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Inter-laboratory assessment by trained panelists from France and the United Kingdom of beef cooked at two different end-point temperatures

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ABSTRACT

Eating quality of the same meat samples from different animal types cooked at two end-point cooking temperatures (55 °C and 74 °C) was evaluated by trained panels in France and the United Kingdom. Tenderness and juiciness scores were greater at 55 °C than at 74 °C, irrespective of the animal type and location of the panel. The UK panel, independently of animal type, gave greater scores for beef flavour (+7 to +24%, $P < 0.001$) but lower scores for abnormal flavour (−10 to −17%, $P < 0.001$) at 74 °C. Abnormal flavour score by the French panel was higher at 74 °C than at 55 °C (+26%, $P < 0.001$). Irrespective of the data set, tenderness was correlated with juiciness and beef flavour. Overall, this study found that cooking beef at a lower temperature increased tenderness and juiciness, irrespective of the location of the panel. In contrast, cooking beef at higher temperatures increased beef flavour and decreased abnormal flavour for the UK panelists but increased abnormal flavour for the French panel.

1. Introduction

Eating quality is one of the most important characteristics by which consumers assess beef (Grunert, Bredahl, & Brunsø, 2004). Although factors such as the amount of visual fat and the colour of the meat or extrinsic factors such as price, brand, etc. (reviewed by Hocquette et al., 2012) influence purchase, aspects of the meat such as taste and tenderness play an important role in the decision to re-purchase after consumption of the meat (Grunert et al., 2004; Monson, Sanudo, & Sierra, 2005). Meat acceptability and the individual preferences of consumers depend on the individual sensory responses during meat consumption, including perception of tenderness, juiciness, and flavour (Gagaoua, Micol, Richardson et al., 2013; Jeremiah & Gibson, 2003). Of the sensory traits of beef meat, it is generally believed that tenderness is the most important (Huffman et al., 1996; Legrand, Hocquette, Polkinghorne, & Pethick, 2013). Various studies indicate that consumers are willing to pay a premium for beef meat provided if it is guaranteed to be tender (Boleman et al., 1997; Miller, Carr, Ramsey, Crockett, & Hoover, 2001; Platter et al., 2005).

Despite considerable efforts to improve beef eating quality, research has shown that there can still be a high level of uncontrolled variability in beef tenderness (Maher, Mullen, Moloney, Buckley, & Kerry, 2004). This may be the reason why consumers would like a system to predict beef eating quality, which is adequate, simple, sufficiently documented and controlled by an independent third party (Verbeke et al., 2010). Eating quality is influenced by both genetic and environmental factors including genotype, age, and diet, as well as pre-slaughter management and *post-mortem* processing conditions. In addition, cooking is the final step applied prior to consumption and gives meat its final characteristics and is, therefore, another important factor (Obuz & Dikeman, 2003). Meat preferences of members of a taste panel depends upon their previous cultural experiences and eating habits (Dransfield et al., 1984; Grunert et al., 2004; Oliver et al., 2006) though this should not affect their ability to respond to differences in tenderness, juiciness or flavour (Sanudo et al., 1998).

The objective of this study was to compare beef eating quality scores of samples of the same meat cooked to two different end-point temperatures (55 °C or 74 °C) and assessed by sensory panels in France and the United Kingdom which differed in their protocols and sensory scales.

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† Deceased. We would like to dedicate this work to the memory of Didier Micol.

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The results allowed an evaluation of the effect of end-point cooking temperature on beef sensory traits determined by trained panels. These data will increase our understanding of the relationships among meat sensory attributes according to cooking temperature.

2. Materials and methods

Animal management followed the European Union directive number 86/609/EEC concerning animal care.

2.1. Animals and diets

This study was conducted as part of the European "ProSafeBeef" project (www.prosafebeef.eu). The overall aim of "ProSafeBeef" was to improve safety and quality in beef production and processing, across Europe through research and innovation. It was based on 240 cattle including young bulls, steers and heifers reared in three European experimental research centres, France, UK and Ireland, respectively (Table 1) as recently reported by (Gagaoua et al., 2016). The experiment in France involved 74 young bulls of 3 different breeds: Limousin (Li), Blond d'Aquitaine (BA) and Aberdeen Angus (AA). The experiment in Ireland involved 96 heifer calves of two genotypes, Belgian-Blue x Holstein-Friesian (BF) and Aberdeen Angus × Holstein-Friesian (AF). The experiment in UK involved 72 steers half of which were Belgian-Blue × Holstein (BH) and the other half Charolais × Friesian (CF). During the finishing period, in the three experimental farms, the animals were kept in either extensive (grazing) or intensive conditions (indoors) (Gagaoua, Micol, Hocquette, et al., 2013; Gagaoua, Micol, Richardson, et al., 2013). Basal diets offered to the animals consisted of pasture, grass silage or high concentrate diets, and were supplemented with lipids and/or antioxidants from plants additives.

