that were chosen, all of which are

directly related to product appearance. Credence attributes (extrinsic traits) were those associated with the production process (animal welfare, organic, quality certification, breed) (Bernués, Olaizola, & Corcoran, 2003). Other factors that affect the purchase motives were: type of packaging, label information, safety, traceability, known seller, cooking usage, known brand, price, nutritional value, and tradition (Chamorro, Miranda, Rubio, & Valero, 2012; Sepúlveda, et al., 2008; Bernués, et al., 2003).

Additional questions regarding purchase behaviour and questions concerning socio-demographic data (age, gender, education and profession) were also included. Details about questionnaires and associated scales are reported in Table 1. All scales were translated into Italian for administration.

2.5 Statistical analysis

Consumer segmentation based on familiarity with different types of fresh meat was accomplished through k-means cluster analysis. The 15-items of the involvement scale were reduced to four latent variables in accordance with Verbeke and Vackier (2004), using a principal component analysis. Both analyses were performed with UnscramblerX 10.2.

A Mann-Whitney U-test was carried out, crossing the groups of consumers for familiarity scores, involvement scores, socio-economic variables and purchasing drivers, using SPSS version 17 software (SPSS Inc., Illinois).

A Friedman test was performed to assess the significant differences related to ranking of label information using Fizz Calculation software (2.46A, Biosystemes, Couternon, France).

The differences between the liking of appearance and taste for the two familiarity clusters were tested by one-way ANOVA, where familiarity levels (low and high) were treated as a fixed effect.

To detect the difference in liking, the linear mixed model provided by SPSS version 17 software (SPSS Inc., Illinois) was used, considering respondents as a random effect, meat type and storage time as repeated effects variables and meat familiarity clusters as between-subject, fixed-effect factors. Model selection was based on Akaike and Schwarz's Bayesian information criteria (Wang & Goonewardene, 2004). After having individually examined appearance and taste liking, the relationship between the two ratings was assessed by selecting the appearance liking as a covariate in the linear mixed model predicting taste liking. For multiple comparisons, Bonferroni adjustments were made.

3. RESULTS

3.1 Differences in familiarity with fresh meat by cluster

Consumers were classified into two groups based on their familiarity ratings for the 11 types of meat, using the k-means cluster analysis. The low familiarity (LF) segment consisted of 56 subjects with a mean familiarity score for meat of 3.3, while the high familiarity (HF) group (37 consumers) had a mean value of 4.0 for familiarity with the 11 types of meat. The overall familiarity scores were significantly different



($p < 0.05$) between the two clusters; thus, validating the difference between consumer groups on the familiarity dimension.

Familiarity scores with the different meats by cluster are shown in Fig.1. Significantly higher familiarity for each meat type was expressed by the high familiarity segment, except for poultry meat. The order of familiarity for each product was the same for both clusters of consumers. Beef meat was the most familiar meat for both clusters of consumers ($HF = 4.9 \pm 0.05$; $LF = 4.7 \pm 0.07$). Veal meat was less familiar than beef for both consumer segments ($HF = 4.5 \pm 0.10$; $LF = 3.9 \pm 0.07$), but also showed a significant difference ($p < 0.01$).

Table 1 Questionnaire details: variables and related scales.

Variable	Scale
1 Involvement (15 items, three for each facet)	<i>Product importance</i>
	I don't care at all about meat ^a
	Meat is very important to me
	For me meat is absolutely necessary
	<i>Hedonic value</i>
	I can say that I actually do not like to eat meat ^a
	I enjoy a meal with meat more than a meal without meat
	I appreciate meat very much
	<i>Symbolic value</i>
	You can tell a lot about a person based on his/her choice of meat
	My choice of meat gives other people an image of me
	My choice of meat conveys nothing about me to other people ^a
	<i>Risk importance</i>
	I don't have a lot to lose when I make a bad choice of meat ^a
	I would find a bad choice of meat terrible
	I find it very annoying to make a wrong choice of meat
	<i>Risk probability</i>
	I never know if I make the right choice of meat
	When I buy meat, I know that I make the right choice ^a
	I feel lost when having to choose meat
2 Rating of Importance for 18 quality cues	5-point scale
	1= no, very low
	2= low
	3= slightly
	4= quite
	5= very
Cues:	Appearance; Marbling; Leanness; Sensory proprieties; Label information; Safety; Traceability; Known seller; Quality certification; Animal welfare; Type of packaging; Organic; Cooking usage; Known brand; Price; Nutritional value; Tradition; Breed
3 Ranking of label information	8 items to rank
Items:	Price; Cut; Expiry date; Origin; Brand; Slaughter; Weight; Other

^a item was scaled in reverse

Heifer meat was third in familiarity and also was significantly different between clusters ($p < 0.001$), with the low familiarity cluster having tried it rarely (2.07 ± 0.1) and the high familiarity having tried it at least once (3.59 ± 0.09). Goat, sheep, game and barnyard animals also had low familiarity for both clusters.

The socio-demographic characteristics of consumers differed between the two familiarity clusters. The high familiarity group consisted of 54% male and older (mean value = 39.5 year old) meat consumers, who were significantly different from the low familiarity group for age (mean age = 32.6; $p < 0.03$). The low familiarity segment consisted of a larger number of women, 73%, indicating that gender is an important factor in meat familiarity.

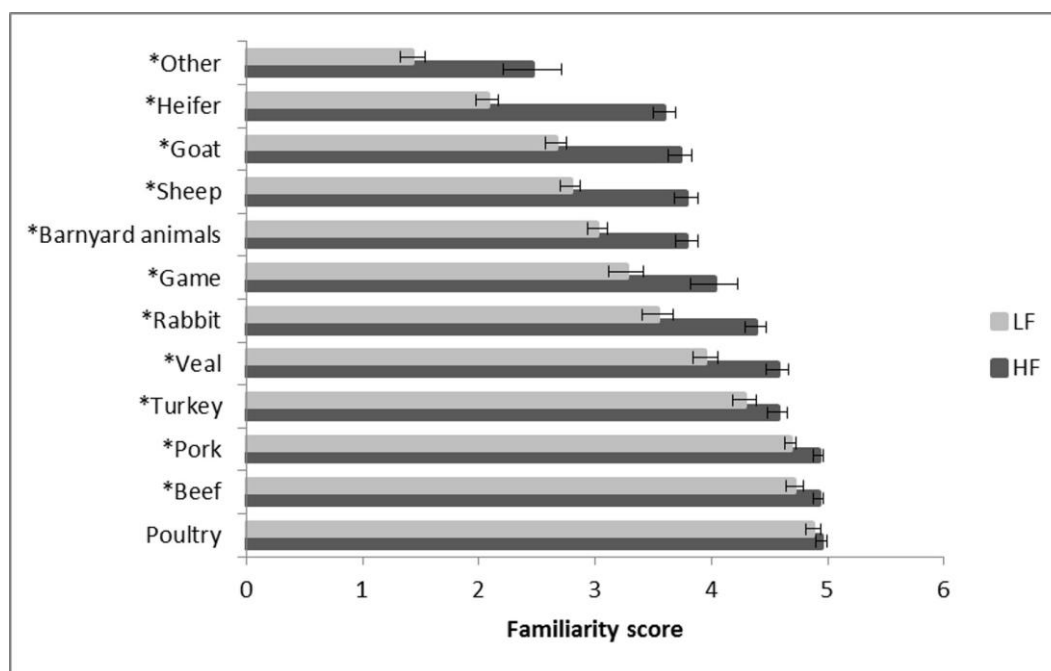


Fig. 1 Mean value and standard error of familiarity ratings for each of the 11 meat types for the high familiarity (HF) and low familiarity (LF) clusters.

3.2 Consumer involvement with fresh meat

The principal factors underlying consumer involvement with fresh meat were analysed through component analysis. In agreement with Verbeke and Vackier (2004), four principal factors describing the involvement for fresh meat were uncovered.

Table 2 shows the 15 questionnaire items with their relative factor loadings: the items with the highest loadings in the factor analysis were selected to represent each sub-dimension for further analysis. The four factors explained 72.1% of the total variance in the involvement concept. The first factor (26.2% of explained variance) reflected “pleasure value” – items loading high on this factor were those on the sub-dimensions “product importance” and “hedonic value”. This factor can be interpreted to reflect the fact that consumers place high importance on meat and that they are very satisfied when they consume meat products - they enjoy and need meat during their meal. The second factor, accounting for another 18.3% of explained variance, is closely associated with the sub-dimension of “symbolic value”. Thus, consumers consider the food they eat to express their self-concept, and the choice of meat reveals a great deal about a person. “Risk importance” was the third factor and explained 15.3% of variance.



Consumers think that a bad choice of meat could be very detrimental and that the meal could be a failure if the wrong choice is made. The “risk probability” factor was the fourth factor (12.3% of variance) and encompassed the confidence to select the right type of meat and the general uncertainty when consumers have to choose meat.

The differences between the mean ratings on each involvement factor for consumers having high and low familiarity with meat are presented in Fig. 2. The involvement profile for meat products significantly differed between the two familiarity clusters. Pleasure value ($p<0.001$) and symbolic value ($p<0.05$) were significantly higher for the HF compared to the LF group. Moreover, while for HF consumers the main factor of involvement was pleasure value, followed by risk importance, symbolic value and risk probability, for the LF group the main factor was risk importance, followed by pleasure value, symbolic value and risk probability. No significant differences between clusters were found for the two subdimensions of perceived risk: risk importance and risk probability. Consumers in both familiarity groups thought they had a relatively small probability of making a wrong purchase decision for meat (mean probability risk = 3.1 on a 7-point scale), but attributed a rather high importance to the negative consequences of an eventual poor meat choice (mean risk importance = 4.8).

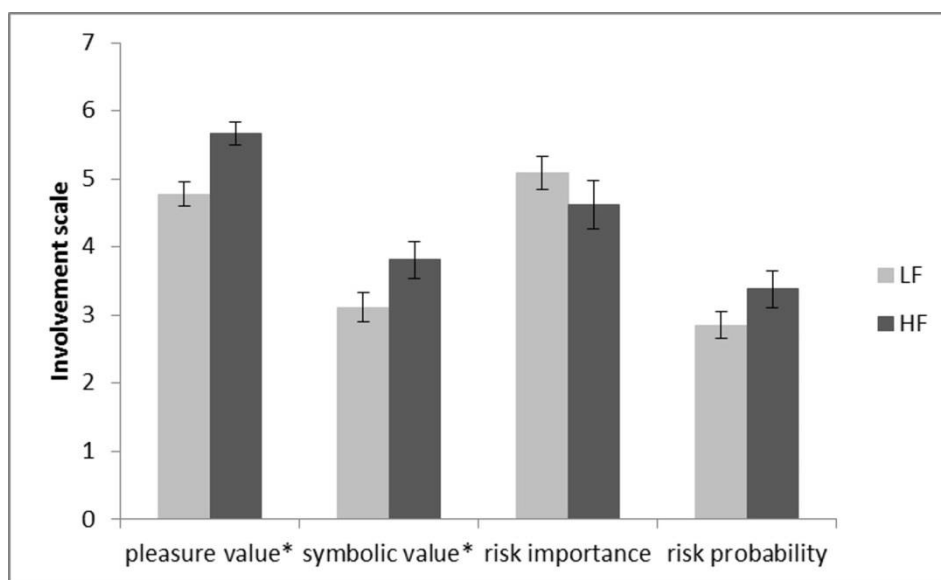


Fig. 2 Mean value and standard error for each of the four involvement factors for the high familiarity (HF) and low familiarity (LF) clusters.

3.3 Major cues for consumer expectations of fresh meat quality

The respondents rated a list of factors according to the importance for predicting meat quality at the point of purchase. The results expressed by consumers belonging to the two familiarity clusters are reported in Fig. 3. Regardless of familiarity, “appearance,” “label information” and “safety” were the evaluative criteria that had the major importance for purchase decision, all scored over 4.5 on the importance scale. The next most important factor for the LF cluster was “organic” (4.3 ± 0.1) which was rated significantly higher than for the HF cluster (3.9 ± 1.9). All other cues were scored between 3 (average importance) and 4 (quite a lot of importance) by the LF consumers. The lowest importance were assigned to “nutritional value” (2.6 ± 0.14) and “sensory proprieties” (1.5 ± 0.13).

The HF group attributed significantly higher importance ($p < 0.05$) than the LF group to additional information provided at the point of purchase, e.g. “traceability”, “known seller”, “type of packaging” (all ≥ 4 = quite a lot of importance), “known brand” and “nutritional value” (mean value ~ 3 = average importance). The least important evaluation criteria driving buying choice for the HF consumers were “sensory proprieties”, which scored below “little importance” (1.8 ± 0.2).

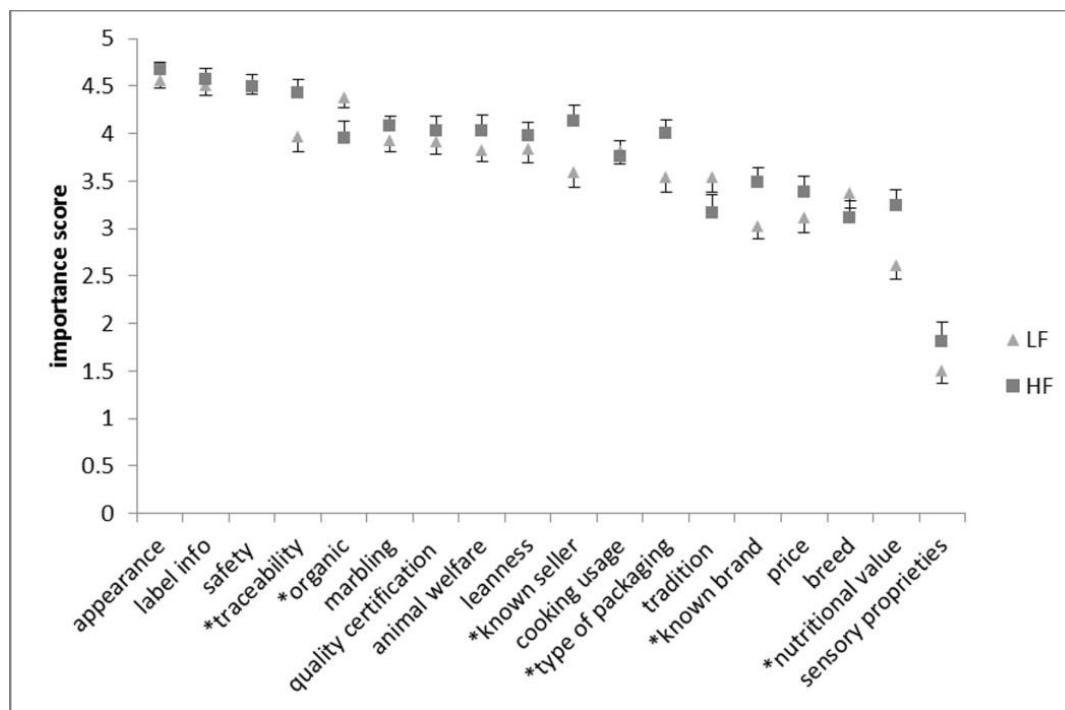


Fig. 3 Mean value and standard error of the ratings of cue importance to the evaluation of the quality of meat for the high familiarity (HF) and low familiarity (LF) clusters.

3.4 Ranking of label information on fresh meat

When subjects ranked the importance of label information, no significant difference was detected between the HF and LF clusters. The relative order of importance of the cues was the following:

[Origin, Expiration date] > [Cut, Price, Slaughter, Brand] > [Weight] > [Other].

The attributes inside the parentheses are not significantly different, while attribute groups separated by a “greater than” sign (>) are significantly different at $p < 0.001$. Thus, the origin of the meat and its expiration date were the major label cues that captured the attention of the consumers, and these were significantly different from cut of meat, price, the point of slaughter and brand. The least important aspect of label information was the weight.

3.5 Effect of familiarity on liking of the visual appearance and taste of fresh meat

The relationship between liking for appearance and taste in consumers with different familiarity with meat was examined. The results are reported in Table 3. Consumers with high familiarity rated significantly higher ($p < 0.01$) the liking of both the appearance and taste of fresh meat, and appearance was scored higher than taste for both familiarity groups. The mean judgments ranged between the anchors “like moderately” (anchored at +36.2 of the LAM scale) for the HF group and “like slightly” (+11.2 of the LAM scale) for the LF consumers.



3.5.1 Liking of appearance

As reported, appearance is one of the main factors used by consumers when deciding which meat they want to buy, regardless of their familiarity with the products. A significant difference was revealed between the two familiarity clusters in their ratings of product appearance with days of display in MAP ($p < 0.001$), but the liking trends of the two clusters were similar (Figs. 4a and 4b). The liking scores expressed by the high familiar group were significantly higher for all meat categories (Fig. 4a), in the order of veal < heifer beef < young bull beef. Consumers preferred red meat more than veal and the young bull over heifer.

The liking scores for aging of packed slices of meat (Fig. 4b) decrease significantly from the first day to the third day, while no differences were found between the third and sixth day for all types of meat. Consumers perceived a decrease in freshness of meat when rating the liking for slices of meat at three days of packaging.

Table 2 Factor loading from principal components analysis of the 15-item involvement scale.

	Factor 1	Factor 2	Factor 3	Factor 4	Included ¹
<i>Product importance</i>					
I don't care at all about the meat*	0,65				v
Meat is very important to me	0,82				v
For me meat is absolutely necessary	0,77				v
<i>Hedonic value</i>					
I can say that I actually do not like to eat meat*	0,64				
I enjoy a meal with meat more than a meal without meat	0,66				v
I appreciate meat very much	0,80				v
<i>Symbolic value</i>					
You can tell a lot about a person based on his/her choice of meat		0,69			v
My choice of meat gives other people an image of me		0,63			
My choice of meat conveys nothing about me to other people*		0,83			v
<i>Risk importance</i>					
I don't have a lot to lose when I make a bad choice of meat*			0,53		
I would find a bad choice of meat terrible			0,86		v
I find it very annoying to make a wrong choice of meat			0,64		
<i>Risk probability</i>					
I never know if I make the right choice of meat				0,85	v
When I buy meat, I know that I make the right choice*				-0,52	
I feel lost when having to choose meat				0,84	v

*Item reversely scaled

¹Item included in the final involvement profile (10 items) v

3.5.2 Liking of taste

Some differences could be observed when consumers tasted the cooked meats. In addition to the significant differences between the two familiarity clusters ($p < 0.001$), the HF cluster had a lower level of discrimination between samples, when comparing different categories of meat. In fact, the liking ratings for veal, heifer and young bull beef were not different from each other (Fig. 4c). In contrast, the scores of the LF group for heifer beef were higher on an absolute basis than those for veal and young bull beef. However, for both familiarity groups, liking of the taste of different meat categories (Fig. 4c) did not appear related to ratings of the visual appearance (Fig. 4a). In particular, for the less familiar consumers, the perceived appearance and the taste of beef showed an inverse relationship. For these respondents, the mean liking for visual appearance was numerically higher for young bull than heifer beef, while the mean liking for taste was numerically greater for heifer than for young bull beef.

Fig. 4d shows the decrease in liking for both segments of consumers by the third day of storage ($p < 0.05$), with no further change by the sixth day. The mean liking scores on the first day were 17.5 and 23.3 for LF and HF, respectively, decreasing to 10.89 and 19.24 on the third day of storage.

For both familiarity groups, the taste of meat (Fig. 4d) showed a similar decrease in the liking of appearance during storage (Fig. 4b). This suggests that respondents, regardless of familiarity level, used the perceived visual appearance of meat to predict the decline of its eating quality during storage. To examine this effect more closely, the ratings of liking of appearance (A) were used as scale predictors of the experienced taste, by selecting the former as a covariate in the mixed linear model for evaluating the sources of variability in the liking of taste (T). The liking of appearance was significantly correlated with liking of taste, and the coefficient relating the two liking scores differed by familiarity cluster, as described by the following predictive equations:

$T = 15.0$ (S.E. = 6.15; $p = 0.02$) + $A * 0.094$ (S.E. = 0.0449; $p = 0.04$) for LF cluster, and

$T = 15.0$ (S.E. = 6.15; $p = 0.02$) + $A * 0.260$ (S.E. = 0.0671; $p < 0.01$) for HF cluster.

