Meta Science 90 (2012) 828–835

Contents lists available at SciVerse ScienceDirect

Meat Science

journal homepage: www.elsevier.com/locate/meatsci

Physico-chemical, textural and structural characteristics of sous-vide cooked pork cheeks as affected by vacuum, cooking temperature, and cooking time

José Sánchez del Pulgar [a], Antonio Gázquez [b], Jorge Ruiz-Carrascal [a,*]

[a] Food Science, School of Veterinary Sciences, University of Extremadura, Tecnología de Alimentos, Facultad de Veterinaria, Universidad de Extremadura, Avda. Universidad s/n, 10071 Caceres, Spain
[b] Histology, School of Veterinary Sciences, University of Extremadura, Tecnología de Alimentos, Facultad de Veterinaria, Universidad de Extremadura, Avda. Universidad s/n, 10071 Caceres, Spain

ARTICLE INFO

Article history:
Received 3 June 2011
Received in revised form 4 November 2011
Accepted 7 November 2011

Keywords:
Pork
Sous-vide
Vacuum
Texture profile analysis
Instrumental colour
Collagen solubilization

ABSTRACT

This paper describes the influence of different factors on sous-vide cooked pork. Pork cheeks were cooked at different combinations of temperature (60 °C or 80 °C), time (5 or 12 h) and vacuum (vacuum or air packaged). Weight losses were lower and moisture content higher in samples cooked for a shorter time ($P=0.054$) and at a lower temperature ($P<0.001$). Samples cooked at 60 °C showed more lightness (L^*) and redness (a^*) ($P<0.001$). Lipid oxidation showed an interaction between cooking time and temperature ($P=0.007$), with higher TBARs values for samples cooked for 12 h at 60 °C and lower for those cooked for 12 h at 80 °C. Samples cooked at 80 °C for 12 h showed lower ($P<0.05$) values for most textural parameters than all the other types of samples. Vacuum packaging showed no influence on any of the studied variables. For the treatments evaluated, cooking temperature × time combination seems to be more important than vacuum packaging in the textural and colour parameters of pork cheeks.

1. Introduction

Sous-vide cooking can be defined as the cooking of raw materials under controlled conditions of temperature and time, inside heat-stable vacuumized pouches or containers. After heating, the products are rapidly cooled down to 0–3 °C (Schellekens, 1996). This technique was originally developed for the catering industry, as the method allows for the manipulation of prepared food after thermal treatment without the risk of microbial contamination (Armstrong, 2000). Nowadays, many top level restaurant chefs are using sous-vide cooking because of its ease and appropriateness for the management of prepared food. Chefs usually cook meat at lower temperatures and for much longer time periods than those used by the catering industry (Roca & Brugués, 2003). For example, temperatures chosen for pork primal are around 60–63 °C for chefs (Myhrvold, Young, & Bilet, 2011), while temperatures for pork in catering most likely reaches 75–80 °C (Armstrong, 2000). This cooking procedure has indeed spread worldwide, as thermostatized water baths and vacuum packaging machines are becoming common appliances in the kitchens of many restaurants. In addition, several cook books and other publications that describe this cooking technique have been published over the past five years.

As Roca and Brugués (2003) report, top level cooking chefs observe that the most outstanding features found in the meat cooked for such long times and at such moderate temperatures are the meat's unique textural characteristics. However, according to our review of the literature, there seems to be scarce scientific information on the cooking of meat in the sous-vide manner. Hansen, Knochel, Juncher, and Bertelsen (1995) reported data for sous-vide roast beef cooked at either 59 °C or 62 °C for 5 h, and Vaudagna et al. (2002) studied beef samples cooked at temperatures ranging from 50 to 65 °C, with time only reaching 390 min, whereas the top chefs' reports indicate that some meat cuts should be cooked for up to 24 h (Roca & Brugués, 2003).

Some early work (Laakonen, Wellington, & Sherbon, 1970) focused on the effect of low temperature and long cooking time on meat quality. Although this paper provided some important information about the features of meat cooked under these conditions, the meat was not cooked in the sous-vide manner. According to the studies, long cooking times seem to lead to higher collagen solubilization, which in turn would cause greater formation of gelatin and less meat toughness. In the mammalian connective tissue, this would happen above 65 °C (Laakkonen, 1973). Moreover, cooking meat at these moderate temperatures would involve a lower myofibrilar protein coagulation, which for most proteins of this kind takes place at temperatures above 70–80 °C (Palka, 2003; Palka & Daun, 1999). The latter is important in meat texture, since the coagulation of myofibrilar protein is considered as one of the reasons for the increase in meat toughness during cooking.

* Corresponding author. Tel.: +34 927 257123; fax: +34 927 257110.
E-mail address: jruiz@unex.es (J. Ruiz-Carrascal).

0309-1740/$ – see front matter
doi:10.1016/j.meatsci.2011.11.024

Other potential effects of sous-vide cooking at moderate temperatures for long periods of time, compared with conventional cooking, are lower moisture loss, less lipid oxidation derived from the absence of oxygen in the pouch, modifications of the profile of volatile flavour compounds, and different colour characteristics. Such colour variations may be due to a different development of the Maillard reaction on the meat surface, combined with a different extent of myoglobin denaturation (García-Segovia, Andrés-Bello, & Martínez-Monzo, 2007; Martens, Staburvik, & Martens, 1982). However, it is still somewhat unclear why some of these effects take place and how vacuum-cooking leads to some specific consequences in contrast with others derived from cooking in the presence of air.