2.2. Slaughtering and sampling

Animals were slaughtered when they achieved fat class 3 on the EUROP grid of carcass classification (European Economic Community Regulations (EEC) No. 1208/81). They were slaughtered under standard conditions in either a commercial or an experimental slaughterhouse, depending on the facilities of each country. The carcasses were not electrically stimulated and they were chilled and stored at 4 °C until 24 h *post-mortem*. The *Longissimus thoracis* (LT) muscle was excised from the right side of each carcass 24 h after slaughter. The samples were cut into steaks (5 cm thick) and placed in 80-micron sealed plastic bags (40 nylon/60 polyethylene with permeability specifications of 50 cm^3 $O_2/m^2/d$, 10 cm^3 $N_2/m^2/d$, 150 cm^3 $CO_2/m^2/d$ and 2.4 g H_2O/d at 23 °C and 75% RH (Terinex, Bedford, England)) in a Multivac A300/42 vacuum packager (Multivac UK, Swindon, UK) to −980 mbar and kept between 2 and 4 °C for 14 days (young bulls from France and heifers from Ireland) or 10 days (steers from UK) for ageing. Each loin sample was then frozen and stored at −20 °C until sensory assessment.

Table 1
Numbers of *Longissimus thoracis* beef samples assessed using sensory protocols in the United Kingdom and in France at two end-point cooking temperatures (55 and 74 °C).

		Data from United Kingdom (scale 0–8)		Data from France (scale 0–10)	
Gender	Breeds	55 °C	74 °C	55 °C	74 °C
Young bulls	AA	24	24	24	24
	Li	25	25	25	25
	BA	25	25	25	25
Steers	CF	16	32	–	–
	BH	40	40	–	–
Heifers	AF	47	47	–	–
	BF	47	47	–	–

Abbreviations: young bulls (AA: Aberdeen Angus, Li: Limousin, BA: Blond d'Aquitaine); Heifers (AF: Aberdeen Angus x Friesian, BF: Belgian-Blue x Friesian), and Steers (BH: Belgian-Blue x Holstein, CF: Charolais x Friesian). Beef sample cells in the table indicated by (−) were not evaluated.

2.3. Sensory panels

Sensory assessment was conducted in two dedicated laboratories in the UK and France. In both laboratories, the expert panelists used were trained in accordance with the ISO standards ISO/TC 34 (ISO_8586, 2012). Briefly, the sensory panelists were selected based on their sensory sensitivity, appropriate training and experience in sensory testing. Formal evaluation allowed selection of those panelists capable of making consistent and repeatable sensory assessments of meat products that is, making comparative judgements both within a session and from one session to another. The continuous accuracy and precision of these panelists has been assured in both countries by regular training sessions and subsequent evaluation of performance, according to the ISO 8588-1 standards. For the present study, both laboratories used panelists with several years experience of sensory evaluation of meat and meat products.

For sensory evaluation, meat samples from the young bulls (France) were assessed for sensory scores in France (INRA, Le Magneraud). Meat samples from the heifers (Ireland), the steers (UK) and the young bulls (France) were assessed for sensory scores in the UK (University of Bristol) (Table 1). Meat samples from France and Ireland were transported to the UK while maintained at −20 °C and were clearly and appropriately labelled. The descriptors used in the sensory evaluation of beef meat by the two trained sensory panels are given in Table 2. Within each sensory protocol, scores were averaged across panelists for each steak, and the means were used in the statistical analyses.

2.3.1. The French sensory protocol

Steaks were thawed, without stacking or overlapping, at 2 to 5 °C in vacuum packs for at least 24 h or 48 h before cooking and sensory assessment at 55 °C or 74 °C. One hour before sensory assessment, the meat samples were cut into four approximately 1.50 cm thick steaks, 2 steaks to be assigned for cooking to 55 °C and 2 steaks for cooking to 74 °C. After exposure to air for 1 h at 18 °C, the steaks were grilled on a double grooved plate griddle (SOFRACA, Morangis, France) heated to 310 °C for 30 min before cooking. Steaks were heated for 2 min between two aluminium foil sheets, until the end-points temperature of 55 °C or 74 °C in the geometric centre of the steak was reached (measured using a temperature probe (Type K, HANNA HI 98704, Newark, USA)). After grilling, each steak was cut into twelve 3 × 2 × 1.5 cm portions which were immediately presented to 12 panelists (one portion per panelist). The panelists rated the steaks on a 10 cm unstructured line scale (from 0 to 10) measured in mm for the following attributes: global tenderness (0 – extremely tough, 10 – extremely tender), juiciness (0 – extremely dry, 10 – extremely juicy), beef flavour intensity (0 – extremely weak, 10 – extremely strong) and abnormal flavour intensity (0 – extremely weak, 10 – extremely strong). The sessions were carried out in a sensory analysis room equipped with individual booths under artificial red light to reduce the influence of the appearance of the samples. Each session

Table 2
Definitions of the eating quality descriptors used in the sensory evaluation of beef meat with trained sensory panels[a].

Attributes	Definition
Global tenderness	Ease of chewing the sample between teeth: from extremely tough (0) to extremely tender (8 or 10)
Juiciness	Amount of moisture released in the mouth: not juicy (0) to extremely juicy (8 or 10)
Beef flavour	Flavour associated with cooked beef: extremely weak beef flavour (0) to extremely strong beef flavour (8 or 10)
Abnormal beef flavour	Abnormal flavour not found in cooked beef: none (0) to strong off-flavour (8 or 10)

[a] For the UK protocol, a 0–8 point category scale was used, and for the French protocol, a 0–10 unstructured scale was used.