After the correction for liking of appearance, neither meat type nor time of meat storage affected liking of the taste, demonstrating that the previously described diminution of eating quality during meat storage may be accounted for by the diminution in the perceived visual appearance of the product.

4. DISCUSSION

4.1 High and low familiarity clusters profiles

The cluster analysis of consumers revealed significant differences according to overall familiarity scores and for most of the 11 types of meat included in the questionnaire. As was similarly reported previously by Turrini and collaborators (2001) for Italian consumers, the consumers in the present study were more familiar with poultry, beef and pork meats, followed by turkey, veal, rabbit, game and barnyard animals (Turrini, Saba, Perrone, Cialfa, & D'Amicis, 2001). The low familiarity expressed for heifer meat was expected, because of its only recent introduction into the Italian market. The low familiarity with goat,



sheep, game and barnyard animals is consistent with the fact that these are unusual meat types for Italian consumers.

The socio-demographic characteristics of consumers differed between the two familiarity clusters, in terms of gender and age. The high familiarity group consisted of older consumers, while the low familiarity segment consisted of younger consumers with a larger percentage of women. Similar differences by gender have been found by several authors, showing that women seem to be less familiar than men with fresh meat and meat products (Verbeke, Pérez-Cueto, Barcellos, Krystallis & Grunert, 2010; Yen, Lin & Davis, 2008). Education levels were not found to differ significantly between the two familiarity clusters, but both had relatively high education levels. This lack of difference may have increased the behavioural differences between genders, because Latvala and collaborators (2012) found that with increased education, men have an increased consumption of meat, while women have a decreased consumption (Latvala et al., 2012).

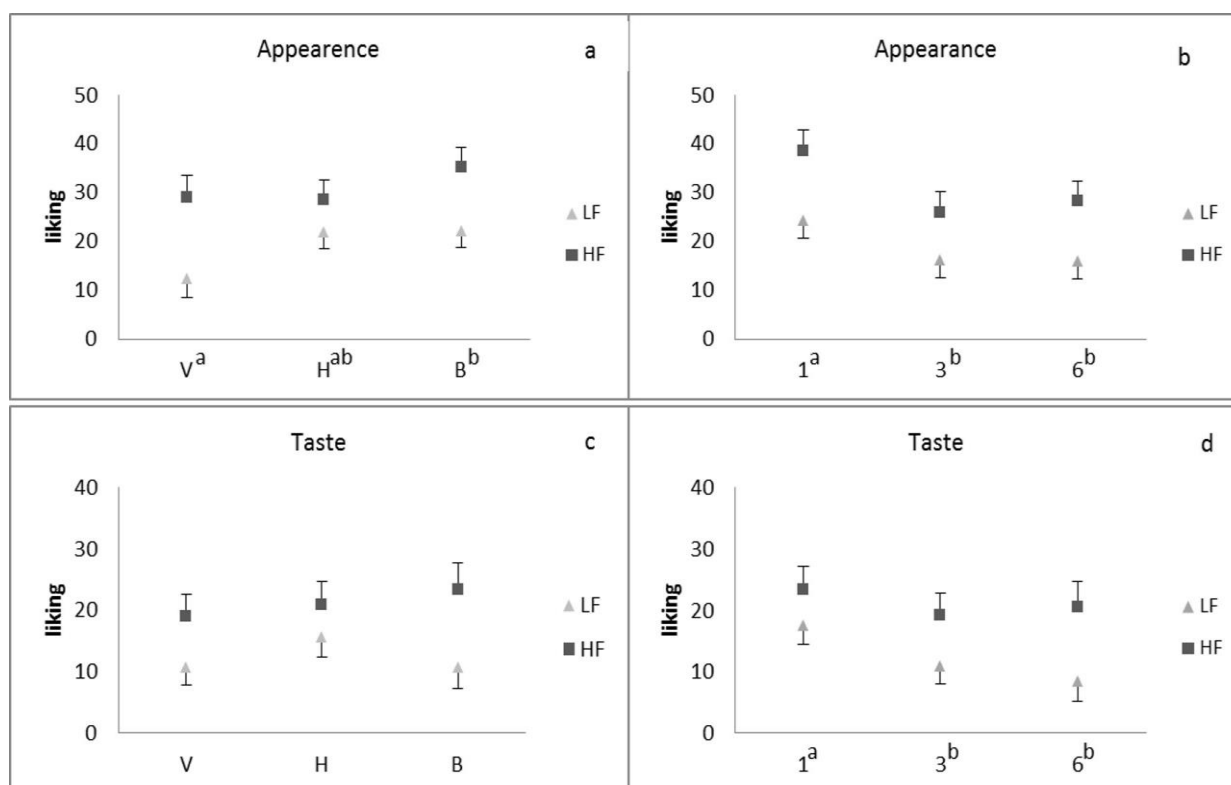


Fig. 4 Mean value and standard error of liking of appearance (a and b) and liking of taste (c and d) for the high familiarity (HF) and low familiarity (LF) clusters for their evaluation of veal (V), heifer (H) and young bull beef (B) (a and c) and at different storage times (1, 3 and 6 days of packaging) in MAP (b and d).

The involvement profile for meat products significantly differed between the two familiarity clusters. As previously reported for regular consumers of both meat (Verbeke & Vakier, 2004) and fish (Brich & Laweley, 2014), consumers with high familiarity showed a high food involvement, greater than that of the low familiarity segment. Consumers in both familiarity groups thought they had a relatively small probability of making a wrong purchase decision for meat but attributed a rather high importance to the negative consequences on of an eventual poor meat choice.

Table 3 Mean ratings and standard errors of liking of appearance and liking of taste expressed on Labelled Affective Magnitude (LAM) scale for the two familiarity clusters. Data are averaged across meat type and days of display.

	Familiarity	
	Low	High
Appearance	18,6±2,89 ^b	31,1±3,55 ^a
Taste	12,3±2,47 ^b	21,0±3,04 ^a

^{a,b}: Means on the same row with different letters are significantly different at $p < 0.01$.

Consumers are exposed to and perceive different meat quality cues, both intrinsic and extrinsic, when forming their quality expectations - in its search, credence, and experience dimensions. They make purchase decisions based on their values, concerns, lifestyles and socio-demographic features, etc. (Grunert, Bredahl & Brunsø, 2004; Bernués, et al., 2003). Visual appearance characteristics, especially colour, are widely considered to be intrinsic quality cues that are highly related to consumers' expectation of meat quality at the moment of purchase (Grunert et al., 2004; Ngapo, Martin & Dransfield, 2007). Beef labels are important sources of information about meat quality for consumers, and credible and reliable labels are key cues for the perception of credence attributes of meat (Grunert et al., 2004), among which safety was the major concern of our respondents. European consumers' concerns about beef safety have increased in the past few decades due to the occurrence of several beef crises, and these events have greatly affected meat consumption behavior (Van Wezemael, Verbeke, Kügler, de Barcellos, & Grunert, 2010).

Organic production is very important for LF consumers. This cluster, who is less involved in fresh meat, likely trust in this credence attribute, because it is assured by compulsory certification and labeling. In addition, it encompasses assurances regarding a number of different product and process values and concerns, including safety, nutritional, management, environmental and ethical aspects shared with all organic foods (Braghieri & Napolitano, 2009). On the other hand, HF consumers, because of their high involvement with fresh meat, require sufficient information in order to evaluate the product attributes carefully before purchase, so as to reduce any perceived risk. Consistently with that view, the HF group attributed high importance to the additional information provided at the point of purchase, e.g. traceability, known seller, type of packaging, known brand and nutritional value. These results corroborate the previous findings of Sepúlveda et al. (2008), who found a difference in buying behavior between regular and non-regular beef buyers. Indeed, greater confidence in credence attributes, such as brand, label and information on the quality of the beef at the time of purchase, were associated with more regular buyers (Sepúlveda et al., 2008). Banović et al. (2012) explained that consumers with a higher level of product familiarity focus on information that they know is more relevant and diagnostic for their product evaluation, while consumers with a lower level of product familiarity are less capable of understanding which cues are relevant to infer meat quality. Moreover, HF consumers likely know



that the consumption quality resulting from organic production is not higher than conventional breeding for pork and beef (Walshe, Sheehan, Delahunty, Morrissey, & Kerry 2006).

Although, the taste of food is frequently cited as the most important driver of purchase interest, with freshness having equal importance to such factors as convenience, healthfulness, and retail source (Cardello & Schutz, 2003), in this study both HF and LF consumers scored sensory proprieties as the least important evaluation criteria driving their buying choice. This result may be partially explained by the poor predictive relationship between pre-purchase assessments of sensory meat quality and actual, experienced quality after consumption (Grunert et al., 2004). Such a lack of prediction is due to the high biological variation among animals (Carpenter, Cornforth, & Whittier, 2001; Verbeke et al., 2010) and to the misinterpretation of certain intrinsic cues, especially marbling, for predicting sensory experience during consumption (Grunert et al., 2004).

Labeling information turns experience and credence attributes into search attributes, enabling consumers to evaluate beef characteristics during purchase and to select products corresponding to their preferences (Banterle & Stranieri, 2008). According to our results it seems that familiarity with meat did not affect the importance attributed to the label information. The origin of the meat and its expiration date were the major label cues that captured the attention of the consumers, thus, helping them to choose which product to buy and reducing their uncertainty about safety. Bernués et al., (2003) found that the origin of beef and its expiration date were the most important pieces of information demanded by European consumers, as they signaled both quality and safety on beef labels. Expiration date is a mandatory piece of information for beef labeling that Italian consumers consider very important (Bernués et al., 2003), and it is related to the perception of freshness and the hygiene of the meat (Verbeke & Ward, 2006). Country of origin has been found to be the most helpful evaluation criteria used by German consumers (Becker, Benner, & Glitsch, 2000), and other studies have reported a strong effect of preference for local origin (Font i Furnols et al., 2011; Hersleth, Næs, Rødbotten, Lind, & Monteleone, 2012; Sepúlveda, Maza, & Mantecón, 2010). Indeed, several researchers have developed new methods to guarantee the origin of food products and meat, e.g. the use of isotope ratio for authentication of lamb meat (Piasentier, Vallusso, Camin, & Versini, 2003).

The cut of meat, price, the point of slaughter and brand were less important aspects of label information, followed by weight. It has been reported that price has lost its function as an indicator of quality in the food market (Becker et al., 2000) and, in the presence of other extrinsic cues; it plays a minor role in choice across all levels of product knowledge (Solheim & Lawless, 1996). Based on our results, the same may be said for brand, i.e. when accompanied by information about origin and expiration date, brand played a minor role in the quality assessment of fresh meat. Moreover, Bernués et al., (2003) argued that brand identity for fresh meat is less important than it is for other foods, probably because consumers are used to buying unbranded and unpackaged meat.

4.2 Effect of familiarity on liking of the visual appearance and taste of fresh meat

The mean liking scores for meats assessed by both consumer clusters ranged between 10 and 34 on the LAM scale. This translates to ratings of between “like slightly” and “like moderately.” Napolitano and colleagues, who also assessed liking of beef meat in Italy, reported mean values of 6 (like slightly) on a 9-point hedonic scale for both expected and blind measurements. The highest mean rating was obtained for the expected liking of organic meat, which had a mean score of 7.5 (between “likely moderately” and “like very much”), but the blind condition rating was close to “like moderately.” Thus, both from the data of Napolitano et al. (2010) and the present data, it appears that Italian consumers find beef meat to be of relatively low-moderate acceptance. However, Meiselman, Johnson, Reeve, and Crouch (2000) demonstrated that differences in acceptability of the same product can be influenced by eating environment, and the context factors have an enhancing effect of food acceptability when comparing traditional laboratory tests with meal served in restaurant settings (King, Weber, Meiselman and Lv, 2004).

The consumer behavior literature has established that meat familiarity affects the usage of available information to form quality expectations at the point of purchase and may influence meat quality experience upon consumption (Banović et al., 2012). In a study on the relationship between expected and experienced sensory beef quality, Banović et al. (2012) stressed that any contribution to the predictability of sensory beef quality that occurs during the “experience” phase is of paramount importance, in order for the beef industry to remain competitive in the market. With this in mind, the relationship between liking for appearance and taste in consumers with different familiarity with meat was examined. Our results showed that the high familiarity cluster liked the meat more, regardless of storage or animal effects. That was not surprising, as it is in agreement with several studies demonstrating how familiarity affects hedonic response and that a linear relationship exists between liking or pleasantness and the level of food familiarity (Tuorila et al., 1994; Tuorila et al., 2008; Lee et al., 2010).

As reported, appearance is one of the main factors used by consumers when deciding which meat they want to buy, regardless of their familiarity with the products. Independent of the absolute levels of liking scores, the trends of the two clusters were similar. All consumers preferred red meat more than veal and the young bull over heifer. These results are consistent with the fact that, within red coloured meat, bright red is generally preferred to pale red or dark red (Greibitus, Jensen, & Roosen, 2013; Killinger, Calkins, Umberger, Feuz, & Eskridge, 2004). In addition, heifer meat usually shows more marbling than bull slices (Field, Nelms, & Schoonover, 1966) and several authors have reported that marbling negatively affects consumer preferences for and acceptability of red meat (Brewer, Zhu, & McKeith, 2001; Moeller et al., 2010). Moreover, heifer is a new entry into the Italian market and consumers are less confident with this meat type.



From the analysis of storage time, it was observed that consumers perceived a decrease in freshness of meat when rating the liking for slices of meat at three days of packaging. Similar results have been found by Vitale and collaborators (2014) who showed that trained panel scores for beef meat colour after 3 days of display in MAP are higher than those for the first day of package, especially in aged meat. These results are supported by instrumental data that indicate that a^* and chroma values decrease over the duration of retail display, while L^* values increase (Vitale, Pérez-Juan, Lloret, Arnau, & Realini, 2014). In addition, Walshe et al. (2006) found a decrease of colour stability (a^* value) during the increase of retail storage condition.

The taste of the meat led to different results, showing no significant differences by meat type, and the ratings were not related to ratings of the visual appearance of the meat. However, the decrease in liking with storage was also reflected in the ratings of the taste for both segments of consumers by the third day of storage. It is known that packaging meat in an atmosphere containing a high concentration of oxygen can negatively affect eating quality, with the meat becoming less tender and juicy and acquiring a more oxidative flavour (Aaslyng, Tørngren, & Madsen, 2010; Zakrys, O'Sullivan, Allen, & Kerry, 2009). Indeed, Scandinavian consumers expressed an overall greater liking for meat packaged without oxygen (using CO_2 and N_2) than those packaged with oxygen.

Our analysis of liking demonstrated that the diminution of eating quality during meat storage may be accounted for by the diminution in the perceived visual appearance of the product. It is well known that colour is the main contributor to the visual appearance of meat and that the color of meat undergoes significant changes during storage, from a red–purple color to brown. This change is related to the different forms of myoglobin that develop in the meat. Consumers most frequently prefer beef with red colour, followed by purple and brown (Carpenter, Cornforth, & Whittier, 2001) and they use the colour of raw meat as an indicator of freshness (Troy & Kerry, 2010) and/or spoilage (Mancini, 2009). A major contribution of our results is in showing that, in contrast with the findings of Carpenter and colleagues (2001), taste liking is related to the storage changes that occur in the appearance of beef, regardless of familiarity level. However, both groups of consumers had the same degree of risk awareness related to poor purchase choice, and both showed the same high degree of attention to the expiration date on fresh meat labels. Furthermore, the use of perceived visual appearance as an intrinsic cue to predict the sensory quality of meat upon consumption lacks reliability and provides contradictory results when it is not related to the inherent freshness of the meat.

5. CONCLUSION

Greater levels of consumer familiarity with meat are associated with greater levels of product involvement and different involvement factors. High familiarity consumers associate higher pleasure and symbolic value to fresh meat than do low familiarity consumers, but risk perception is similar and the awareness of negative consequences of a poor choice are relatively high for both clusters. As a



result, regardless of familiarity level, consumers assign great importance to the visual appearance of meat, resulting in perceptions of a loss of freshness after three days of storage in MAP and to an associated reduction of liking of taste upon consumption.

However, since the liking of taste does not match the perceived appearance variability related to myoglobin and marbling levels, consumers must trust extrinsic cues, with high familiarity / high involvement consumers mainly trusting expert opinion (seller or brand), and low familiarity / low involvement consumers trusting more in organic production.

6. REFERENCES

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IV. Experiment 2

PREDICTION OF EATING QUALITY OF MEAT FROM BUTCHER'S STEAK APPEARANCE JUDGMENT

1. INTRODUCTION

Product quality has been defined in a variety of different ways; the most popular definition of quality has been fitness for use (Lawless, 1995). Quality is also often defined as the characteristic of products that meets (or better exceeds) end-users' or consumers' expectation or satisfaction (Cardello, 1995; Casabianca, Trift, & Sylvander, 2005). The quality attributes of meat products are generated both by intrinsic and extrinsic cues that are relevant from the consumer standpoint at the point of sale (Font-i-Furnols & Guerrero, 2014). Eating quality is very important to ensure consumer satisfaction and subsequent purchase (Grunert, Bredahl & Brunsø, 2004). The most important quality aspects of beef at consumption are that it tastes good, is tender, juicy, fresh, lean, healthy and nutritious (Grunert, 1997). The prediction of tenderness and flavour at the consumer level is of paramount importance for the industry to remain competitive in the market. To achieve this goal, the meat industry has developed both quality grading systems and meat standards (Hocquette et al., 2014).

Visual appearance characteristics, especially colour, are intrinsic quality cues that are highly related to consumer expectations of meat quality, and consumers use colour of fresh meat as an indicator of storage time, freshness and safety (Mancini, 2009; Verbeke, Pérez-Cueto, Barcellos, Krystallis, & Grunert, 2010). However, fresh meat has a lower degree of differentiation when compared to other food products (Banović, Aguiar Fontes, Barreira, and Grunert, 2012), and it is very difficult for consumers to link appearance and colour with the experienced sensory quality of meat, probably due to the high biological variation among animals (Carpenter, Cornforth & Whittier, 2001; Verbeke, et al., 2010). As a consequence, consumers often entrust purchase recommendations to the butcher or rely on additional information provided at the point of purchase (Grunert et al., 2004). At the point of purchase, the butcher is regarded as a guarantor of high quality meat, and the known co-operation between producer and retailer may be the best way to overcome consumer uncertainty in evaluating the quality of beef (Grunert, 1997).

An expert is defined by the American Society of Testing Materials as someone (often operating alone) with extensive experience in a product category who performs perceptual evaluations to draw conclusions about the effects of variations in raw materials, processing, storage, aging, and so on (ASTM, 2005). As such, a butcher may be considered an expert on meat quality. Numerous systems of classifying beef quality have been developed in different countries that rely on appearance evaluation by experts, e.g. the American grading system (USDA, 1997), the Japanese grading system (Japan Meat

Grading Association, 2000), and the Meat Standard Australia (MSA) (Polkinghorne, Thompson, Watson, Gee & Porter, 2008). On the other hand, in Europe, some advanced carcass grading systems (EUROP system) have been established starting from '80 to the newer modification (EU n. 1234/2007- n. 1249/2008), but reliable systems guaranteeing eating quality are still lacking, in spite of numerous private and official quality signs which exist at the consumer level (Hocquette, Legrand, Jurie, Pethick, & Micol, 2011). To address this lack of official quality designations, some countries have developed labelling systems. In France, the “Label Rouge” is a certified process that ensures that the final products are at a higher quality level than the standard product (INAO, 2009). In Wales, “Celtic Pride Beef” also designates a specialised and differentiated premium beef product, ensuring consumers of a high quality beef production protocol (Hocquette et al., 2014). In Italy, as well as in Europe, similar quality designations are increasing in number, aided by geographic origin labels, also related to the production practices (Codron, Giraud-Heraud, & Soler, 2005). In the last few years, some studies have focused on the labelling of beef eating quality. A consumer survey with beef consumers conducted in different European countries found that consumers hold a strong interest in both beef eating-quality guarantees and in beef muscle profiling (Verbeke et al., 2010). Ellies-Oury et al., (2013) developed a method to predict meat tenderness based on “grain of meat”, evaluating the whole carcass and the ribs. However, they have not found any significant relationships between grain of meat and tenderness, either instrumentally or by sensory methods. On the other hand, the “butcher’s thumb” approach has been seen to be a most effective way to assess beef tenderness (Purslow, 2005).