This paper thus aims to analyse the effect of cooking time and temperature as well as vacuum packaging on the various physico-chemical and histological features of sous-vide cooked pork cheeks. Our research is considered pertinent due to both the scarcity of information regarding the sous-vide cooking effects on meat and the growing use of this procedure in restaurants and ready-to-eat food industries.

2. Material and methods

2.1. Experimental design

The physico-chemical and structural features of the *masseter* muscles in Iberian pork cheeks were analysed when cooked in different time × temperature combinations and when packaged either under vacuum conditions or in the presence of air. Pork cheeks were chosen because this type of meat cut is usually included in traditional stew recipes that are sous vide cooked nowadays. Another reason is that these meat pieces have a lot of connective tissue. The experiment was conducted using a 2 × 2 × 2 completely randomized design, with a total of eight different combinations of time (5 and 12 h), temperature (60 and 80 °C), and vacuum (vacuum packaged or air packaged), which were used for cooking 40 cheeks from Iberian pigs (n = 5 for each batch). In addition, a control group (n = 5) of pork cheeks boiled in a sauce pan for 30 min was also considered. Five other pig cheeks were used for performing analyses of fresh meat. All cheeks were from a homogeneous batch of pigs averaging 150 kg live weight and 15 months of age. Fresh raw pork cheeks averaged 72.8 g, 3.2 cm thickness and 8.1 cm length, and showed 73.6% of moisture, 4.3% of fat and 20.7% of protein. All the cheeks belonged to a homogeneous production batch of Iberian pigs. The mentioned combinations of time and temperature were suggested by chef Antonio Perez ("Atrio" restaurant, Caceres, Spain). Table 1 shows the different groups considered in the experiment.

2.2. Cooking procedure

Cheeks were provided by Iberselec Montanchez Ltd. Their visible connective and adipose tissue outside were removed before packaging at the University of Extremadura's meat pilot plant. Each plastic bag (nylon/polyethylene pouches; heat resistance of −40 °C/+120 °C, O_2 permeability of 9 cm^3/m^2 per 24 h at 4 °C/80% RH and water steam permeability of 1.2 g/m^2 per 24 h) (Joelplas SL, Barcelona, Spain) containing an individual pork cheek was heat sealed in a vacuum Tecnotrip EVT-14 packaging machine (Tecnotrip, Barcelona, Spain). The vacuum level was set to 70% as the highest vacuum level allowed by the equipment for the vacuum packaged group, and to 0% for the non-vacuum packaged group. The packaged cheeks were then cooked in a thermostatized water bath by applying the time–temperature combinations described above and shown in Table 1.

Table 1
Temperature, time and vacuum conditions used for cooking the pork cheeks of the different experimental groups considered in the study.

Group	Temperature (°C)	Time (h)	Vacuum
60-5v	60	5	Yes
60-12v	60	12	Yes
80-5v	80	5	Yes
80-12v	80	12	Yes
60-5a	60	5	No
60-12a	60	12	No
80-5a	80	5	No
80-12a	80	12	No
Traditional	100	0.5	No

The temperature of the water in the bath was controlled by using a thermocouple Testo735-2 (Testo, Lenzkirch, Germany). The internal temperature was monitored by using the same thermocouple equipped with a special probe for meat. This device was applied to a different pork cheek that nonetheless had similar characteristics to those of the samples included in each batch. This single sample was not used in the physicochemical analysis. The temperature recorded during the thermal process is shown in Fig. 1. After the cooking process finished, the packages were removed from the water bath and submerged in cold water (4 °C) for 30 min. Subsequently, the packaged cheeks were kept under refrigeration (2 °C) overnight. Pig cheeks cooked in the sauce pan in a traditional manner (n = 5), were submerged, unpackaged, in 1.5 L of boiling water for 30 min. After the traditional cooking took place, the cooked cheeks were vacuum packaged and cooled by following the same procedure described above for the rest of the groups.

The day after the cooking process, the *masseter* muscle was dissected from the rest of the cheek, and the moisture content, moisture loss, instrumental colour, and texture profile were analysed. In addition, some cheeks were also selected for microscopy and a 1 cm^3 sample was taken and immersed in formaldehyde immediately. The rest of the sample was kept at −80 °C until the analysis of TBARs.

2.3. Moisture content and water losses

Cooking loss was calculated by measuring the differences in weight before and after cooking, while moisture content was determined by drying the samples (5 g) at 102 °C (Association of Official Analytical Chemist, 2000).

2.4. Instrumental colour measurement

Objective colour was measured across the cut surface of the cooked *masseter* muscle after chilling. The L^* (lightness), a^* (redness)

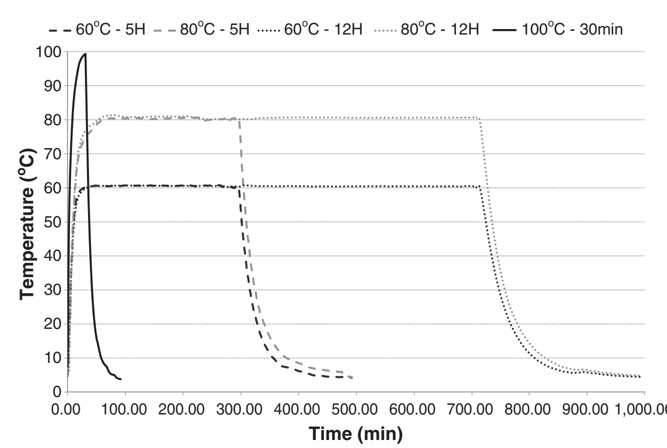

Fig. 1. Internal temperature in pork cheeks under the different temperature–time combinations.