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Advanced glycation end products, physico-chemical and sensory characteristics of cooked lamb loins affected by cooking method and addition of flavour precursors

Mar Roldan [a], Jürgen Loebner [b], Julia Degen [b], Thomas Henle [b], Teresa Antequera [a], Jorge Ruiz-Carrascal [c,*]

[a] Food Science, Faculty of Veterinary Science, University of Extremadura, Spain
[b] Institute of Food Chemistry, Technische Universität Dresden, Germany
[c] Department of Food Science, University of Copenhagen, Denmark

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ABSTRACT

The influence of the addition of a flavour enhancer solution (FES) (D-glucose, D-ribose, L-cysteine and thiamin) and of sous-vide cooking or roasting on moisture, cooking loss, instrumental colour, sensory characteristics and formation of Maillard reaction (MR) compounds in lamb loins was studied. FES reduced cooking loss and increased water content in sous-vide samples. FES and cooking method showed a marked effect on browning development, both on the meat surface and within. FES led to tougher and chewier texture in sous-vide cooked lamb, and enhanced flavour scores of sous-vide samples more markedly than in roasted ones. FES added meat showed higher contents of furosine; 1,2-dicarbonyl compounds and 5-hydroxymethylfurfural did not reach detectable levels. N-ε-carboxymethyllysine amounts were rather low and not influenced by the studied factors. Cooked meat seems to be a minor dietary source of MR products, regardless the presence of reducing sugars and the cooking method.

1. Introduction

Oven roasting and sous-vide cooking are probably the two most used cooking methods nowadays in Spain for whole lamb primal cuts in restaurants and in the catering industry. The temperature and length of the cooking process have a large effect on the physical and chemical properties of meat and its eating quality (Roldan, Antequera, Martin, Mayoral, & Ruiz, 2013). While roasting implies oven temperatures between 180 and 200 °C, which usually leads to a core temperature of around 68–72 °C, sous-vide cooking temperatures recommended by chefs for lamb meat are around 60–65 °C, but for much longer times than those for roasting (Ruiz, Calvarro, Sánchez del Pulgar, & Roldán, 2013).

Flavour is one of the most important quality parameters of cooked meat and develops during cooking by complex reactions between natural components present in raw meat (Sanchez del Pulgar, Roldán, & Ruiz, 2013). These precursors include reducing and phosphorylated sugars, amino acids, thiamine and lipids (Farmer, Hagan, & Paraskevas, 1999). The addition of some of these precursors is a promising strategy for increasing consumer acceptance of cooked meat (Aliani, Ryland, Williamson, & Rempel, 2013).

The development of the flavour and surface colour in cooked meat mainly results from the development of Maillard reactions (MR) and lipid degradation, but also from the interactions between both reaction pathways (Farmer et al., 1999). Some authors have reported the higher flavour-generating potential of some sugars, like ribose (Farmer et al., 1999; Lauridsen, Miklos, Schäfer, Aaslyng, & Bredie, 2006), ribose 5-phosphate (Farmer et al., 1999), glucose (Farmer et al., 1999; Lauridsen et al., 2006), and glucose-6-phosphate (Farmer et al., 1999). On the other hand, sulphur compounds undoubtedly play a significant role in meat flavour due to their interesting olfactory properties and generally low odour and taste thresholds. Thus, sulphur-containing amino acids like cysteine and cystine as well as other compounds, like thiamine (vitamin B1), are important precursors for the resulting roasted or cooked meat aroma (Cerny, 2007). For example, heterocyclic compounds formed due to reaction of cysteine and ribose or the degradation of thiamine (Cerny, 2007), provide savoury, meaty, roast and boiled flavours.

In the course of the MR different species of sugar- and protein-derived products are formed. While these products are responsible for the flavour of heated foods (Farmer et al., 1999), some authors have also highlighted potential negative implication in health

* Corresponding author. Address: Dairy, Meat and Plant Product Technology, Department of Food Science, University of Copenhagen, Rolighedsvej 30, 1958 Frederiksberg C, Denmark. Tel.: +45 23810623.

E-mail address: jorgeruiz@food.ku.dk (J. Ruiz-Carrascal).

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(Henle, 2008). In order to evaluate the development of the whole reaction cascade, reaction products from different stages are useful. Because Amadori products (indirectly analysed as furosine) generally arise before sensory changes become noticeable, they are used as early indicators for quality changes caused by glycation reactions (Erbersdobler & Somoza, 2007). Amadori compounds are degraded to highly reactive α-dicarbonyls, such as glyoxal (GO), methylglyoxal (MGO), and 3-deoxyglucosulose (3-DG), during the advanced stage of glycation. In particular 3-DG and MGO, are known to occur in considerable amounts in some foods (Degen, Hellwig, & Henle, 2012) and are precursors of aroma-active compounds (Bravo et al., 2008) and of advanced glycation end products (AGEs) like the N-ε-carboxymethyllysine (CML), a stable advanced Maillard product (Hull, Woodside, Ames, & Cuskelly, 2012). Hydroxymethylfurfural (HMF) is a thermodynamically controlled product formed in the course of the Maillard reaction and during degradation of hexoses at high temperatures and at acidic conditions (Henle, 2008). It is formed on the surface of fried or roasted food products (Danowska-Oziewicz, Karpińska-Tymoszczyk, & Borowski, 2007).