The primary aim of this work was to define a quality meat grid system guaranteeing beef eating quality, in order to increase the value of Italian Simmental young bull beef. The number of these animals has been increasing from 50000 to more than 62000 in the last 5 years (2007-2012) (North-East of Italy), especially in the mountain areas, because of several advantages for farmers. In fact, the dual purpose breed, Italian Simmental, adapts well to the most difficult and hard farming and breeding condition and is characterised by good resistance to disease and high fertility (Piasentier, Menta, & Degano, 2010).

The second aim was to establish the relationship between expert judgments of the raw meat and sensory profiles obtained from a trained sensory panel.

2. MATERIALS AND METHODS

The experimental design was arranged in three steps:

1. The development of the grid system for the evaluation of the steaks quality by experts
2. Relationship between EUROP carcass and steak quality classifications
3. Evaluation of the intrinsic properties of the steak quality classes by trained panel



2.1 Expert evaluation

Four experts were involved. One was a butcher familiar with choosing carcasses in the slaughterhouse according to EUROP classification. Another was a wholesale butcher who used the appearance of steaks to recommend meat purchases in accordance with the customer expectations. The other two experts were researchers with long experience in meat quality assessment and determinants. Individual interviews with the experts were conducted to define the grid system to evaluate the quality of the rib-eye muscle of a steak between the 8th - 9th ribs. Only criteria which made consensus were kept.

2.2 Steak samples, carcass evaluation and pH

Twenty-nine Italian Simmental young bulls were randomly chosen from the genetic centre of Italian Simmental, fed corn silage-based diets and slaughtered at 694 ± 11.6 kg (mean \pm se) of weight. Animals were slaughtered at an EU-licensed abattoir. Carcass weight, fatness and conformation (EUROP Classification) were recorded after slaughter. After 48 hours, a section of rib cut between the 8th - 9th ribs was obtained and Longissimus thoracis (LT, rib-eye) muscle evaluated by the experts, using the developed grid system. The section was aged at 4°C for 7 days. After this ageing period, LT was submitted to pH and colorimetric analysis and then dissected from the rib section, frozen and stored at -20°C until the time of sensory evaluation, according to standard procedure (AMSA, 1995). pH measures were performed by a glass piercing electrode connected to a pH-meter (HI 8484 Hanna instruments, Japan) (AMSA, 2012).

2.3 Trained panel

10 subjects were recruited at the University of Udine. They participated in 10 training sessions, during which time a common vocabulary was developed to describe the beef samples (Table 1). The panel then performed a quantitative descriptive analysis (QDA) (Meilgaard et al. 1999) of LT muscles from the 29 young beef carcasses. The panel evaluated the muscle of each animal in duplicate. Evaluations were conducted in individual testing booths during 15 sessions (4 samples for each session, including replication). The samples were presented monadically, randomized between subjects and sessions, and coded with a three-digit number. Judges were instructed to refresh their mouth after the taste of each sample with water and carrots between each samples. The taste of meat samples was evaluated after portioning and cooking. The firing was done in a convection oven (RATIONAL SCC 61), until the sample reached 70 °C at the centre of the product.

2.4 Statistical analysis

The quality grid system was analysed to assess which sensory descriptors contributed to the overall quality assessment. Partial least square regression (PLS-1) was accomplished between the expert descriptors (X-matrix) and the overall quality judgment (Y-variable) (Wold & Josefson, 2000; Bertuccioli, 2008). Partial least squares (PLS) is a procedure used to associate a set of independent variables

(predictors) to response variables (observations) by decreasing the original number of descriptors to a reduced number of orthogonal factors called latent variables (LV) (Wold, Trygg, Berglund, & Antti, 2001). A principal component analysis was performed to verify the agreement of experts and to define the two groups of samples, i.e. the high quality and standard quality meats. The Chi-Square Test for two independent samples was applied to evaluate if quality classes affected the frequency distribution of comments and the frequency distribution of carcass evaluations for the single animal (SPSS vers. 17 software; SPSS Inc., Illinois).

The trained sensory panel performance was evaluated for better handling the actual data (not reported) (Naes, Brockhoff & Tomic, 2010), using PanelCheck vers.1.4.0 software (<http://www.matforsk.no/panelcheck>). PLS-DA models were applied in order to investigate the possibility of discriminating the young bull beef samples into two categories based on quality level.

Table 1 Description of sensory attributes used for the sensory profile of cooked meat.

Category	Attribute	Description
Appearance	Cooking loss	Visual estimation of water released from meat during cooking
Odour & Flavour	Beef ⁴	Aroma of cooked beef lean
	Metallic ^{3,4}	Aroma of Ferro sulphate
	Bloody ⁴	Aroma associated with undercooked meat
	Liver ^{3,4}	Aroma associated to animal liver
	Brothy ⁴	Aroma associated with boiled meat or soup stock
	Stale ^{3,4}	Off-aroma like flat, stale, animals, cloying
Taste	Browned ^{1,4}	Aroma associated with meat that is cooked more and charred on the outside, toasted
	Sweet ^{3,4}	Taste elicited by sugar
	Umami ⁴	Taste elicited by monosodium glutamate (MSG)
	Salty ⁴	Taste elicited by salts
	Sour ^{3,4}	Taste elicited by acids
	Bitter ^{3,4}	Taste elicited by caffeine
Texture	Coarseness ³	Degree of granularity of the muscle fibres
	Chewiness ²	Easiness to chew the meat samples for swallowing
	Juiciness ^{2,3}	Moisture released by the product in the mouth during early chewing
	Tenderness ^{1,2,3}	Minimum force required to chew the meat sample: the lower the force the higher the tenderness
	Adhesivness ¹	Perception of mouth residuum that remains stuck to the teeth once the chewing is finished

¹Ruiz, Guerrero, Arnau, Guardia, & Esteve-Garcia, 2001; ²Braghieri et al., 2012; ³Rødbotten, Kubberød, Lea & Ueland, 2004; ⁴Mougan, Tansawat, Cornforth, Ward, & Martini, 2012;

PLS-DA (also referred to as discriminate PLS) is a common chemometric technique increasingly used for discrimination or classification purposes (Chevallier, Bertrand, Kohler, & Courcoux, 2006). This classification method is based on the PLS approach, where the response/dependent variable is categorical (Barker & Rayens, 2003). PLS model uses one response variable, which codes for class membership as follows: 0 for members of one class, +1 for members of the other one. The PLS-DA model was built between the sensory attribute matrixes (X) and the class matrix (Y). The aim of our analysis was not the building of a prediction model able to classify correctly the sample on the basis of sensory profile, but was the understanding the relationship between the quality of raw meat judged by experts and the evaluation of cooked samples by trained panels. Classification performance was assessed in terms of sensitivity, specificity and total accuracy (Kjeldahl & Bro, 2010). Sensitivity was estimated as the number of positives (high quality samples) in the dataset correctly detected by the model divided by the total number of positives (true positive rate). The observed specificity was defined as the number of negatives (standard quality samples) correctly classified by the algorithm divided by the total number of negatives in the dataset (true negative rate). The sensitivity and specificity were estimated at a given threshold or cut-off limit. In this case, adopting a cut-off value of 0.5, samples with a predicted Y-value smaller than 0.5 were identified as belonging to class 0, whilst those with predicted Y-values greater than 0.5 were predicted as class 1 (Barbin, Sun & Su, 2013). The accuracy of the model was estimated when samples were properly classified in the validation phase (leverage validation method). PCA, PLS-1 and PLS-DA were performed by The Unscrambler X v.10.2 software (CAMO Software, Norway).

3. RESULTS AND DISCUSSION

3.1 Building and validation of quality grid

3.1.1 Define the criteria

The expert consensus of descriptors related to the overall quality of meat is reported in Fig. 1. The analysis of individual interviews showed the agreement with ten criteria: seven meat characteristics, two descriptors of fat and the presence of any defects. A global “overall quality” assessment score was added, defining the global opinion of the expert in a summary score. The seven criteria were scored on 5-point scales, ranging from “poor” to “excellent”. A space for notes was inserted to let the judges freely express their comments for each attribute and to explain their responses. E.g. the meat colour could be too dark or too light.

3.1.2 Identify the indicators for assessing each criterion and construct each criterion separately

The twenty-nine steaks were scored for meat quality by the four experts separately. The expert performance was evaluated considering the homogeneity of the scores performing a PCA. Results (not reported) showed that there was a concordance in the evaluation of samples, i.e. the loadings plot of

PCA revealed that the judges provided the same scores for the meat, because they were very closed to each other in the graph. Thus, the descriptors' average scores were used for the following analyses, after evaluation of concordance between the four members of the jury using the PCA. The results of PLS-1, summarised in table 2, indicated the relative importance of each descriptor in the overall quality assessment.

The PLS-1 explained 84% of Y-variance after the first, and 2% after the second component. The explained variance of the X-variable is, respectively, 35% and 13%. "Meat exudation" is the only descriptor that loaded on the second factor, while the "cohesion between muscles" loaded on the third, but this factor appeared not related to overall quality judgment. Five significant variables were identified with the PLS-1 that contribute to overall quality (correlation loading ≥ 0.7): rib-eye dimension, meat colour, marbling, meat firmness and fat cover. The presence of any defect was not included in this analysis, because experts assumed that the presence of defects automatically defines a low quality steak.

		Poor	Below average	Average	Good	Excellent	Note
Meat	Rib-eye Dimension						
	Meat Marbling						
	Meat Colour						
	Meat Exudation						
	Meat Firmness						
	Fibre Size						
	Cohesion among muscles						
Fat	Fat Colour						
	Fat Cover						
Overall	Defect						
	Overall Quality						

Fig. 1 Form of quality grid of young bull beef steak.

An analysis of the notes (Fig.2) taken by the experts was carried out. It was interesting to observe that some descriptors were unidirectional. The increase of these attributes led to an increase of the overall quality judgment. For example, the more cohesive the muscles are to one another, the better the quality judgment is, or similarly, the bigger the area of the rib-eye is, the higher the quality is. Another example is that of the fibre size: the smaller the fibres are, the better the quality is. In literature, this relationship was reported. The evaluation of the rib-eye dimension is also used as a trait by JMGA grading to estimate the yield grade (Polkinghorne & Thompson, 2010). At the same time, fine fibre in meat is a requirement of the top grades in the USDA grading scheme, because it seems to be linked to tenderness (Purslow, 2005). The fat colour is another characteristic that is evaluated in the Canadian

system, where the carcasses with yellow fat are excluded from the high quality beef (Polkinghorne & Thompson, 2010).

On the other hand, other quality traits could be considered bidirectional, that is, the lack or the excess of one characteristic could affect the overall quality. These descriptors are “meat marbling”, “fat cover”, “meat colour”, “meat exudation” and “meat firmness”. Meat marbling and fat cover are important to consumers who are interested in healthy products and who usually prefer lean meat and carcasses. On the other hand, fat is also positively associated with acceptability. Higher graded carcasses are characterised by greater marbling levels in several grading systems used to assess the eating quality of meat (Hocquette et al., 2012).

Corbin et al., (2015) indicated that consumers were more accepting of the tenderness of samples with higher marbling levels compared to samples with lower marbling levels, despite the similar WBSF. They argued that marbling plays a role in the tenderness acceptability but it is still not clear the relationship between fat and tenderness.

The colour of muscle foods is dependent upon myoglobin, the primary red pigment in meat. However, the ultimate perceived colour is affected by many factors such as species, animal genetics and nutritional background, post mortem changes in muscle (especially the dynamics of pH and meat temperature decline), inter- and intramuscular effects, post mortem storage temperatures and time, and a host of processing variables, including antimicrobial interventions (AMSA, 2012). Colour is a quality trait included in most of the countries that adopted the grading schemes, in Canada, Japan, South Korea, USA, and Australia (Polkinghorne & Thompson, 2010).

Meat firmness has been evaluated by touch, pushing the rib and feeling the hardness or softness of the meat. This procedure has been judged relevant by Ellies-Oury et al., (2013) to determine the tenderness of meat.

3.2 Classification of the steak and aggregation of the different criteria to form the quality index

In order to classify meat samples, a PCA was performed using all the quality traits (Fig.3). The classification was made dividing the samples into two groups: the right part of the PCA, where overall quality was loaded, contains samples with High Quality (HQ), while the left part of the PCA contains samples defined as being of Standard Quality (SQ). Finally, 15 samples were sorted into the standard quality group, while 14 samples were sorted into the high quality cluster. The analysis of the comments was performed using a frequency matrix of the comments. The percentage of times for which a comment was reported is shown in Fig.2. Some of the standard quality steaks were described as too fat, but especially with a low degree of fat and with a low marbling, a smaller dimension of rib and more exudative meat. A darker colour of meat is quite more frequently used to describe the standard quality cluster. Moreover, the presence of defect is a peculiarity of the standard quality meat.

Table 2 Correlation loading scores and relative significance of descriptors on the first and second latent variables; x=significant attribute

	F1	F2	Significance
Rib-eye Dimension	0.73	-0.22	x
Meat Colour	0.75	0.13	x
Meat Marbling	0.76	0.06	x
Fat Cover	0.80	-0.11	x
Fat Colour	0.44	-0.01	
Meat Exudation	-0.17	0.74	
Meat Firmness	0.69	-0.10	x
Fibre Size	0.08	0.42	
Cohesion	0.36	0.49	
Overall Quality	0.92	0.172	

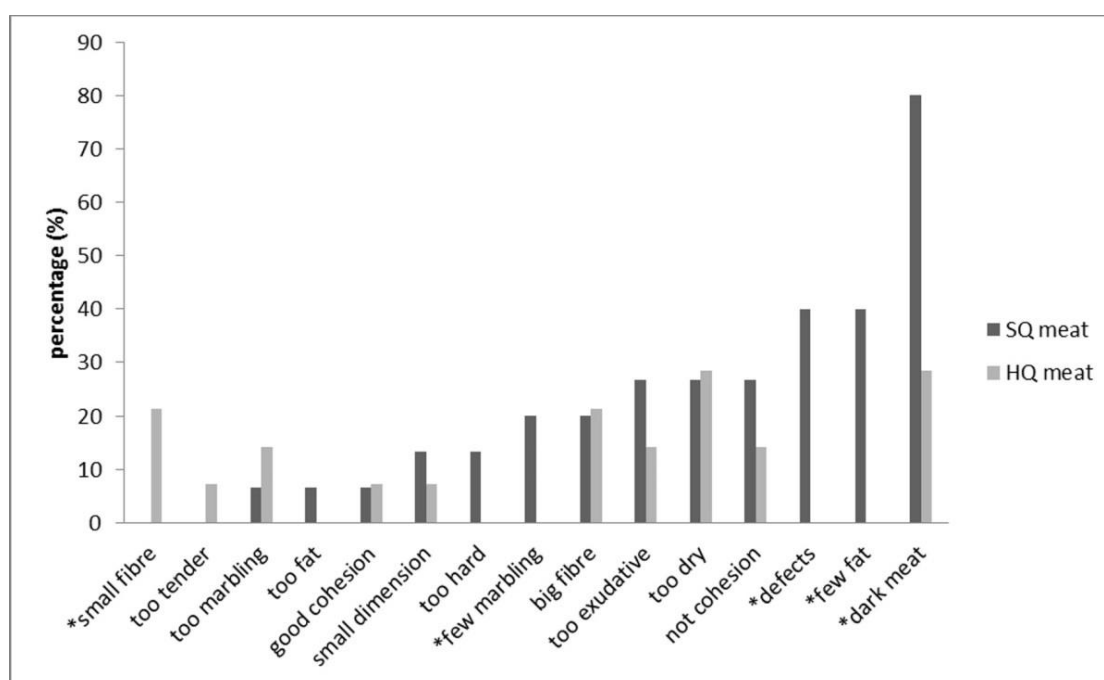


Fig. 2 Frequency of notes written by experts during the steak evaluation for SQ (standard quality) and HQ (high quality) meat
*significance levels $P \leq 0.10$

A method to combine scores was applied in order to aggregate our different sensory traits and to produce an overall sensory score for practical application. We decided to include all the sensory descriptors defined in the scheme, despite the low relationship between “muscle cohesion” and “overall quality”, but we took in account the load of each descriptors to weight each criteria for the overall quality assessment (significant variables identified with the PLS-1, see Table 2). In this scoring system, the highest quality score that a steak could have is 50. We considered critical variables, those with a significant correlation with “overall quality”. If the steak evaluation did not obtain a value of at least 3

(average in the 5-point scale) for those critical traits, it was automatically excluded from the HQ level. A further criterion to reaching the high quality category was a lack of any defects. If these requisites were satisfied, the sum of all items had to be ≥ 30 points to sort the sample into the high quality cluster. For example: if the sum of all descriptors for one sample resulted in a score of 30, but the meat colour and texture scores were below 3, the sample was classified as Standard Quality, and not as High Quality. This classification is supported also by the PCA results, where the samples that took place in the right part of the first component had a quality index ≥ 30 , while the standard quality steaks are located in the left part of the same component.

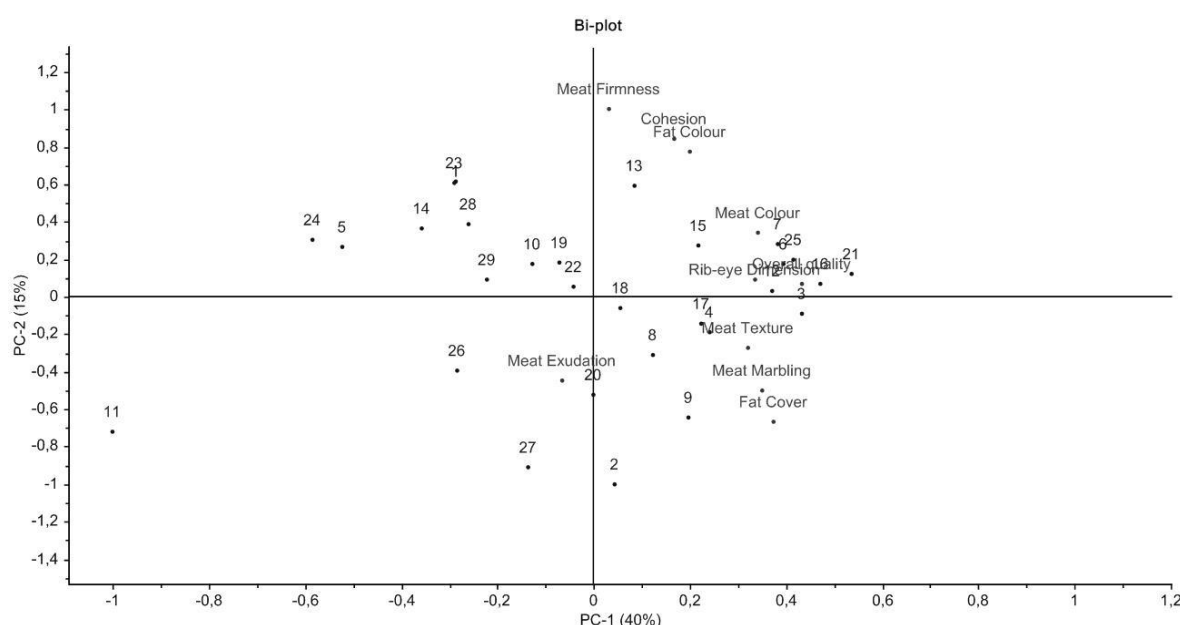


Fig. 3 PCA of 29 steaks distribution based on expert judgments.

The quality index and the results for each descriptor are reported in Tab.3. The mean value for the high quality (35.32) steaks was significantly higher ($P < 0.001$) than that for the standard quality meat (26.12). The high quality steaks were scored from “average” to “good” for all quality traits, except for “meat exudation” and “muscle cohesion”, while the standard quality steaks scored “average” on only two traits: fat colour and fibre size. It is possible to assume that these two quality traits were identical among samples. Significant differences were observed for the area of rib-eye ($P = 0.025$), amount of fat (cover and marbling; $P < 0.001$), meat colour ($P = 0.023$) and meat firmness ($P = 0.001$). It is clear that most of the evaluated descriptors contribute to the quality classification as perceived by the experts.

3.3 EUROP classification and pH of two meat quality levels at slaughter

The 29 selected carcasses from the genetic centre of Italian Simmental concerned all young bull beef had a conformation located between U ($n = 18$, 63%) and R ($n = 10$, 34%) with only one E (3%). Their fat grade was 3 out of 5 in 83% of the evaluations. One carcass was scored too lean (grade of 2) and the other four were graded too fat (grade of 4). The fat grade and the carcass conformation may be

considered uniform, as assumed by Ellies-Oury et al., (2013). Moreover, comparing their data, collected for Charolais cattle (a meat breed), with our results on Italian Simmental (a dual purpose breed) the carcass evaluation turned out to be similar in terms of fat cover and conformation, indicating that the Italian Simmental young bull could be a good breed also in meat production.

Table 3 Mean scores and SMEs for the descriptors of the steaks belonging to the two quality levels, along with the relative *P* value (significance levels $p \leq 0.05$).

Descriptor	HQ mean	SQ mean	SEM	<i>P</i>
Rib-eye dimension	3.53	2.73	0.90	0.025
Meat colour	3.47	2.73	0.81	0.023
Meat marbling	3.78	1.46	0.70	0.000
Fat cover	3.75	1.46	0.71	0.000
Fat colour	3.94	3.92	0.26	0.884
Meat Exudation	2.81	2.62	1.32	0.692
Meat Firmness	3.75	2.31	1.07	0.001
Fibre size	3.59	3.85	0.97	0.491
Cohesion	2.91	2.59	1.25	0.558
Overall quality	3.81	2.58	0.56	0.000
Quality index	35.32	26.12	3.27	0.000

The carcass conformation scores reported in Fig.4 show the distribution of carcass conformation and fattening grade between the HQ and the SQ steaks. The classification results show the conformation of carcasses, belonging at E, U and R category, and the fat cover, ranging between 2 and 4. The main differences are related to the presence of an E in the HQ group and the presence of a fat grade of 2 in the SQ group. Three is the minimum fat grade required for the high quality meat cluster, while the E carcass conformation is a potential criterion to include the sample in that group. The relationship between EUROP conformation and quality of the steak were also evaluated, leading to the conclusion that the average overall quality score is not significantly related to the conformation sub-classes (chi square regression = $P > 0.05$ for both parameters). The aim of carcass evaluation is to assess an economical value, while the quality meat grading schemes would be an additional instrument useful in helping consumers and sellers during the marketing process. These results confirmed that these modelling approaches are not in competition but are complementary to each other, as argued by Houquette et al. (2014).

Mean pH resulted 5.60 for SQ meat and 5.58 for HQ meat. The one-way ANOVA showed no significant differences between the two groups ($P = 0.434$, $SEM = 0.10$), the mean value of which is compatible with a normal post-mortem decrease of pH. It has been argued that meat colour is highly related to ultimate

pH, and Hoffman et al. (2009) found an inverse correlation between them, as occurs in very dark meat (DFD) that is characterised by a high pHu (Hoffman, Mostert, Kidd, & Laubscher, 2009). The pale samples are associated with lighter meat, lower pHu and a greater drip loss (Qiao et al., 2007). It seems that also slightly and not significant differences in pH affect meat colour.

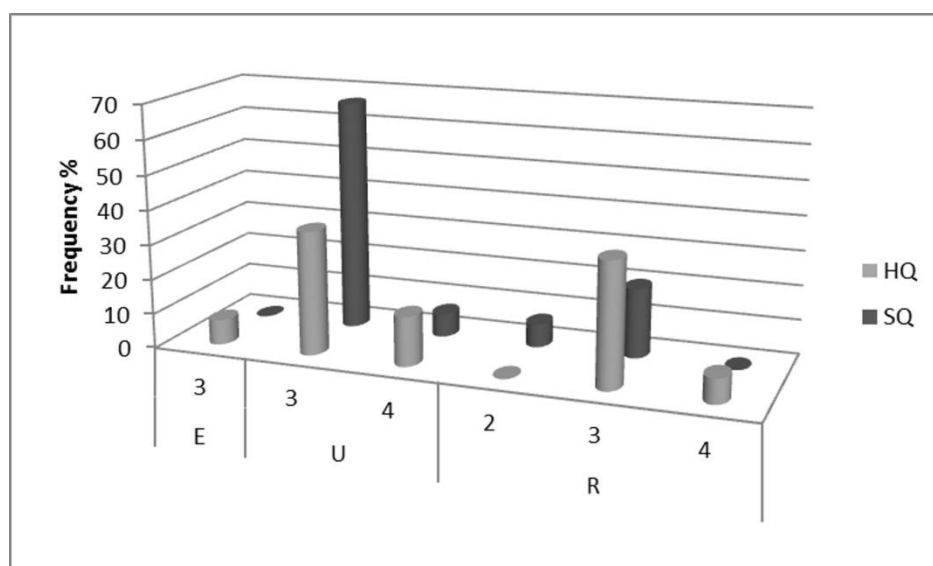


Fig. 4 Carcass conformation scores (% of frequency) between High Quality (HQ) and Standard Quality (SQ).

3.4 Relationship between quality level of steak and sensory profile of cooked meat

The means scores of sensory profile of beef samples of Italian Simmental young bull are reported in Fig.5. Regardless of the quality level to which they belong, the sensory profile of this meat was dominated by high odour and flavour of beef, followed by metallic and bloody notes. Liver, brothy, browned odour/flavour are perceived at a slight intensity, which means these attributes are not species-specific for Italian Simmental young beef. The taste of meat was scored with high intensity of umami and sweet tastes, followed by sour, salty and bitter. This meat is tender with a good juiciness, quite chewy and coarse, but not very adhesive.

The PLS-DA model with leverage validation had coefficients of prediction of 0.90 and 0.82 for calibration (R^2C) and for validation (R^2V), respectively. The calibration root mean square error was 0.15 and the validation root mean square error was 0.20, after seven latent variables. Results for the classification model were satisfactory (Fig.6), with all HQ samples predicted accurately (sensitivity=1.00), as well as with SQ samples. No misclassification of steaks occurred, all the samples were classified in the correct group (specificity=1.00). The accuracy of the model resulted 90%. Only one sample belonging to the standard quality group reported a prediction value >0.5.

It is well known that the texture of cooked meat is affected by structural changes that reduce the water retention capacity, reflected mainly in juiciness perception. Moreover, there are changes in the flavour profile, due to other flavours arising from non-volatile precursors that result from deamination of aminoacids, with the consequent formation of aldehydes hydrocarbons, nitrites and amino compound

(Terra, Campos, & Campagnol, 2011). However, the experts' judgment and the classification criteria adopted in this work seem to be good tools for discrimination.

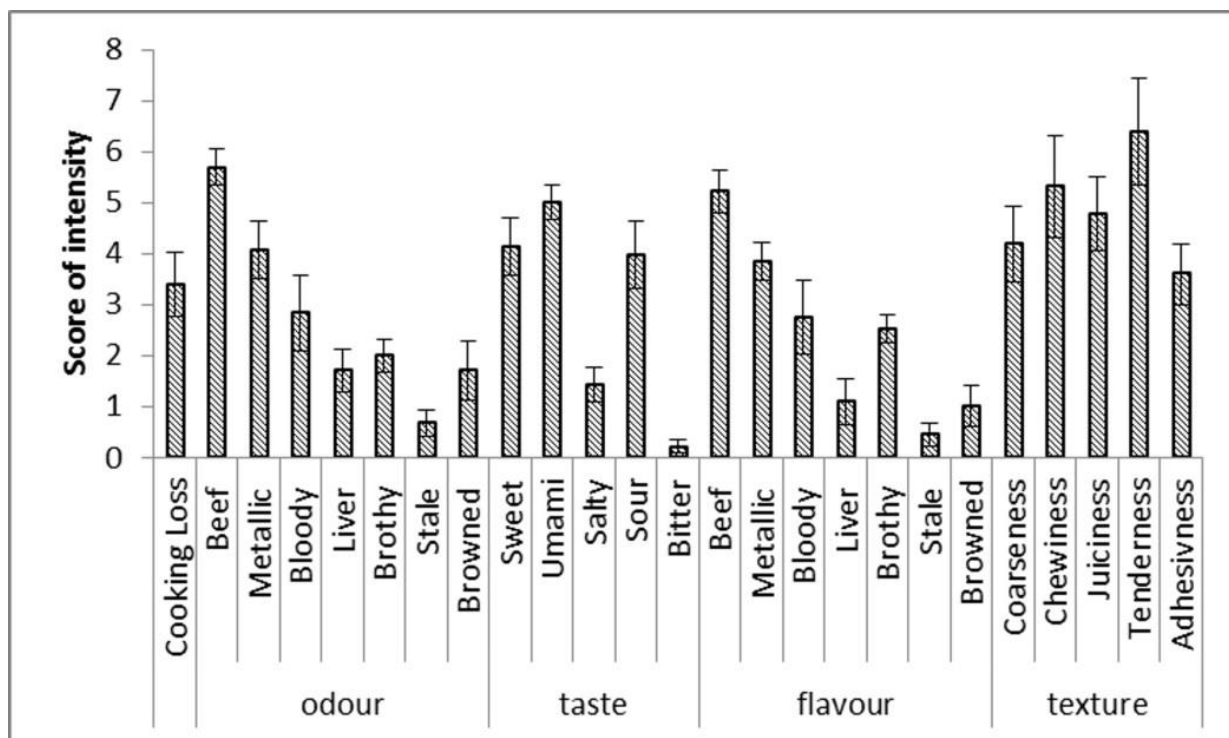


Fig. 5 Mean and standard deviation of 29 steaks of Italian Simmental young bull beef evaluated by trained panel.

One-way ANOVA was performed to assess the significant differences between the two quality levels. In Fig.7, the spider plot represents the differences between the two quality levels of fresh meat identified by experts using the quality grid for cooked meat. The major differences between two types of meat were related to textural attributes. Tenderness and juiciness were significant higher ($P \leq 0.05$), while chewiness and coarseness were significant lower ($P \leq 0.01$) in HQ meat than in SQ meat.

A tendency toward significant differences was observed for metallic odour ($P = 0.057$), brothy ($P = 0.075$) and liver ($P = 0.064$) flavour, and cooking loss ($P = 0.083$). The lack of significance of these attributes could be due to a halo-effect linked to tenderness (Corbin et al., 2015). The metallic odour was often associated with bloody odour, probably related to iron content (Gomez, Pflanzner, Cruz, de Felício, & Bolini, 2014; Campo et al., 2006). Metallic odour was scored slightly higher in the HQ samples than SQ meat. On the other hand, brothy and liver flavour and cooking loss was higher in the standard quality steaks than in the high quality ones. In previous work, it has been observed that consumer liking is positively correlated with umami, bloody, and sweet flavour, and negatively correlated with liver and stale flavour (Corbin et al., 2015).

Juiciness and tenderness are pleasant attributes that are usually recognised and appreciated by consumers, when these attributes were deliberately manipulated (Gomes et al., 2014; Schmidt et al., 2010). On the other hand, a chewy and coarse meat was inversely related to tenderness and juiciness

(Anderson et al., 2012). Variation in texture, especially in tenderness, was related to several factors, like the connective tissue characteristics, sarcomere length, fibre type (Anderson et al., 2011), the denaturation of proteins and pH (Rødbotten et al., 2004) as well as the intramuscular fat content, total collagen content, insoluble collagen content and muscle fibre proprieties (revised by Hocquette et al., 2014). It can be concluded that trained panel responses have good predictive value with respect to consumer satisfaction and likelihood of repeat purchase (Van Wezemeeal et al., 2014). The results confirmed what has been argued by Purslow (2005), i.e. that the most effective way of assessing meat tenderness is through the use experts.

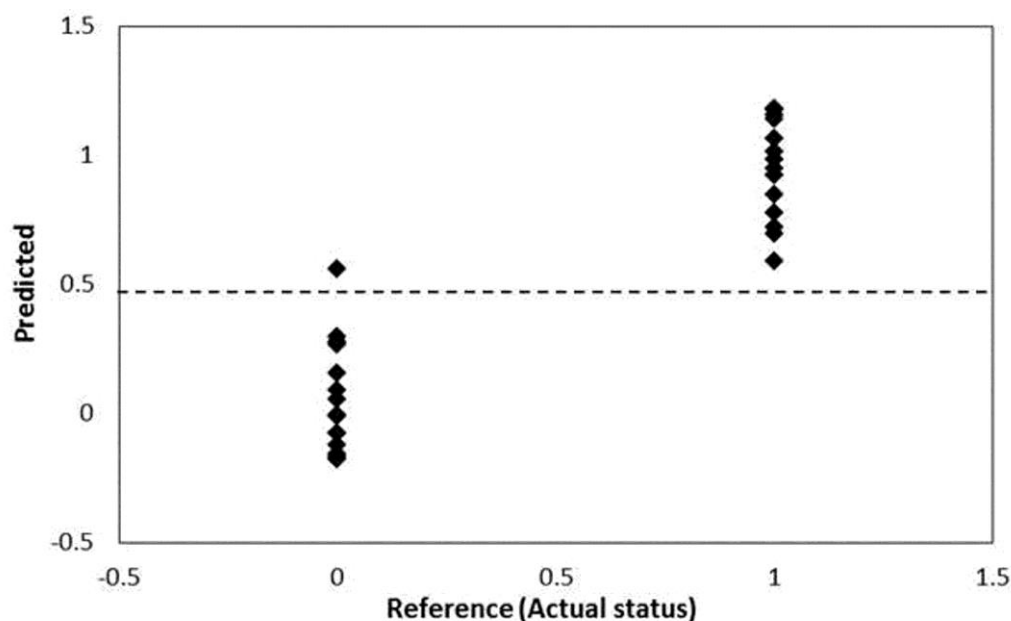


Fig. 6 Prediction of beef class based on PLS-DA regression using the sensory profile for a two-group model: 0 (standard quality) and 1 (high quality).

Starting from the overall quality judgments of experts due on steaks appearance, it has been possible to classify the samples, finding a relationship with the differences in the sensory profile of the cooked steaks. That means that the quality grid system and the development of the classification method are valid methods that can be used to predict differences in eating characteristics.

4. CONCLUSION AND IMPLICATIONS

The results obtained by the EUROP classification and the sensory analyses confirmed that the Italian Simmental young bull beef performed well, despite its dual purpose nature. None of the tested animals produced unacceptable ratings from the expert evaluations. A quality grid system was developed, based on the evaluation of raw steaks. The experts were able to classify the steaks with different overall quality levels using the developed grid, establishing a quality index. Those differences were also reflected in the cooked meat when evaluated by a trained panel. It is possible to conclude that the classification system was validated in this study and assured the identification of high quality meats. At the same time, it is important to underscore the importance of the expert in evaluating the quality of

these products. Expert evaluation of the quality grid system could be a very helpful tools to valorise the Italian Simmental meat, classifying the meat with a major quality level.

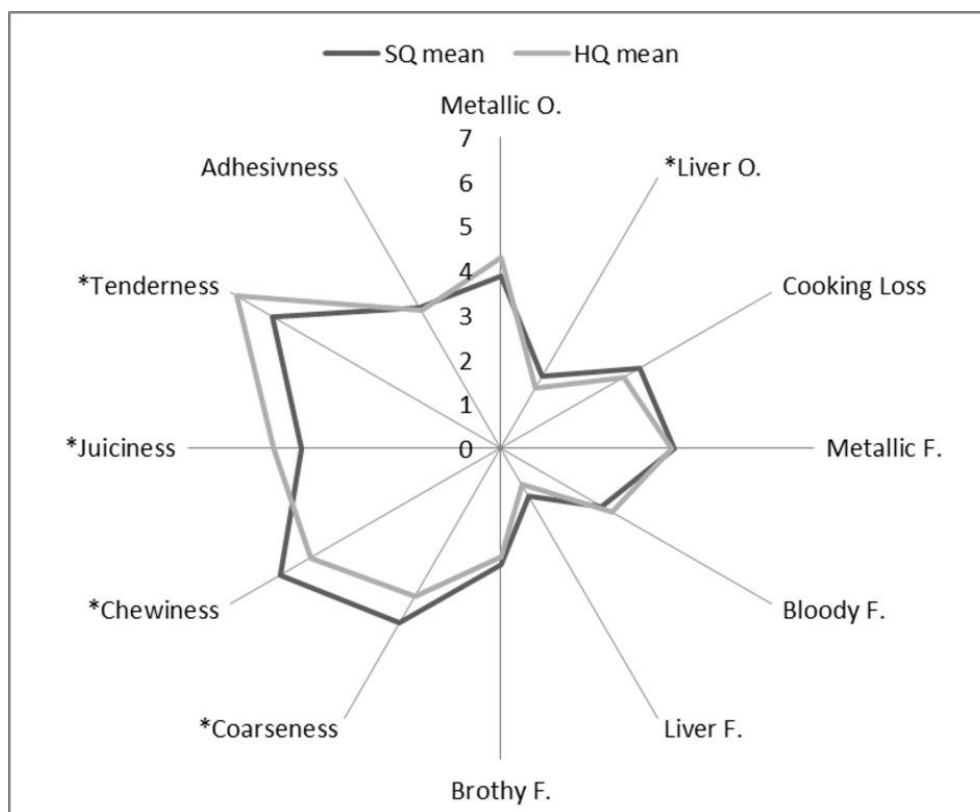


Fig. 7 Mean scores of discriminant attributes related to the HQ meat (light grey) and SQ meat (dark grey).
*significance levels $P \leq 0.05$

This research was only a preliminary step, and the interesting results will lead to more in-depth research. The evaluation of classification was made by a trained panel instead of consumers. The preliminary step should be performed with trained panel that could be more objective in the evaluation. Further research will be carried out with consumers to understand eating quality satisfaction and the likelihood of repeat purchase.

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V. Experiment 3

INFLUENCE OF FAMILIARITY WITH GOAT MEAT ON LIKING AND PREFERENCE FOR CAPRETTO AND CHEVON

1. INTRODUCTION

Goat husbandry in Italy is aimed at milk and cheese production. In 2010 year, goat meat production were 2103 tonnes in Italy. In particular, 86.7% of slaughtered goats were young animals that weighed less than 10 kg (ISTAT, 2010). The “capretto”, i.e. four to seven-week old kid fed on milk (Piasentier, Mills, Sepulcri, & Valusso, 2000; Piasentier, Volpelli, Sepulcri, Maggioni, & Corti, 2005), is the traditional and, still, the main meat product (Boyazoglu & Morand-Fehr, 2001) in this class. It is a major component of farm income during the Easter (regular kidding) and Christmas (early, de-seasoned kidding) times. However, not all the young kids are available during these holidays periods, because of late births that occur randomly or are programmed to extend the dairy season. Moreover, the concentration of demand during these peak periods also concentrates imports at these times, with an increased availability of capretto that forces prices down (Rubino & Claps, 1995). As a consequence, there is producer interest to diversify fresh goat meat offerings, to provide heavier carcasses and chevon meat beside traditional capretto outside the peak demand periods.

Animal age, changes in feeding regime, birth, rearing and slaughter season modifies the intrinsic characteristics of goat meat (Bas, Dahbi, El Aich, Morand-Fehr, & Araba, 2005; Casey & Webb, 2010; D'Alessandro et al., 2013), including its perceived appearance, texture, taste and flavour (Madruga & Bressan, 2011). Sensory diversity is an important factor in consumer attitudes towards meats (Sañudo et al., 2007), but chevon may not be well appreciated and valued in the market. Indeed, in Italy, while capretto meat is considered a delicacy, like in France and Latin America (Naude & Hofmeyr, 1981), fresh meat from later matured goats has no real market, except in some southern regions of Italy, such as Puglia and Calabria for 3-4 month old animals sold during summer, and a few traditional areas for does and bucks. Most of this meat is used for processed products (Rubino & Claps, 1995).

A limited or a complete lack of prior experience with a food (Verbeke & Vackier, 2004) or with its flavour principles (Prescott, Young, Zhang & Cummings, 2004) may result in poor consumer acceptability for it. On the other hand, familiarity for products with similar sensory profiles, i.e. familiar flavours, can provide a context for newly developed foods, signaling their palatability and safety, thus increasing their liking and purchase (Prescott et al., 2004). Deliza and MacFie (1996) and Tuorila et al. (2008) demonstrated that familiarity is one of the most important drivers of preference for food products, because it reduces product uncertainty and leads to a more likely match between expectations and product characteristics.