The formation of Maillard reaction products (MRP) depends directly on the processing temperature and time and is greatly heightened by long exposure to high heat (Hardy, Parmentier, & Fanni, 1999). MRP content in foods is affected by its composition, the method and conditions of the industrial or culinary preparation, as well as possible reheating (Li, Risch, & Reineccius, 1994). Chao, Hsu, and Yin (2009) reported that culinary treatments, such as frying or baking have a greater impact on the formation of MRP than boiling.

In the present study, the effect of the addition of several flavour precursor (glucose, ribose, cysteine and thiamine) on cooking loss, moisture content, instrumental colour, sensory features and development of MR in either sous-vide cooked or roasted lamb loins was investigated. Such information may contribute to the development of flavour precursor mixtures for lamb meat that enable a better final cooked meat flavour, especially in sous-vide cooked meats, in which the extent of MR is limited.

2. Material and methods

2.1. Experimental design

Twenty lamb loins were randomly assigned to one of the four groups according to a 2 × 2 factorial design, with two levels of flavour precursor addition (either a flavour enhancer solution (FES) or distilled water -control-), and two different cooking treatments (either sous-vide cooked or roasted in the oven). The FES was composed of sugars, amino acids and vitamins in the following concentrations: D-glucose: 1.376 M; D-ribose: 0.060 M; L-cysteine: 0.075 M and thiamin: 0.034 M (D-glucose, L-cysteine and thiamine were obtained from Acofarma, S.C.L., Madrid, Spain, and D-ribose from Suplementos Solgar, S. L., Madrid, Spain). All of them were food grade. Such compounds were selected based on previous studies (Aliani & Farmer, 2005; Meinert, Schäfer, Bjergegaard, Aaslyng, & Bredie, 2009). D-glucose and D-ribose, both of them reducing sugars, were selected due to their implication in MR. L-cysteine, a sulphur amino acid, and thiamine, a sulphur vitamin, were selected because they are known precursors for the formation of sulphur volatile flavour compounds in cooked meat.

All loins were from a homogeneous production batch of male lambs averaging 26 kg live weight and 90 days of age, slaughtered at a local abattoir. Whole fresh boned out lamb loins, trimmed of subcutaneous fat, were individually weighed. Then, loins were injected to a target of 110% of their initial weight with the previously cited solutions by using a culinary syringe of 250 ml, and they were subsequently vacuum-packaged and tumbled (Dorit VV-T-10 Killwangen tumbler, Germany) intermittently for one hour at 8 rpm in order to improve flavour precursors spreading within the muscle.

After tumbling, half the loins ($n = 5$) of each FES level were vacuum-packaged and sous-vide cooked in a thermostatized water bath at 60 °C during 12 h, which were the temperature-time conditions selected in a previous study (Roldan et al., 2013). The rest of the loins of each FES level ($n = 5$) were cooked in an oven at 180 °C with dry air until reaching an internal temperature of 73 °C. Temperature was monitored during cooking using a digital probe thermometer (112 thermocouple Testo735-2, Lenzkirch, Germany). After cooking, all loins were immediately chilled and kept refrigerated at 2 °C until sensory analysis, a maximum of 48 h after cooking. Just before re-heating for sensory analysis, the loins were weighed, and the colour of the loin surface and the cut surface were measured. A sample for moisture content was also taken. The rest of the loin was vacuum packaged and kept frozen at −80 °C until analysis.

2.2. Analytical procedures

2.2.1. Moisture and cooking loss

Moisture content was determined by drying the samples (5 g) at 102 °C (A.O.A.C., 2000). Samples were analysed in duplicate. Total cooking loss was calculated by difference in weight after injection and after cooking.

2.2.2. Instrumental colour measurement

Colour was measured across the external surface and the cut surface of the cooked loins after chilling. L^* value (lightness), a^* value (redness) and b^* value (yellowness) were obtained using a Minolta Colorimeter CR-300 (Minolta Camera Co., Osaka, Japan) programmed to used the built-in internal illuminant D65. Means of readings at three locations on each sample were determined. Before each series of measurements, the instrument was calibrated using a white ceramic tile.

Browning index (BI) was calculated using Hunter L, a, and b values (Maskan, 2001) as

$$\mathrm{BI} = \frac{[100 \times (x - 0.31)]}{0.17}$$

with

$$x = \frac{(a + 1.75 \times L)}{(5.645xL + \alpha - 3.012xb)}.$$

2.2.3. Sensory analysis

Sous-vide cooked and oven roasted lamb loins were assessed by a trained panel of 12 members, using a descriptive analysis method. The sensory traits, their definitions and extremes are explained in Table 1. Questions were presented to assessors in the normal perception order, as follows: visual analysis, texture, taste and flavour.

panellists were selected from faculty, staff and researchers of the university using individual taste, flavour and aroma recognition thresholds. Selected subjects underwent further training in meat and meat products sensory characteristics over five years, and have subsequently participated in several panels for cooked meat sensory analysis.

Four lamb loins from different groups were evaluated in each session. Sample order was randomised. The sessions were held 3 h after breakfast. During each session, two slices of lamb loins (1 cm thickness) from each batch were separately served warm to each panellist. A glass of water was provided for each assessor. All sessions were done in a six-booth sensory panel room at 22 °C equipped with white fluorescent lighting (220–230 V, 35 W).