The purposes of the research were: i) evaluating the most important properties of representative types of goat meat, comprising traditional capretto and chevon from older animals unsold at Easter or born too late to be finished for the Easter period, paying particular attention to the sensory aspects directly perceivable by consumers; and ii) investigating the variability and structure of liking for goat meat by consumers who differ in their familiarity with the product.

2. MATERIALS AND METHODS

2.1 Goat meat procurement

The goat meat was obtained from 38 buck kids of Alpine breed, born in six farms of the Friuli Venezia Giulia region (N-E Italy), randomly allotted into five groups: traditional milk capretto (MC), heavy summer capretto (HSC), summering chevon (SCh), fall chevon (FCh) and late fall chevon (LFCh) (Table 1). The kids were suckled by dams in the farms of origin up to weaning at 1-1.5 months, when the MC group was slaughtered in April. After weaning, the kids of SCh group were moved, within the dams' flocks, to mountain farms and reared at pasture until slaughter, which occurred in late July (4-5 months of age). The remaining kids were brought into the experimental farm of the University of Udine and fed with a mixed diet (Table 1) in multiple boxes on straw until slaughter, which occurred at the beginning of July for the HSC group (3-4 months of age), at the beginning of October for FCh group (5-5.5 months of age) and in late November for LFCh group (5.5-6 months of age; born later at the end-season).

Twenty four hours after slaughtering at an EU-licensed abattoir and after dressing using standard commercial techniques, the carcasses were weighed (Table 1) and visually evaluated for meat and fat colour and for kidney and subcutaneous fat deposition. Finally, the carcasses were divided into thighs, shoulders and trunk (Colomer Rocher et al., 1987). All procedures met the requirements of the European Commission Directive, 86-609-EC for Scientific Procedure Establishments.

Muscles *Longissimus lumborum* (LL) and *thoracis* (LT) were obtained from the left and right trunk. pH measurement, using a glass piercing electrode (Crison 52-32) connected to a Hanna HI8424 (HANNA Nord Est Srl, Italy) pH meter and instrumental analyses were conducted on samples of right LL, after one day (pHu) and seven days of ageing, respectively. The samples for chemical analysis were taken from the right LT 24 hours after slaughtering and immediately stored at -20°C until analysis. The sensory profile was performed on the left LT (panellist training) and LL (sensory profile), and the consumer test was performed on slices of thigh, all of them stored at -20°C after seven days of ageing.

2.2 Instrumental analysis

The meat colour was evaluated on fresh samples of right LL at 48 h after slaughtering according to the CIE L*, a*, b* colour system by a Minolta CM-2600d Spectrophotometer (Minolta Camera, Osaka, Japan) with D65 as light source, with a measured area diameter of 8 mm and 10° of observer angle. Slices of LL muscle of 2 cm thickness were cooked in a waterbath in plastic bags at 75°C for 45 minutes. Each slice



of meat was weighed before and after cooking (drying with paper and cooling until 4°C). The cooking loss (CL) was calculated as the difference between the weight before and after cooking and expressed as a percentage of the initial sample weight. Shear force was measured on cooked loin (see CL), using a Warner–Bratzler device (Warner Bratzler Share Force, WBSF) with a triangular hole of 60° in the shear blade, mounted on a Lloyd TA Plus texture analyzer (Llyod, UK). The samples were cylinders 15 mm in diameter (7 sample/slice). Samples were made in the fiber direction and cut perpendicularly to the fiber direction. Test speed was 100 mm/min. Texture parameters measured were maxim force and total work of the test.

2.3 Chemical analysis

Extraction of total lipids was performed according to the procedure of Folch, Lees and Sloane-Stanley (1957) on LT samples. A total of 15 mg of nonadecanoic acid (C19:0) was added to a 1.5 g sample of minced meat sample and homogenised in 30 mL of a chloroform-methanol mixture (2:1 v/v) using an Ultra-Turrax homogeniser (T 25 basic; Ika-Werke, Staufen, Germany). Fatty acid methyl esters (FAME) were prepared using methanolic HCl (Sukhija & Palmquist, 1988) and were separated using a Carlo Erba gas chromatograph (GC) (HRGC 5300 mega-series; Rodano, Milan, Italy) equipped with a 60m SP-2380 fused silica capillary column (0.25 mm i.d., film thickness 0.25 µm; Supelco Inc., Bellafonte, PA). The oven temperature was increased from 160 to 180 °C at 1 °C/min, from 180 to 260 °C at 5 °C/min and then held at 260 °C for 5 min. Helium was used as the carrier gas at the rate of 1.2 mL/min, and FAME were identified using external standards (Supelco 37-component FAME mix including conjugated linoleic acids; Sigma-Aldrich, Milan, Italy). The FAME were quantified comparing the retention time with the internal standard (C19:0) and were expressed as the percentage of the total lipids that were identified.

2.4 Sensory analysis

The samples of the five goat meat types were presented monadically, randomized between subjects and sessions. Both trained descriptive panellists and consumers performed their evaluations in individual booths in a sensory laboratory (Meilgaard, Civille & Carr, 2007). The appearance evaluation was carried out on raw meat samples under incandescent white light. The taste of meat samples was evaluated after portioning and cooking. The firing was done in a convection oven with humidity control (Self Cooking®, Rational AG, Landsberg, DE), until reaching 70°C at the heart of the product in approximately five minutes, monitored by an internal thermocouple. The samples were labelled with numeric codes and their taste was assessed under red light. The assessors were instructed to rinse their mouth by eating a piece of carrot and drinking a sip of water, before starting the analysis and between each sample.

2.4.1 Descriptive profile

The loins were thawed at 4°C overnight for 24 h before the test and cut into pieces of equal size before cooking. Sensory profiling was carried out by a panel of eight trained assessors experienced in meat



evaluation. During a preliminary phase, discussions were held that aimed at developing a common sensory vocabulary and to avoid doubt about the meaning of attributes. The panel developed a profile protocol for a quantitative descriptive method containing 24 attributes relating to: fresh meat appearance (colour, ca, and watering, wa); meat odour (goat intensity, go, metallic, mo, liver, lo, toasted, to, herbaceous, ho, milk, do); meat taste (sweet, st, umami, ut, salt, sat, acid, at, bitter, bt); meat flavour (goat intensity, gf, metallic, mf, liver, lf, toasted, tf, herbaceous, hf, milk, df); meat texture (fibrousness, f, chewiness, c, juiciness, j, tenderness, t, adhesiveness, a). The sensory evaluation was replicated seven times in seven sessions. In each session, every judge assessed five meat samples, from five different kids, one for every goat meat type. The panel rated the intensity of each sensory attribute on an unstructured linear scale from 0 to 10 (0 = no intensity, 10 = extreme intensity).

2.4.2 Consumer test

One hundred and four consumers were recruited to participate in the hedonic test on goat meat at the University of Udine. They were well balanced by gender and age comprised a range of age from 21 to 75 years (mean age = 39.4 years; male mean age = 39.8 years; female mean age = 38.9 years), with the majority (72%) aged between 25 and 64 years old, representative of the Italian adult population. Consumers were asked to rate their liking/disliking for the taste of the five cooked goat meat types, using the Labelled Affective Magnitude (LAM) scale that is a linear hedonic scale ranged from – 100 to +100 and anchored from “greatest imaginable dislike” to “greatest imaginable like” (Cardello & Schutz, 2004). The frozen thighs, sliced into thick slices (approx. 2.5 cm), were thawed at 4°C overnight 24 h before the test, trimmed, cut into 2.5 cm³ samples and then cooked for tasting, without added condiments or dressing. Finally, consumers completed a questionnaire concerning their familiarity with goat meat (Bäckström, Pirttilä-Backman & Tuorila, 2004) and the frequency of meat consumption. At the end of the consumer session, subjects were compensated with snacks and drinks.

2.5 Statistical analysis

Normality of data distributions was tested by the Kolmogorov-Smirnov test. Live weight, carcass weight, meat instrumental characteristics and fatty acids were subjected to one-way analysis of variance with ‘goat meat type’ as a fixed effect, using the Helmert post-hoc contrast to check the significance of the differences among levels following two alternative effects: ‘kid age’ or ‘feeding regime’. For evaluating the ‘kid age’ effect the following contrasts were tested: SvW, suckling vs. weaned rams, i.e. MC vs. mean(HSC, SCh, FCh, LFCh); HvC, heavy summer capretto vs. chevon, i.e. HSC vs. mean(SCh; FCh, LFCh); G_cvM_c, grazing vs. mixed diet fed chevons, i.e. SCh vs. mean(FCh, LFCh); FvL, fall vs. late fall chevon, i.e. FCh vs. LFCh. For evaluating the ‘feeding regime’ effect the following contrasts were tested: SvW, as described above; GvM, grazing vs. mixed diet fed rams, i.e. SCh vs. mean(HSC, FCh, LFCh); HvC_m, heavy summer capretto vs. mixed diet fed chevon, i.e. HSC vs. mean(FCh, LFCh); FvL, as described above. The effect of goat meat type on fatness scores was studied using the Kruskal-Wallis test, with the non-



parametric Mann–Whitney U-test to check the significance of the ‘feeding regime’ contrasts among the levels of goat meat type (SPSS version 7.5.21 software; SPSS Inc., Chicago, IL).

Every sensory attribute was initially analysed following a two way factorial design in which the goat meat type and panellist were treated as a fixed effect and as a random variable, respectively. Statistically significant attributes were then analyzed by Principal Component Analysis (PCA) carried out using PanelCheck vers.1.4.0 software (<http://www.matforsk.no/panelcheck>), in order to geometrically represent and explain the dimensionality of the meat goat sensory space. Appearance and texture attributes were plotted separately from odour, taste and flavour attributes.

The liking data were first analysed by a repeated measures model, with ‘goat meat type’ as a within-subject factor and consumer ‘familiarity’ with goat meat as a between-subject factor. Then, the internal preference analysis was applied to the hedonic data matrix, consisting of goat meat types (objects) and consumers (subjects) to obtain a single bi-dimensional map, based on meat type acceptability information obtained from each consumer. For this purpose, the MDpref procedure of Senstools for Windows Vers.3.1.x (OP&P Product Research BV) was used, centring the data by row (i.e. liking ratings of the subjects for the objects). Senstools computed the most preferred meat type for each consumer. Eventually, the correlation coefficients between the sensory attributes from the trained panel and the two preference dimensions were calculated and plotted as coordinates on the preference map (McEwan, 1996).

The Chi-Square Test table was applied to evaluate if familiarity affected the frequency distribution of consumer preferences for the different goat meat types.

3. RESULTS AND DISCUSSION

3.1 Appearance and texture of goat meat types

The goat meat types were clearly differentiated according to their appearance and texture properties. The instrumental parameters (Table 2) and the sensory attributes perceived by panellists (Figure 1) were in close agreement with each other, and consistently provided a significant explanation of meat peculiarities.

The pHu values (Table 2) were in line with those observed in previous experiments (Piasentier et al., 2005). However, the pH detected in fall chevon (5.68 on average) was lower than that of capretto and SCh (5.87 on average), likely because of a higher pre-slaughter stress susceptibility of the youngest ram kids and those finished at pasture, in comparison with the more mature, confined rams (Webb, Casey & Simela, 2005). As already observed in lamb meat (Piasentier, Valusso, Leonarduzzi, Pittia, & Kompan, 2002), the cooking loss was deeply affected by ultimate pH (Trout, 1988), ranging from the highest value in FCh meat (21.7%) and the lowest in HSC (12.6%). The fall chevon was tougher (34.5 N on average) than HSC meat (23.7 N, $p=0.003$). SCh presented intermediate values of WBSF, in agreement with the

intermediate age and the physical activity at pasture of its provider rams. However, the youngest capretto presented intermediate WBSF values (29.1 N), comparable to the summering chevon meat and not statistically different from the average of weaned rams.

The sequence of goat meat types described above is the same as projected in the first latent component of the PCA group average configuration of sensory attributes shown in Figure 1. PC1 accounted for a very high proportion of the original sensory variability (92.7%), as a consequence of its high correlation with texture descriptors of goat meat. The left half of PC1 was loaded by fibrousness and chewiness; the most matured chevon meat types (LFCh and FCh), characterized by the highest WBSF values, had negative PC1-scores. Instead, along the right half of PC1, which was loaded by tenderness and juiciness, were located the other meat types, following an order that is negatively correlated with that of WBSF and CL, respectively, and showing the high levels of juiciness and tenderness of HSC meat.

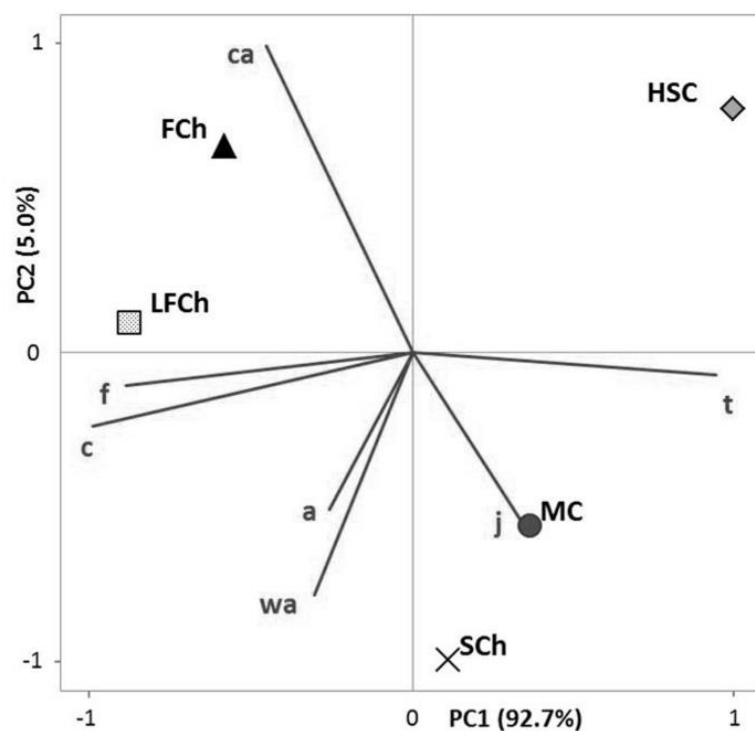


Fig.1. PCA group average configuration of goat meat types (MC=traditional milk capretto, HSC=heavy summer capretto, Sch=summering chevon, FCh=fall chevon and LFCh=late fall chevon) on the basis of appearance and sensory texture attributes: colour (ca), watering (wa), fibrousness (f), chewiness (c), juiciness (j), tenderness (t) and adhesiveness (a). Correlations with the space dimensions are reported as vectors.

A significant decrease of tenderness and juiciness with the age and/or body weight was observed previously in other studies and highlighted by physical analysis (Dhanda, Taylor and Murray, 2003) or sensory descriptors (Carlucci, Girolami, Napolitano, & Monteleone, 1998).

Table 1 Age, feeding regime, live weight (LW), cold carcass weight (CCW) and number of ram kids per goat meat type.

		Goat meat type					SEM		Significance of 'kid age' contrasts ³			
		MC	HSC	SCh	FCh	LFCh			SvW	HvC	G _c vM _c	FvL
Kids	no.	10	7	7	7	7						
Age	months	1-1.5	3-4	4-5	5-5.5	5-5-6						
Feeding regime		Suckled milk	Mixed diet	Grazed herbage ²	Mixed diet	Mixed diet						
Hay ¹	g/d	--	530	--	390	340						
Concentrate ¹	g/d	--	410	--	740	780						
LW	kg	11.3	19.1	23.3	24.8	26.4	0.34	0.000	0.000	0.000	0.021	
CCW	kg	5.34	7.91	10.61	11.06	11.49	0.170	0.000	0.000	0.000		

MC=traditional milk capretto, HSC=heavy summer capretto, SCh=summering chevon, FCh=fall chevon and LFCh=late fall chevon.

¹: Average daily intake in the last two months before slaughtering. Meadow hay: DM=89%; CP=9%DM; NDF=62%DM. Commercial concentrate: DM=89%; CP=18%DM (15%DM for LFCh); NDF=29%DM (22%DM for LFCh).

²: Mountain pasture based on: *Phleum alpinum*, *Festuca pratensis*, *Poa alpina*, *Trifolium repens* and *pratense*.

³: Contrast: SvW, suckling vs. weaned rams, i.e. MC vs. mean(HSC,SCh,FCh,LFCh); HvC, heavy summer capretto vs. chevon, i.e. HSC vs. mean(SCh,FCh,LFCh); G_cvM_c, grazing vs. mixed diet fed chevons, i.e. SCh vs. mean(FCh,LFCh); FvL, fall vs. late fall chevon, i.e. FCh vs.LFCh.

A higher occurrence of collagen cross-links in older animals leads to a harder meat in comparison with that provided by their younger counterparts. The apparently odd position of traditional capretto meat in that chronological ranking could be explained by different reasons, as highlighted by Berge et al. (2003) in lamb meat. Indeed, other factors being constant, the suckling kids could have suffered a greater cold shortening, due to less subcutaneous fat covering their thin muscle mass, and a lower calpain activity and smaller fibre dimensions in comparison with the older rams. Regarding juiciness and the observed negative correlation with CL, Cross, Durland and Seideman (1986) stressed that the water remaining in the cooked product is the major contributor to the sensation of juiciness during meat eating. This phenomenon is particularly justified in goat meat that, as seen even in the present experiment, is characterized by a relatively low intramuscular fat content (Webb et al., 2005). As for meat appearance, instrumentally assessed by colour parameters (Table 2), the redness value of traditional capretto was significantly lower than in the other meat types ($P=0.000$); moreover, a numerically increasing redness intensity was observed with kid age, consistent with the known parallel rise of the muscle myoglobin content (Berge et al., 2003). The yellowness value, b^* , was higher in MC and SCh than in weaned rams and fall chevon meats, respectively.

Eventually, the lightness, L^* , did not show significant differences among goat meat types, but, in agreement with b^* , their values were slightly higher in MC and SCh. Priolo, Micol and Agabriel (2001) suggested that meat from ruminants finished at pasture is generally darker than meat from animals reared in a stable. Ryan, Unruh, Corrigan, Drouillard and Seyfert (2007) demonstrated that Boer goats raised in confinement and consuming diets with concentrate had higher a^* and b^* values than goats rangeland grazing without concentrate supplementation, while Lee, Kouakou and Kannan (2008) showed that L^* and b^* values of loin chops from Boer \times Spanish intact male goats fed only a *Medicago sativa* hay diet were higher than those fed a concentrate diet consisting predominantly of alfalfa meal and yellow corn. The outcomes of our experiment are not easy to justify, likely because in our trait the feeding system can not be separated by age of animal. However, they appeared consistent with those of sensory analysis. For example, the meat types (FCh and LFCh) with the highest a^* values were scored with the highest colour intensity by trained judges. The second latent component of the PCA group average configuration (PC2, Figure 1) explained only a low (5%) but meaningful percentage of the original sensory variability, essentially linked to the perceived appearance of the goat meat types. Indeed, PC2 was loaded by a negative correlation between colour and watering traits. The HSC meat was placed in the first quadrant because of its dried appearance that was positively associated with the lowest cooking loss value (Table 2), i.e. an index of a high water holding capacity. In the fourth quadrant were located the MC and SCh meats because of their lowest colour score ratings, correlated with the highest lightness and yellowness values (Table 2). By contrast, in the opposite second quadrant were placed the two fall chevon meats (FCh and LFCh) which received the highest colour scores by panellists, in accordance with their high instrumental redness.



Table 2 Instrumental sensory parameters of goat meat types: ultimate pH (pH_u), cooking loss (CL), hardness (Warner Bratzler Shear Force, WBSF) and colour (lightness, L*, redness, a*, and yellowness, b*).

	Goat meat type					SEM	Significance of "kid age" contrasts ¹			
	MC	HSC	SCh	FCh	LFCh		SvW	HvC	G _c vM _c	FvL
pH _u	5.85	5.89	5.86	5.66	5.70	0.020		0.022	0.053	
CL	18.4	12.6	13.8	21.7	19.9	0.627		0.001	0.000	
WBSF	29.1	23.7	28.2	38.4	37.0	1.26		0.003	0.011	
L*	40.7	38.0	40.3	39.9	38.1	0.413				
a*	4.11	5.72	5.87	6.09	6.37	0.150	0.000			
b*	11.5	10.4	11.7	10.9	10.7	0.136	0.050	0.077	0.034	

MC=traditional milk capretto, HSC=heavy summer capretto, SCh=summering chevon, FCh=fall chevon and LFCh=late fall chevon.

¹: Contrast: SvW, suckling vs. weaned rams, i.e. MC vs. mean(HSC,SCh,FCh,LFCh); HvC, heavy summer capretto vs. chevon, i.e. HSC vs. mean(SCh,FCh,LFCh);

G_cvM_c, grazing vs. mixed diet fed chevons, i.e. SCh vs. mean(FCh,LFCh); FvL, fall vs. late fall chevon, i.e. FCh vs. LFCh.



Table 3 Fat amount in various body deposits in the ram kid groups that provided the goat meat types.

		Goat meat type					SEM	Significance of 'feeding regime' contrasts ³			
		MC	HSC	SCh	FCh	LFCh		SvW	GvM	HvC _m	FvL
Kidney score ¹	points	1.8	2.0	2.0	2.1	2.6	0.061	.054	0.027	0.024	
Subcutaneous score ²	points	1.6	2.1	2.1	2.3	2.3	0.055	.000			
Intramuscular	g lipids/100g fresh LL	1.5	2.7	2.3	3.0	2.9	0.15	.001			

MC=traditional milk capretto, HSC=heavy summer capretto, SCh=summering chevon, FCh=fall chevon and LFCh=late fall chevon.

¹: From 3 (excessive) to 1 (little) (Colomer Rocher et al., 1987).

²: From 5 (very high fat cover) to 1 (low fat cover) (Colomer Rocher et al., 1987).

³: Contrast: SvW, suckling vs. weaned rams, i.e. MC vs. mean(SCh,HSC,FCh,LFCh); GvM, grazing vs. mixed diet fed rams, i.e. SCh vs. mean(HSC,FCh,LFCh); HvC_m, heavy summer capretto vs. mixed diet fed chevon, i.e. HSC vs. mean(FCh,LFCh); FvL, fall vs. late fall chevon, i.e. FCh vs. LFCh.

3.2 Fat and flavour profiles of goat meat types

The fat distribution in the body deposits is summarized in Table 3.

The different methodology adopted for assessing fat quantity allows only a relative but still significant comparative analysis of the evolution of fat deposits between goat types. The young, milk fed ram group, providing MC meat, was the leanest one, regardless of fat deposit. Moreover, because the intramuscular fat is deposited later than subcutaneous and abdominal fat, due to the preferential order in adipose tissue development, different ratio between the fat amount in various body deposits were showed. The ratio between intramuscular lipids concentration, kidney and subcutaneous fat score were less than 1 in MC, whereas, in all the other experimental groups that comprised older animals, these ratios were greater than 1. The deposition of subcutaneous and marbling fat in weaned rams occurred slowly during the growing season, confirming the lean nature of goat carcasses (Webb et al., 2005). However, in the late fall rams (LFCh meat), near to their puberty, the visceral fat (kidney score 2.6, Table 3) still appeared as an important and dynamic deposit due to the energy concentration of the diet (Table 1).

The fatty acid (FA) profile of LT of goat meat types is summarized in Table 4. The intramuscular goat fat was generally characterized, as expected (Banskalieva, Sahlu & Goetsch, 2000), by a high content of palmitic (C16:0), stearic (C18:0), and oleic (C18:1 n -9) acids, and by significant differences across meat types, mainly according to feeding regime. HSC, FCh and LFCh meats, provided by rams fed on mixed diets, had a similar fatty acid profile, but different from that of grazing chevon and, noticeably, from that of suckling capretto. In Table 4, this result is highlighted by the high frequency of significant effects for the contrasts 'grazing vs. mixed diet fed rams' (GvM) and, notably, 'suckling vs. weaned rams' (SvW).

The passage from the suckling, pre-ruminant condition to the weaned, ruminant one involved a significant decrease of the intramuscular fat proportion of short and medium length even-chain saturated fatty acids, important components of kid milk intake (Dhanda, Taylor, Murray & McCosker, 1999), and an increase in the occurrence of odd-chain saturated and unsaturated fatty acids, arising from rumen-derived propionic acid (Wood, Enser, Richardson, & Whittington, 2008). Other significant changes in the FA composition of goat meat resulted from the ruminal bio-hydrogenation of polyunsaturated FA (PUFA), the concentration of which, particularly linoleic acid (C18:2 n -6), was much higher in MC than in the other meat types. In contrast, the latter meat types had higher concentrations of C18:2 n -6t, conjugated linoleic acid (CLA) isomers, and the saturated stearic acid (C18:0) resulting from ruminal bio-hydrogenation (Doreau, Bauchart & Chilliard, 2010). However, the much higher PUFA content of suckling-kid muscle may also be a consequence of its lowest intramuscular lipid content (IML, Table 3), which has an important impact on FA profile. The different FA compositions of neutral lipid and phospholipid and the increasing value of their ratio are related to the increase of IML (Wood et al., 2008).

The goat meat from grazing animals (SCh) had a significantly higher content of PUFA than meat provided by rams fed on mixed diets (HSC, FCh and LFCh), particularly PUFAn-3. Grass is a source of 18:3n-3, which contributes to increased PUFAn-3 in muscle of ruminants (Doreau et al., 2010). In agreement with our results, Bas et al. (2005) showed that goats raised outdoor had higher PUFA proportions than indoor-raised goats. At the same time Ryan et al. (2007) found that *longissimus* samples from goats fed concentrate diets had lower percentages of PUFAn-3, compared to *longissimus* samples from range-fed goats. Even for weaned rams, the differences in muscle lipid content and, consequently, in phospholipid proportion between groups (GvM), may have contributed to dilute PUFA proportion in HSC, FCh and LFCh meats. The PUFA/SFA ratios were significantly different between experimental groups reflecting the differences in PUFA level because of the similar SFA level observed.

Eventually, the lower PUFA content in the muscle of mixed-diet-fed goats in comparison with that of animals kept on pastures could partly result from a higher hydrolysis and hydrogenation of dietary FA in their rumen. This occurrence may also justify the parallel greater proportion of stearic acid, i.e. the end product of PUFA saturation. On the other hand, SCh meat presented a higher CLA proportion than meat types from rams fed on hay and concentrates. Such a finding confirms that grazing goats were characterized by a lower rumen activity and thus a likely higher rumen escape of CLA, an intermediary product of bio-hydrogenation available for tissue deposition. Indeed, the process of bio-hydrogenation is often incomplete and several of the intermediaries can leave the rumen. Forage-based diets promote a higher flow of these intermediaries from the rumen (Sinclair, 2007).

The meat of mixed-diet-fed vs. grazing goats showed a greater proportion of MUFA, particularly oleic acid (C18:1n-9), in line with the findings of Bas et al. (2005), when comparing indoor- vs. outdoor-raised goats. These authors suggested a higher desaturase activity induced by concentrate-rich diets, probably in response to an increase in desaturase gene expression induced by insulin and because this enzyme activity was down regulated by PUFA. However, the level of oleic acid could also reflect the consumption of maize grain of mixed diet fed rams. It was reported that oleic acid characterized the maize-based diets (Melton, Amiri, Davis, & Backus, 1982).

In Figure 2, the PCA group average configuration of the perceived taste and odour of goat meat types is shown. Moving from the young to the old ram kids along the first latent component (PC1, 66.4% of the original variance explained), the meat lost its milk aroma (do, MC) and sweet taste (st, HSC) and acquired an increasing intensity of goat odour (go) and flavour (gf). These attributes, together with livery notes (lf), characterised FCh and, even more, the LFCh meats. The SCh meat had intermediate sensory properties and was in close association with herbage odour on the third latent component (not in the graph). Along PC2 (16.2% of the original variance explained), LFCh set apart from FCh and, primarily, HSC segregated from MC mainly because of metallic (mo) versus toasty odour (to) notes.



The PCA flavour sensory configuration of the goat meat types was not completely overlapped with the FA outcome (Table 4), which was largely affected by feeding regime by assimilating HSC, FCh and LFCh meats. Table 4. Fatty acid profile (% total lipids) of goat meat types.

This means that other factors, apart from FA profile, influenced the flavour perception of goat meats. The development of odour and flavour of meat is a very complex system (Calkins & Hodgen, 2007; Piasentier et al., 2009). It is known that many components that contribute to goat meat odour and flavour are products of the thermal breakdown of lipids. Unsaturated lipids, in particular, are more reactive to heat (Elmore, Mottram, Enser, & Wood, 1999; Madruga, Elmore, Dodson, & Mottram, 2009). However the major precursors of goat meat flavour also comprise water soluble components (Mottram, 1998; Madruga, Elmore, Oruna-Concha, Balagiannis, & Mottram, 2010).

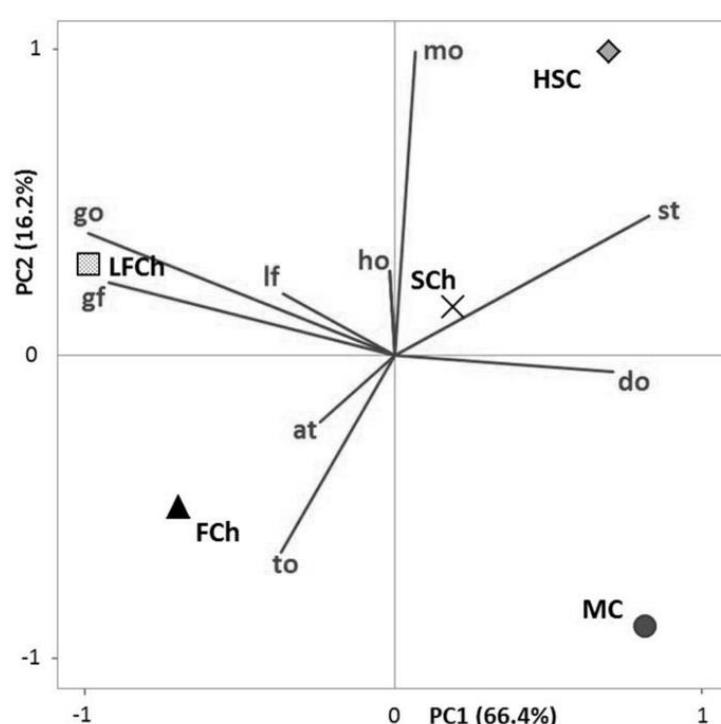


Fig. 2 PCA group average configuration of goat meat types (MC=traditional milk capretto, HSC=heavy summer capretto, SCh=summering chevon, FCh=fall chevon and LFCh=late fall chevon) on the basis of significant sensory flavour attributes: goat odour (go), goat flavour (gf), liver (lf), herbaceous (ho), metallic (mo), milk (do), toasted (to), acid (at) and sweet (st). Correlations with the space dimensions are reported as vectors.

The sweet taste was associated with lactones, and at a high levels of linoleic acid corresponded with elevated amounts of 6- γ -dodecenolactone (Melton, 1990). EPA and DHA contribution to meat flavour was associated with the development during cooking of highly unsaturated volatiles, like as octatriene, 2-ethylfuran, 2-(2-pentenyl)-furan, 1-penten-3-ol and 2-ethylpyridine (Elmore, Mottram, Enser, & Wood, 2000). These aromatic fractions are known to confer pleasant flavour, for example: 1-penten-3-ol leads

to butter flavour (Madruga et al., 2010); octatriene has a cheese flavour (Sérot, Regost, Prost, Robin, & Arzel, 2001) and green notes as well. MC meat was relatively richer in linoleic acid, EPA and DHA.

In the negative part of the first component, the principal attributes are goat odour and flavour (Figure 2), the perception of the intensity of which increased with ram ageing. Madruga, Arruda, Narain and Souza (2000) reported that “goaty” meat aroma increased with slaughter age of the ‘mestiço’ goat and that meat from the youngest goats had the lowest number and total relative abundance of volatiles. According to several authors (e.g., Brennand, Kim Ha, & Lindsay, 1989) the “goaty” flavour is related to branched-chain FA, like as 4-ethyloctanoic acid, 4-methyloctanoic acid, and 4-ethyl oct-2-enoic acid.

There were indications that puberty and/or age caused an increase in the odorous 4-methylnonanoic acid (Young, Berdagué, Viallon, Rousset-Akrim, & Theriez, 1997).

The livery notes that distinguished fall chevon from HSC meat, were consistent with the significantly different content of linolenic acid and the findings of Campo et al. (2003). These authors showed that cod liver and fishy odours were strongly associated with the presence of linolenic acid, with or without cysteine and ribose, in an aqueous model system of meat.

Herbaceous odour contributed heavily to the third latent component. Thus, the perceived intensity of green notes appeared to be independent from that of goat and dairy odours. The metallic attributes that distinguished HSC in comparison with MC may be related to different iron content, denoted by the already mentioned differentiation in redness colour due to myoglobin level. The toasty flavour is more directly related to the protein fraction of meat that is involved in the Maillard reaction, particularly effective at low concentration of lipids and high concentration of amino acids and carbohydrates (Elmore et al., 1999; Song et al., 2010).

3.3 Consumer liking and preference

90% of consumers claimed to eat fresh meat at least 2 or 3 times a month and 41% at least 2 or 3 times a week and more frequently: pork (67% of respondents consumed it at least once per week), poultry (64%) and beef (61%). As expected the goat meat consumption reported by 93% of participants was once a month or less, and only 7% two or three times a month (data not reported in Tables).

The consumers clearly perceived the sensory differences between goat meat types as reflected in the liking ratings (Table 5). In general terms, the most well liked meats were traditional capretto and heavy capretto, the scores of which were close to the ‘like moderately’ level. The less pleasant meat was chevon of FCh and LFCh type that received scores only marginally higher than ‘like slightly’ (Cardello & Schutz, 2004).

In order to better understand the structure of consumer preferences and identify the most important sensory attributes for meat goat acceptability, the internal preference analysis was first applied to the hedonic scores. Then, the sensory information provided by trained panelists was linked to the internal preference mapping space, by correlating for each attribute the mean ratings of the various goat meat types with the derived preference dimensions (McEwan, 1996).



Table 4 Effect of different goat meat types on fatty acid composition (% total lipids) of intramuscular fat.

	Goat meat type					SEM	Significance of 'feeding regime' contrast ¹			
	MC	HSC	SCh	FCh	LFCh		SvW	GvM	HvC _m	FvL
C10:0	0.32	0.27	0.35	0.18	0.15	.020	.068	.008	.067	
C12:0	1.24	0.18	0.36	0.07	0.08	.056	.000	.100		
C14:0	4.30	1.69	3.98	1.20	1.68	.148	.000	.000		
C15:0	0.17	0.44	0.45	0.25	0.29	.018	.000	.015	.002	
C16:0	23.37	19.63	22.38	18.87	20.92	.206	.000	.000		.005
C17:0	0.37	1.34	0.88	1.25	1.27	.035	.000	.000		
C18:0	12.43	19.77	13.85	20.14	19.74	.464	.000	.000		
C22:0	0.20	0.22	0.32	0.22	0.20	.020				
C24:0	0.01	0.17	0.49	0.07	0.04	.025	.003	.000		
SFA	42.43	43.72	43.06	42.25	44.36	.484				
C14:1	0.13	0.13	0.19	0.07	0.06	.013		.006		
C15:1	0.03	0.07	0.03	0.10	0.10	.010	.071	.028		
C16:1	1.28	1.28	2.32	1.37	1.65	.097	.094	.002		
C17:1	0.81	1.30	1.02	0.73	0.73	.060			.002	
<i>trans</i> -C18:1	3.60	2.34	2.49	3.31	2.97	.373				
C18:1 <i>n</i> -9	26.90	37.95	34.05	38.89	38.49	.683	.000	.020		
C18:1 <i>n</i> -7	2.10	1.25	1.67	1.41	1.48	.049	.000	.030		
MFA	34.85	44.31	41.77	45.90	45.49	.715	.000	.075		
CLAt7,c9/t8,c10/c9,t11	0.13	0.34	0.40	0.32	0.33	.014	.000	.069		
C18:2 <i>n</i> -6t	0.02	0.15	0.13	0.18	0.14	.008	.000			
C18:2 <i>n</i> -6	15.51	7.17	8.22	7.46	6.43	.380	.000			
C18:3 <i>n</i> -6	0.08	0.10	0.08	0.05	0.08	.009				
C20:4 <i>n</i> -6	4.60	2.79	3.98	2.35	1.85	.264	.003	.023		
C22:2 <i>n</i> -6	0.02	0.04	0.11	0.05	0.04	.013				
C22:4 <i>n</i> -6	0.27	0.06	0.08	0.14	0.13	.013	.000		.062	

MC=traditional milk capretto, HSC=heavy summer capretto, SCh=summerring chevon, FCh=fall chevon and LFCh=late fall chevon.

¹: Contrast: SvW, suckling vs. weaned rams, i.e. MC vs. mean(SCh, HSC, FCh, LFCh); GvM, grazing vs. mixed diet fed rams, i.e. SCh vs. mean(HSC, FCh, LFCh); HvC_m, heavy summer capretto vs. mixed diet fed chevon, i.e. HSC vs. mean(FCh,LFCh); FvL, fall vs. late fall chevon, i.e. FCh vs.LFCh.

trans-C18:1 corresponds to the sum of t6-8-, t9-, t10-, t11-, t12- and t13/14-18:1.

SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids.



The results are graphically represented in Figure 3, which shows the meat-type's scores and the consumer loadings. On the basis of the subject preference vector scaled to his/her unit variance, the consumer loadings fit on a unit circle. The most preferred meat type for each consumer was indicated by plotting his/her loading using a small-sized symbol having the same shape of the score plot of the most liked meat type. The same results were also provided in the second row of Table 5, which shows the proportion of consumers who gave the highest liking score for each goat meat type. Nearly two thirds of consumers (64%) preferred other meats than traditional capretto. The heavy capretto was preferred by the same proportion (36%) of consumers that gave the highest score to MC meat. Thus, the majority of the respondents preferred juicier and tender meats, with sweet taste and dairy aromatic notes, as highlighted in Figure 3 by the vectors of the sensory attributes that correlated with MC and HSC scores.

The above results were expected, because of the prevalent, Italian dietary habits for meat in general, and goat meat in particular. Italian consumers eat high amounts of pork, poultry and beef from intensive breeding systems and low quantity of mutton (Turrini, Saba, Perrone, Cialfa, & D'Amicis, 2001). Ruminant meat from extensive and pasture systems is generally darker, more cohesive and flavored than meat from ruminants fed on concentrate diets in intensive systems (Pirolo, et al., 2001; Piasentier et al., 2000; Carlucci et al., 1998), and it is judged less desirable by Italian consumers (Font i Furnols et al., 2006; Sañudo et al., 2007). Goat meat is eaten occasionally for Christmas and Easter festivals and, like in France, Spain and Portugal, Italian people largely consume meat from very young goats of dairy breeds.

Although capretto, traditional or heavy, is the more well liked goat meat, a significant proportion (28%) of consumers liked fall chevon the most. They represent a group of consumers that appreciated goat odour and flavour in meats and were not averse to livery notes and marked texture, as were characteristic of the FCh and LFCh meats.

3.4 Consumer familiarity with meat goat

The self-reported consumption frequency of our respondents demonstrated that they were, as a whole, a representative sample of Italian meat consumers. However, a deeper analysis of their dietary habits showed that familiarity with goat meat was not homogenous in the sample. Consumption of goat meat, as expected, was generally rare (only 8% of applicants declared they eat it at least 2 or 3 times a month), but half of respondents revealed that they were familiar with this meat. Indeed, while half of them chose from the familiarity scale (Bäckström, et al., 2004) the options: 'I do not recognize the meat, and I have not tasted it' (5%) or 'I recognize the meat, but I have not tasted it' (45%) (Unfamiliar group, UG); another half of participants selected the choices 'I occasionally eat the meat' (44%) or 'I regularly eat the meat' (6%) (Familiar group, FG). Finding consumers with different degrees of familiarity in the same country, especially when a food is rarely eaten, is not surprising.



Differences in consumption frequency for lamb meat, for example, has been found across and within countries, where the familiarity for products was higher (Spanish and United Kingdom consumers) or where this kind of meat was unfamiliar (German consumers) (Font i Furnols et al., 2006). The two familiarity groups showed significant demographic differences in terms of gender and age. The familiar cluster was comprised of 60% males with a mean age of 44 years old. By contrast, the unfamiliar group was characterized by an inverse proportion of males and females and mean age 10 years younger. Turrini et al. (2001) suggested that woman usually eat less amounts of meat due to differences in nutritional requirements. In a study on organic and conventional beef, the intermediate age cluster expressed higher liking ratings for organic meat than consumers in the younger age cluster (20-39 years old) (Napolitano et al., 2010).

The effect of familiarity on liking and preference for meat goat types was examined and the results reported in Table 6 and Figure 3. The liking ratings for chevon were influenced by the level of familiarity with goat meat. The unfamiliar consumers showed significantly lower pleasantness ratings when tasting chevon versus capretto. In comparison, those consumers who were familiar with the product, rated summering and fall chevon significantly higher, and reduced their ratings for goat meat only when tasting the late fall chevon product.

In Figure 3, the loadings were plotted with filled or empty symbols for denoting UF or FG consumers, respectively. In comparison between them, a higher percentage of consumers of the former group preferred the traditional milk capretto, while consumers in the latter group preferred the fall chevon (consumers liking most MC: 41 vs. 31% and FCh: 12 vs. 24 %, respectively for UF and FG; $\chi^2 = 3.00$, $P = 0.08$).

These results corroborate earlier findings obtained comparing the effect of skatole and volatile branched-chain FA on acceptability of pasture-fed sheepmeat by New Zealand and Japanese consumers with different regularity of mutton consumption. The response of NZ consumers was not affected by the presence of a low level of branched-chain FA compounds, while the less regular Japanese consumers were negatively influenced by the presence of these species-specific compounds. However, the high concentration of branched-chain FA was associated with a significant reduction of liking scores for both groups (Prescott, Young, & O'Neill, 2001). Consumers familiar with a specific type of goat meat had superior ability to detect and appreciate distinctive characteristics of the product, despite the fact that they were used to eating capretto, which is characterized by delicate notes and a low intensity of species-specific sensory attributes. They exhibited lower ratings for goat meat only when tasting the late fall chevon product, the preference dimensions of which were highly correlated with goat and liver odour, flavour, and redness (Figure 3). The relatively low acceptability for this type of meat was likely related to a pronounced sensory distinctiveness from the goat meat currently consumed. However, repeated exposure could change consumer perceptions of meat (Webb et al., 2005).

Table 5 LAM (± 100 points scale) liking scores and preference of consumers for the different goat meat types (104 respondents)

		Goat meat type				Significance of "kid age" contrasts ¹			
		MC	HSC	SCh	FCh	LFCh	SvW	HvC	FvL
Liking	score	30	28	24	20	15	1.74	0.010	0.095
Preference	%	36	36	0	18	10			

MC=traditional milk capretto, HSC=heavy summer capretto, SCh=summering chevon, FCh=fall chevon and LFCh=late fall chevon.
¹: Contrast: SvW, suckling vs. weaned rams, i.e. MC vs. mean(HSC,SCh,FCh,LFCh); HvC, heavy summer capretto vs. chevon, i.e. HSC vs. mean(SCh,FCh,LFCh); G_cvM_c, grazing vs. mixed diet fed chevons, i.e. SCh vs. mean(FCh,LFCh); FvL, fall vs. late fall chevon, i.e. FCh vs.LFCh.

Table 6 Effect of consumer familiarity with goat meat on LAM (± 100 points scale) liking scores and preferences for the different goat meat types (104 respondents).

		Goat meat type						Significance of "kid age" contrasts ¹			
		MC	HSC	SCh	FCh	LFCh	SEM	SvW	HvC	G _c vM _c	FvL
Liking	score										
Unfamiliar		28	25	16	7	10	2.45	0.008	0.001		
Familiar		32	32	31	33	20	2.48				0.021
Difference	score	5	7	15*	26*	10	3.49				

MC=traditional milk capretto, HSC=heavy summer capretto, SCh=summering chevon, FCh=fall chevon and LFCh=late fall chevon.
¹: Contrast: SvW, suckling vs. weaned rams, i.e. MC vs. mean(HSC,SCh,FCh,LFCh); HvC, heavy summer capretto vs. chevon, i.e. HSC vs. mean(SCh,FCh,LFCh); G_cvM_c, grazing vs. mixed diet fed chevons, i.e. SCh vs. mean(FCh,LFCh); FvL, fall vs. late fall chevon, i.e. FCh vs.LFCh.
 *: Difference from 0, $P < 0.01$.

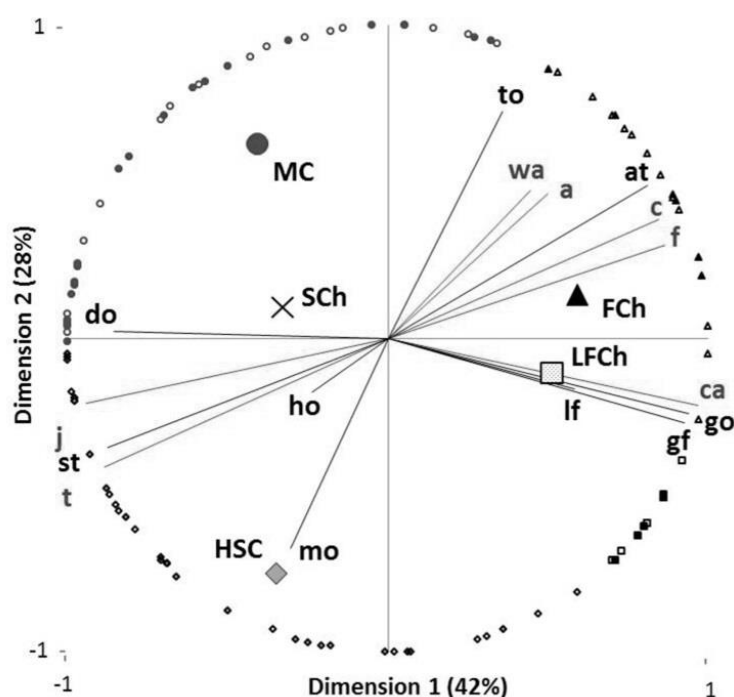


Fig. 3 Internal preference mapping plot of consumer liking expressed for goat meat types (MC=traditional milk capretto, HSC=heavy summer capretto, Sch=summaring chevon, FCh=fall chevon and LFCh=late fall chevon). Correlations between preference dimensions and sensory attributes are reported as vectors. The sensory attributes are coded as: colour (ca), watering (wa), fibrousness (f), chewiness (c), juiciness (j), tenderness (t), adhesiveness (a) goat odour (go), goat flavour (gf), liver (lf), herbaceous (ho), metallic (mo), milk (do), toasted (to), acid (at) and sweet (st). Loadings are plotted with filled or empty symbols denoting unfamiliar and familiar consumers, respectively.

4. CONCLUSION AND IMPLICATIONS

Increasing the age and weaning kids, considered as by-products of goat dairy farming with a low commercial value except during the Easter period, led to types of meat with peculiar sensory attributes, different from those of traditional capretto. Whereas meat from heavy summer kid, 3 to 4-month old, maintained delicate properties, like tenderness, juiciness and sweetness, chevon became progressively redder, goaty in flavour and tougher with increasing ram kid age.

Nonetheless, diversifying fresh meat offerings by providing heavier carcasses outside the peak demand period created by festivals appears to be a promising marketing strategy for the goat industry. Importantly, this research demonstrated that there is a potential and quite broad niche of consumers that appreciate the sensory profile of chevon and that assigning to it the highest preference scores. Moreover, the commercialization of chevon, while expanding its familiarity to consumers, will increase its acceptability, although consumers accustomed to the delicacy of capretto may still dislike the pronounced taste of chevon from the oldest ram kids that are close to their sexual maturity.

The importance of sensory properties in liking score is a paramount. However, there are other factors that affect the purchase decision of consumer (like price, brand) that would be interesting to investigate in further trial.

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VI. Experiment 4

THE EFFICACY OF VISIBLE SPECTRUM IN PREDICTING SENSORY ATTRIBUTES OF CATTLE MEAT

1. INTRODUCTION

Consumers and manufacturers are increasingly seeking products of certified quality (Verbeke, 2011). The meat industry is no exception to this expectation (Grunert, 2006; Verbeke et al., 2010). Furthermore, the meat sector, particularly the beef sector, has to contend with a major challenge due to the broad-ranging variability of the raw material, which ultimately translates into high variability in product quality and low process control over the commercialized final product. Tenderness, juiciness and flavour are important factors which influence beef eating satisfaction. The meat industry needs reliable meat quality information throughout the production process in order to guarantee high-quality meat products for consumers (Damez & Clarjon, 2013). The visible region allowed the measurement of pigments such as chlorophyll in immature canola seed (Williams & Sobering, 1993) and carotenoids in wheat (McCaig, McLeod, Clarke, & Depauw, 1992) by measuring absorbance (reflectance) at the specific wavelengths associated to the pigments. Recently, in a study on apples some relationship between sensory proprieties and visible spectrum was found. Unexpected relationship between colour and sweet and sour has been detected (Corollaro et al., 2014). The widespread use of electromagnetic waves, near infrared waves in particular, for meat quality assessment is due to their practicality and their capability to explore materials (Damez & Clerjon, 2013). While good relationship with chemical characteristics, such as percentage of protein in intramuscular fat, moisture and dry matter have been detect, less interesting correlation occurred between WHC, WBSF, drip loss or cooking loss. Many problems have been found in predicting sensory attributes in the past (Prieto, Roehe, Lavín, Batten, & Andrés, 2009a). The low predictability of sensory attributes was associated to three main problems: (1) the narrow range of intensity score of sensory proprieties, (2) the high homogeneity of analysed samples (3) the small scanned surface of the samples area. Warris (2004) in his studies pointed out that another problem is the subjectivity of the assessor, even when they are well trained. Taking into account these points, the aim of present work was to measure the sensory variability of varying types of cattle meat, in terms of age and gender, and to evaluate the prediction power of visible spectrum analysis in defining the sensory proprieties.

2. MATERIALS AND METHODS

2.1 Meat types and experimental design

Three categories of cattle meat, veal (V), beef from young bull (B) and heifer (H), were evaluated. For each type of meat eight lots have been randomly chosen from the same supplier during four consecutive weeks. The supplier guaranteed the standardization of the procedures of animal husbandry and slaughtering and meat processing within and between experimental lots. A total number of 24 lots were achieved. The cuts of meat were those available in the Italian market. The top (also known as the inside) round cut, containing primarily the *semimembranosus*, *sartorius*, *adductor*, *gracilis* and *pectineus* muscles, was sliced into steaks (2.54 cm thickness) that were placed in polystyrene/ethylvinylalcohol/polyethylene trays and packaged by modified atmosphere technology. Trays were flushed with 80% O₂ and 20% CO₂, keeping a 2:1, gas to meat, headspace. The trays were kept at 4 °C until the analyses were performed.

2.2 Sensory profile

A panel of 10 subjects participated in this study (4 males and 6 females; mean age = 35). Sensory testing was performed at the University of Udine, in a laboratory built according to the UNI-ISO 8589:1990 standard. They participated in 10 training sessions, during which a common vocabulary was developed to describe the samples (Table 1). The sensory evaluation of the steaks was performed using the developed list of attributes consisting of 21 sensory descriptors grouped in one visual descriptor (colour hue), five olfactory attributes evaluated in terms of odour and flavour (beef, metallic, whey, liver and anomalous), five basic tastes (sweet, sour, umami, salty, bitter), and five textural descriptors (coarseness, chewiness, tenderness, juiciness and adhesiveness). The panel performed a quantitative descriptive analysis (QDA) (Meilgaard et al., 2007) of the top round cut. Samples of all the 24 lots were evaluated in duplicate, during eight sessions, two per week (six samples per each session, for a total of 48 evaluations). The samples were presented monadically, randomized between subjects and sessions, and coded with a three-digit number. Judges were instructed to refresh their mouth after the taste of each sample with water and carrots (1 minute break after each sample). In each session, they evaluated three samples and after 10 minutes they evaluated the other three samples. The two weekly sessions were carried out in the same day: one session around 11.00-12.00 a.m. and the second session at 17.00-18.00. In each session the judges evaluated the appearance and taste of all meat types, rating the intensity of each sensory attribute on an unstructured linear scale from 0 to 10 (0 = no intensity, 10 = extreme intensity). Evaluations were conducted in individual testing booths, under incandescent white light for appearance assessment on raw meat steak samples, and under red light for taste assessment. The taste of meat samples was evaluated after portioning and cooking. The firing was done in a convection oven (RATIONAL SCC 61), until the sample reached 70 °C at the centre of the product monitored by an internal thermocouple. The codes of raw and cooked samples were different, in order

to avoid any association between appearance and taste. The data were collected using Fizz Acquisition software (2.46A, Biosystemes, Couternon, France).

Table 1 Description of sensory attributes used for the sensory profile of meat samples.

Category	Attribute	Description
Appearance	Colour Hue ⁶	White/pale pink to red/dark red
Odour & Flavour	Beef ⁴	Aroma of cooked beef lean
	Metallic ^{3,4}	Aroma of Ferro sulphate
	Whey ⁵	Aroma associated to milk serum
	Liver ^{3,4}	Aroma associated to animal liver
	Anomalous	Aroma usually not linked to meat
Taste	Sweet ^{3,4}	taste elicited by sugar
	Umami ⁴	taste elicited by monosodium glutamate (MSG)
	Salty ⁴	taste elicited by salts
	Sour ^{3,4}	taste elicited by acids
	Bitter ^{3,4}	taste elicited by caffeine
Texture	Coarseness ³	Degree of granularity of the muscle fibres
	Chewiness ²	Easiness to chew the meat samples for swallowing
	Juiciness ^{2,3}	Moisture released by the product in the mouth during early chewing
	Tenderness ^{1,2,3}	Minimum force required to chew the meat sample: the lower the force the higher the tenderness
	Adhesiveness ¹	Perception of mouth residuum that remains stuck to the teeth once the chewing is finished

¹Ruiz, Guerrero, Arnau, Guardia, and Esteve-Garcia, 2001; ²Braghieri et al., 2012; ³Rødbotten, Kubberød, Lea and Ueland, 2004; ⁴Mougan & Martini, 2012; ⁵Gorraiz, Beriain, Chasco, & Iraizoz, 1998; ⁶AMSA, 2012

2.3 Colour measurements

The colour of five steaks for each lot of meat (24 lots in total) was measured using a Minolta CM-2600d Spectrophotometer (Minolta Camera, Osaka, Japan) with D65 as light source, with a measured area diameter of 8 mm and 10° of observer angle after black and white calibration. The reflectance spectra were recorded from 360 nm to 740 nm (AMSA, 2012). The trays of each lot of meat were opened to measure the colour and then discarded.

2.4 Statistical analysis

The panel performances were evaluated weekly, performing a two-way ANOVA with PanelCheck vers.1.4.0 software (<http://www.matforsk.no/panelcheck>), considering meat lot, assessor and their interaction as fixed sources of variations (Ares, Barrios, Lareo, & Lema, 2009).

The scores for each sensory attribute were averaged over panel and replicates obtaining one evaluation for each meat lot (total of 24). The meat lots were randomly divided into calibration set (18 samples) and prediction set (six samples) for external validation, but they were adjusted to ensure that the range and standard distribution of the two groups were comparable (Plans et al., 2014). Principal Component analysis was performed on the calibration set to explore the differences among samples, in order to geometrically represent and explain the dimensionality of the meat sensory space.

To explore the relationship between sensory profile and visible spectra profile a partial least squares regressions (PLS) was used on the calibration set. Sensory data were mean centred and scaled to unit variance. Each spectrum was pre-treated by MSC (multiple scattering corrections), to remove the multiplicative interference of scatter. PLS-2 model was performed on both spectral X-data and sensory Y-traits for explaining as much as possible of the covariance between X and Y matrix. PLS-1 regressions were calculated for each sensory attribute (y-single column) and the visible spectra (X-matrix). First, calibrations were attempted by paying particular attention to choosing a relative small number of latent factors to be introduced into the models. Limiting this number is necessary in order to perform a reliable model and to avoid over-fitting and under-fitting of the models (Næs, Brockhoff & Tomic, 2010). Then the calibration models were evaluated by full cross-validation, estimating the determination coefficient of validation (Q^2) of each model (Corollaro et al., 2014).

The best models were externally validated on the prediction set. The predictive effectiveness, reliability and accuracy were evaluated mainly depending on determination coefficient of prediction (R^2_p), standard error (SEP) and root mean standard error (RMSEP) (Cheng, Qu, Sun, & Zeng, 2014). In order to highlight the nature of the errors in prediction phase, an 'error of prediction' (EP) for each sensory attribute was calculated, as a difference between estimated and actual scores for the six predicted samples.

The PCA and PLS were performed by The Unscrambler X v.10.2 software (CAMO Software, Norway). Other analyses were performed by Microsoft Excel, Version 2010.

3. RESULTS AND DISCUSSION

The evaluation of panel performance was performed for each week. The attributes with a significant ($p < 0.05$) interaction 'judge X product' (bitter, salty and umami), as well as the attributes that were not discriminant between samples ($p > 0.05$; sweet, sour, liver and anomalous flavour and adhesiveness) were removed from further analysis. No significant differences in terms of taste has been detected between samples. Moreover, meat samples were not characterised by negative flavour as "anomalous" and "liver".



3.1 Meat sensory profile

The first two principal components from PCA explained 86 % of total variance in the sensory dataset. In Fig.1 is reported the bi-plot, that showed which attributes led on the principal components. The first component (74 % of explained variance) is positively led by “colour hue”, “beef” and “metallic” for the odour and flavour categories, and “coarseness”, while is negatively led by “whey” for the odour and flavour categories, and “juiciness”. The second component (12 % of explained variance) is positively related to “tenderness”, and negatively to “chewiness”. Score distribution (Fig.1) shows that most of the explained variances are related to animal type. Along the first component, samples are divided by age effect, indeed, in the left part are located the veal samples, while beef and heifer meat were indistinctly distributes in the right part of the first component. Veal meat is characterised by tenderness, juiciness and whey flavour, while beef and heifer meat, as expected, have a redder meat, with a more intense flavour of beef and metallic. They resulted also more coarse and chewy. Our findings are in accordance with results reported by Rødboten et al., (2004). Their results suggested that veal was more pale in colour and acidic in flavour (our whey) than beef, which was darker in colour with a more intense flavour not dominated by acidic notes. Furthermore, veal meat was more tenderer than meat from the older animal (beef and heifer).

The second components showed a minor distinction between samples, prevalently associated to the natural variability of the market meat products.

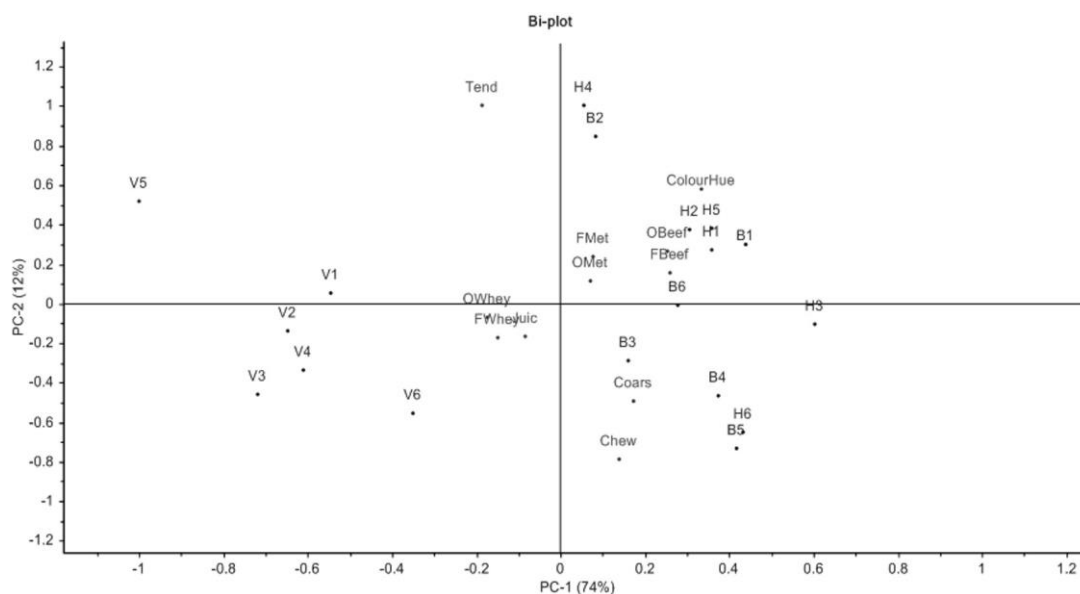


Fig. 1. Bi-plot from Principal Component Analysis on sensory data of top round cuts from 18 lots (calibration set) of veal (V), beef (B) and heifer meat (H), including 11 attributes previously selected: Juiciness (Juic), Tenderness (Tend), Chewiness (Chew), Coarseness (Coars), Colour Hue (ColourHue), Metallic Flavour (FMet), Metallic Odour (OMet), Beef Flavour (FBeef), Beef Odour (BBeef), Whey Flavour (FWhey), Whey Odour (OWhey).

3.2 Meat reflectance spectra

The reflectance spectra (360-740 nm) for the 18 lots (calibration set) of the top round cuts from veal, beef and heifer meat were showed in Fig.2. The spectra had the typical shape for meat spectra with a

maximum pick between 480-520 and 540-580 and a maximum on a plateaux from 630 to 740 nm (Ripoll et al., 2011). Maximum reflectance of each meat types was at 680 nm with a mean value \pm standard deviation of reflectance of 37.3 ± 1.3 for beef, 36.8 ± 2.6 for heifer meat and 39.3 ± 4.2 for veal. The reflectance maximum corresponds to the achromatic absorption caused by refraction and internal reflections in the structural elements of the meat. Indeed, the absorbance at this point is not dependent on the pigment concentration, but by various colourless structural elements (Ripoll et al., 2011; Krzywicki, 1978). The minimum reflectance pick was at 420 nm, corresponding to 4.8 ± 1.6 for B, 5.9 ± 0.3 for H and 7.0 ± 0.6 for V (mean \pm standard deviation). In the visible region, absorption bands at 542 and 572 nm were associated with respiratory pigments, principally myoglobin or deoxymyoglobin (Cozzolino, Barlocco, Vadell, Ballesteros, & Gallieta, 2003). In general, the pale meat has higher reflectance than the red meat because of its brightness, as found in pork meat. The reflectance at 560 nm is believed to be caused by myoglobin, indicating a higher content of myoglobin in the darker meat as suggested by Xing, Ngadi, Gunenc, Prasher, and Garipey (2007). The spectral features in the visible region are very similar to those reported in beef, pork and chicken meat samples, since all these species contain the same primary pigment responsible for meat colour, myoglobin (Andrés et al., 2008; Cozzolino et al., 2003; Xing et al., 2007).

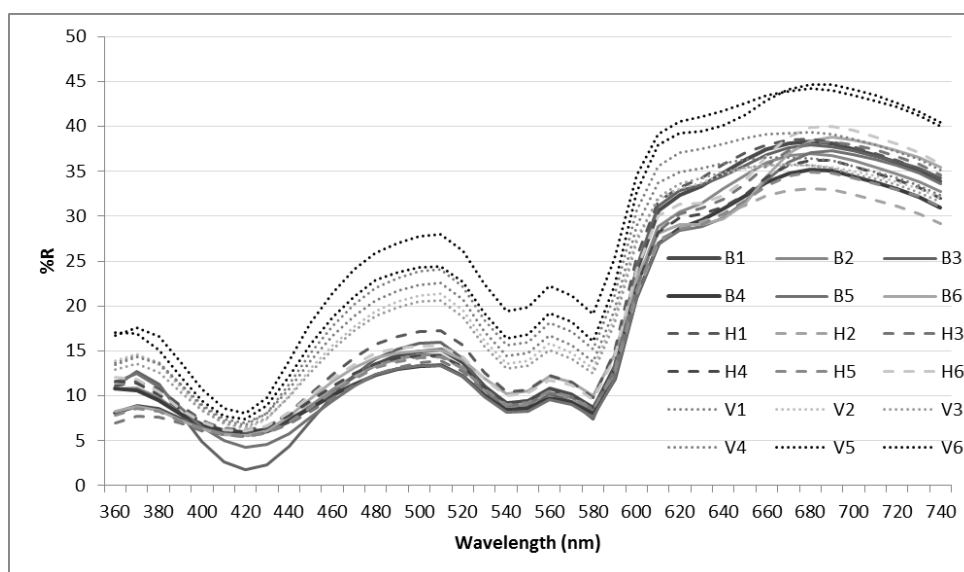


Fig.2 Mean reflectance visible spectra of top round cuts from 18 lots (calibration set) of veal (V), beef (B) and heifer meat (H).

3.3 Prediction model of sensory profile from visible spectrum

The loading plot of the X and Y matrixes from PLS-2 analysis is reported in Fig.3. Most of the wavelengths are loaded on the first factor (79% of explained variance of the X-matrix), while the violet range and part of green and red ranges of the visible spectra (360-450nm) contribute to explain the 12% of variance on the second factor. The overall distribution of sensory attributes is similar to the correlation loadings obtained by PCA. Indeed, the first factor is led by the “colour hue”, “beef” and “whey” odour and flavour (65% of the explained variance of the Y-matrix), the second factor seems to be related to part of “tenderness” and “metallic” (4 % of explained variance of the dependent variables).



These considerations suggest that it could be possible to build a predictive model for some sensory attributes starting from meat visible spectra features. From the analysis emerged that flavour and odour for the same characteristics resulted highly related, thus, the predictive models were built using only the flavour attributes.

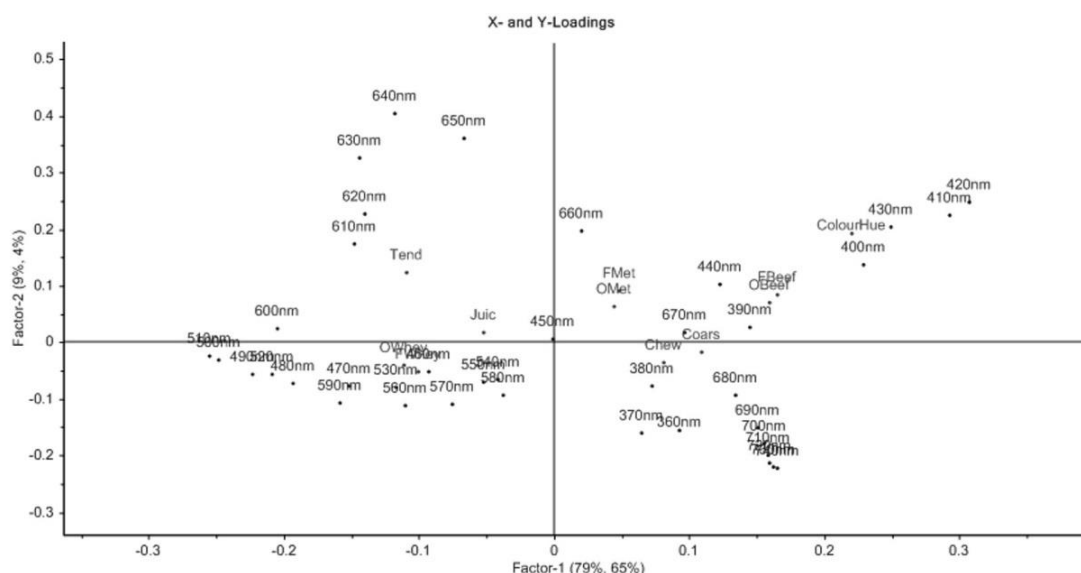


Fig. 3. X and Y loadings plot from PLS-2 analysis on visible spectra and sensory data of top round cuts from 18 lots (calibration set) of veal (V), beef (B) and heifer meat (H). The sensory attributes are: Juiciness (Juic), Tenderness (Tend), Chewiness (Chew), Coarseness (Coars), Colour Hue (ColourHue), Metallic Flavour (FMet), Metallic Odour (OMet), Beef Flavour (FBeef), Beef Odour (OBeef), Whey Flavour (FWhey), Whey Odour (OWhey).

3.3.1 Predictive models

PLS-1 was performed for each sensory attribute, in order to estimate the best prediction model. In table 2, PLS-1 model and relative Q^2 are reported. For each model, the optimum numbers of latent variables were chosen and the best wavelengths were selected. Here, it is reported only the best model for each sensory attributes. The Q^2 might be considered as workable for reliability, when its value is equal or over the 0.8 threshold (Andrés et al., 2007). The models that overcome this condition were colour hue, beef flavour and whey flavour. However, Corollaro et al. (2014) affirmed that the efficiency of the model in sensory attributes prediction could be assumed when $Q^2 \geq 0.77$. According with this statement, the predictive model of coarseness should be considered efficient.

Results showed that some attributes could be better predicted than others. As expected, the best prediction models was obtained for “colour hue” that showed a Q^2 of 0.87 (good efficiency). Colour of adults’ meat is redder than young animals, indeed colour hue increase with the age (as commented in section 3.1). Several authors reported the ability of the Vis-NIR spectra in predicting the colour parameters as L^* , a^* and b^* . Prieto and collaborators found greatest correlation between the visible spectrum and L^* , a^* and b^* parameters compared to the relationship between infrared region and L^* , a^* and b^* parameters (Prieto et al., 2009b). It is known that the colour of meat is related to the concentration of myoglobin, and its forms. The better wavelengths useful for the colour hue prediction was previously reported by other authors. Indeed, Prieto et al. (2009b) and Cozzolino et al. (2000) found

that the wavelengths at 460, 530, 565 and 590 nm were the most useful to predict the colour measured with colorimeter. In our study, more wavelengths were included, probably because trained panel was used to estimate the colour hue instead of instrumental measurements.

Table 2 PLS-1 models and relative Q^2 values, estimated for each sensory attributes, using the best wavelengths suggested by the cross-validation process. Nr. Factors column refers to the number of factors used for achieving the best prediction model.

Attribute(y)	nm	PLS-1 model	Q^2	Nr. Factors
Colour Hue	selected ^a	$y=0.87X + 0.06$	0.87	1
Beef	all	$y=0.81X + 0.66$	0.82	1
Metallic	all	$y=0.72X + 0.45$	0.64	6
Whey	all	$y=0.78X + 0.39$	0.80	7
Juiciness	selected ^b	$y=0.69X + 1.22$	0.66	2
Coarseness	all	$y=0.76X + 1.01$	0.77	1
Tenderness	all	$y=0.53X + 2.07$	0.49	3

^a = 390-440, 460-530, 560,570, 590,600,650-670;

^b = 360-380, 440,450, 490-510, 540, 550, 680;

While “beef flavour” and “whey flavour” are strongly related to colour of meat ($Q^2 = 0.82$ and 0.80 , respectively) in validation, the relationship between colour and metallic resulted the least correlated compared to other flavour ($Q^2 = 0.64$). Beef and whey flavours seem to be more related to age and growth of animals. The lack of validation score in prediction model for the metallic flavour is probably due to the small range of the values (Warris, 2004). On the other hand, the data related to prediction of flavour or aroma reported in literature did not reach higher Q^2 value: i.e. the overall flavour intensity reported by Prieto and collaborators, was 0.59, using Vis-NIR range (Prieto et al., 2009b).

The best model among textural attributes was obtained by coarseness, where the validation regression coefficient resulted 0.77. This good performance of the model resulted quite expected, while good prediction for firmness was found by using Vis-NIR hyperspectral imaging in fish flesh, using mainly the visible wavelengths (Cheng et al., 2014). The importance of the grain of the meat has been discussed in previous studies. The fibre dimension seems to be related to tenderness, which is one of the most important attributes used by consumer for assessing eating quality of the product (Purslow, 2005).

Juiciness obtained the best value in prediction score compared to other studies, even though the regression coefficient in validation resulted 0.66. Using Vis-NIR spectra the correlation values reported were 0.21, 0.50, 0.54 for beef meat (Prieto et al., 2009b; Ripoll et al., 2008; Liu et al., 2003). However, Bowker and collaborators, found that Vis-NIR spectra was a good tool to classify broiler breast meat according to the WHC (Bowker, Hawkins, & Zhuang, 2014). It is interesting to point out, how the wavelengths used by these authors to predict WHC were quite similar to the wavelengths used in our model. The inverse relationship between WHC and juiciness is known and already reported (Webb et



al., 2005). The low prediction score for juiciness found by other authors could be associated to other factors: i.e. a poor performance of panel (Warris, 2004).

The model built for “tenderness” prediction appeared as the worst, giving a Q^2 value of 0.49. Several works reported that the tenderness, analysed as Warner-Bratzler Shear Force (WBSF), is better predicted using NIR instead of visible spectra. The wavelengths between 1400 and 1900 nm are related to water absorbance and explain the C-H molecular bonds. The relationship between these wavelengths and tenderness could be associated to these bounds (Prieto et al., 2008).

3.3.2 External validation of the prediction models

The performances of the models in prediction were evaluated using a separate set of data, comprising six samples, two per type of meat. The prediction ability of the sensory attributes of the new samples was evaluated calculating R^2_p , SEP and RMSEP. Results were reported in Table 3. In general, the highest is the coefficient of determination and the lowest are the errors, the best is the model performance (Cheng et al., 2014). Colour hue and beef notes showed the best coefficients of prediction ($R^2_p = 0.98$ and 0.99, respectively), with the lowest RMSEP and SEP. These two models as previously discussed are the most effective, reliable and accurate and for these reasons we were expecting a good prediction agreement. The models built for coarseness and whey showed a lower accuracy, however with an R^2_p coefficients of 0.70 and 0.76 respectively and a RMSEP of 0.51 and 0.41 they are still acceptable. The prediction of metallic and tenderness resulted very poor with the lowest R^2_p coefficient and the highest RMSEP and SEP. The low reliability and accuracy of these two models exclude them from the list of attributes predictable with the visible spectra instruments. These results did not surprise and confirm those obtained with the internal cross-validation.

What was unexpected, it was the results obtained for juiciness. The juiciness prediction was less accurate than the cross-validation prevision. Indeed, the R^2_p resulted 0.43 and the RMSEP resulted the highest (0.74). However, the SEP maintained a quite good score (0.52).

Table 3 Prediction results of sensory attributes by using the optimal model; R^2_p , coefficient of determination of prediction; RMSEP, root mean square error of prediction; SEP, standard error of prediction.

Attribute	Prediction		
	R^2_p	RMSEP	SEP
Colour Hue	0.97	0.34	0.38
Metallic	0.61	0.63	1.15
Beef	0.98	0.39	0.68
Whey	0.70	0.51	0.49
Coarseness	0.76	0.41	0.49
Juiciness	0.43	0.74	0.52
Tenderness	0.60	0.73	0.96

For a better comprehension of these results an EP value was calculated as a difference between estimated and actual scores for the six predicted samples. In Fig. 4, the EP values for the five most accurate models were reported. The histogram allows a quick examination of the prediction residuals, showing the presence of outliers among the samples used in the external validation phase. In general, the distribution of residuals was homogenous across samples, showing no bias in prediction phase. However, the prediction of juiciness gave an unexpected result, because one sample, V2, showed a very high EP value, -1.46, compared to the other samples (range from 0.31 to 0.21).

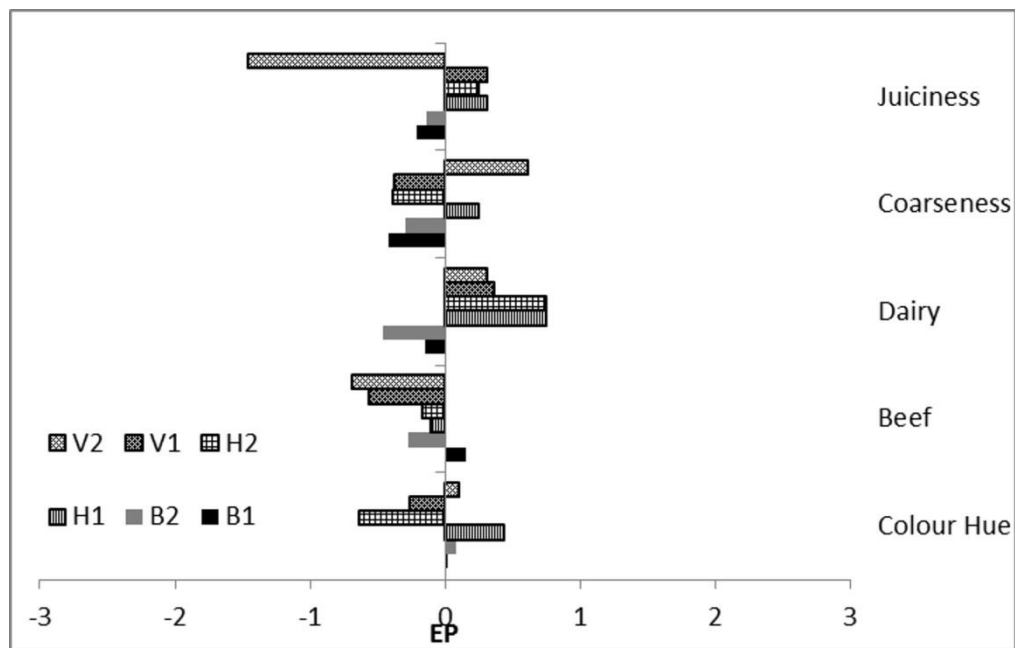


Fig.4. Error of Prediction for each sensory attribute (EP = estimated score – actual panel score) of six samples (prediction set for external validation) of top round cuts from veal (V), beef (B) and heifer meat (H).

Removing this sample in prediction phase, the results ($R^2p = 0.75$ with $RMSEP = 0.25$ and $SEP = 0.25$) appeared more similar to the calibration results. It seems that the visible spectra could be a good predictor of juiciness for beef, veal and heifer, but it should be taken into account that some outlier could be detect. Concluding the predictive scores seems to be equally distributed between the narrow ranges of the actual score, indicating the goodness of prediction models.

4. CONCLUSION

The spectral features in the visible region of cattle meat undergo significant changes during animal growth, due to pigment concentration and structural modifications interfering with refraction and internal reflection. At the same time, the intensity of some sensory attributes evolves in meat. Indeed, the sensory differences in cattle meats were mainly detected in terms of animal age.

Because of this parallel trend, the visible spectrum provides reliable predictions of the sensory properties of meat, and in particular of the intensity of hue, beef and whey flavours, coarseness and juiciness.

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VII. Concluding remarks

Understanding the consumer perception of fresh meat is a focus point for meat industry. Consumers need reliable and useful information to choose the product at the purchase. Appearance and colour resulted important at different levels: by consumers to make a choice at purchase, by expert to define the quality of meat, and resulted a tool for predicting the eating quality and proprieties.

By segmentation of consumers, according their familiarity, it has been possible to define their personal attitude (involvement) and the importance that they give to extrinsic factors at purchase. However, regardless of familiarity level, consumers assign great importance to the visual appearance of meat, resulting in perceptions of a loss of freshness after three days of storage in MAP and to an associated reduction of liking of taste upon consumption.

Adopting a quality grid system, which was developed by expert based on appearance of raw steaks, it was possible to identify the high quality meat (HQ) from the standard one (SQ). Quality levels' differences were also reflected in the cooked meat when evaluated by a trained panel. HQ meat were characterised by higher intensity of tenderness and juiciness compared to SQ. These results indicating that appearance allows to classify different quality levels.

Increasing the age and weaning kids, an increase of colour intensity could be highlighted, which is linked to the intensification of all the specie-specific attributes. Consumer with high familiarity with goat meat preferred darker and more intense goat flavour meat. It was found a niche of consumers able to appreciate chevon meat.

The spectral features in the visible region of cattle meat undergo significant changes during animal growth and parallel modifications of some sensory attributes occur. The ability of the visible spectrum of cattle meat in predicting the sensory attributes has been performed. The intensity of some age-related attribute could be predicted with a high degree of accuracy, such as beef and whey flavours, coarseness, juiciness and colour hue. Other characteristics resulted less related with the visible spectrum.

In conclusion, consumers are able to discriminate meat based on colour and appearance, when it is associated to the shelf life of cattle meat and to the different age of goat animals. In this case the intensity of peculiar attributes as goat flavour increase with the increase of colour intensity. On the other hand, the expert appearance evaluation and the visible spectra measurements are associated with different sensory characteristics of standard meat, providing the chance to predict meat taste perception.



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