Innovative Food Science and Emerging Technologies 26 (2014) 134–142

Contents lists available at ScienceDirect

Innovative Food Science and Emerging Technologies

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

Effect of high-pressure-processing and modified-atmosphere-packaging on the volatile compounds and odour characteristics of sliced ready-to-eat "lacón", a cured–cooked pork meat product

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ARTICLE INFO

Article history:
Received 8 July 2014
Accepted 18 September 2014
Available online 16 October 2014

Editor Proof Receive Date 30 October 2014

Keywords:
High-pressure-processing
Modified-atmosphere-packaging
Volatile compounds
"Lacón"
Cured–cooked pork meat

ABSTRACT

Volatile compounds and odour characteristics of sliced "lacón", a cured–cooked pork meat product, vacuum-packaged (VP), modified-atmosphere-packaged (MAP), and high-pressure-processed (HPP) at 500 or 600 MPa were investigated during a 120-day refrigerated-storage period. A total of 142 volatile compounds were identified by gas chromatography–mass spectrometry. Benzenic compounds, alcohols, esters and ketones predominated, followed by acids, aldehydes, hydrocarbons, nitrogen compounds, terpenoids, sulphur compounds, halogenated compounds and ethers. In VP "lacón", levels of esters, alcohols, acids and benzenic compounds increased until day 120 while ketones and sulphur compounds peaked on day 60 and declined afterwards. In MAP "lacón", the levels of esters, sulphur compounds and alcohols were lower, and the levels of hydrocarbons higher, than in VP "lacón". In HPP "lacón", the levels of acids, alcohols, esters and sulphur compounds were lower, and the levels of aldehydes higher, than in VP "lacon". Differences in odour characteristics between treatments were negligible, according to sensory analysis.

Industrial relevance: High-pressure-processing (HPP) and modified-atmosphere-packaging (MAP) prolonged the shelf-life of sliced "lacón", a cured–cooked meat product. Different volatile profiles evolved in HPP, MAP and vacuum-packaged (VP) "lacón" stored at 4 °C. HPP "lacón" showed on day 60 a volatile profile similar to that of VP "lacón" on day 0. In particular, "lacón" treated at 500 MPa maintained a more stable volatile profile.

1. Introduction

Traditional dry-cured "lacón" is made from pig forelegs by a procedure similar to that of dry-cured ham in the North-West of Spain (Lorenzo, Prieto, Carballo, & Franco, 2003). Even though the product is desalted and boiled before consumption, its NaCl concentration may remain as high as 6.3% (Cobos, Veiga, & Díaz, 2004). Chemical changes and sensory characteristics of dry-cured "lacón" are affected by its high salt content (Garrido, Domínguez, Lorenzo, Franco, & Carballo, 2012; Purriños, Franco, Carballo, & Lorenzo, 2012; Purriños et al., 2011). In order to satisfy consumer preferences for healthier meat products (Duranton, Guillou, Simonin, Chéret, & de Lamballerie, 2012), a low-salt cured–cooked "lacón" is currently manufactured. It is usually marketed as a ready-to-eat (RTE) product in trays of mechanically- or manually-cut slices. Cured–cooked "lacón" is a better substrate for microbial growth than dry-cured "lacón" because of its lower salt content and higher water activity that increases the risk associated with bacterial contamination during post-manufacture steps such as cutting, slicing and packaging (del Olmo, Calzada, & Nuñez, 2014).

The use of high-pressure-processing (HPP), a mild preservation technology, to control post-cooking recontamination in a wide range of RTE meat products, including cooked (ham, sausages, turkey, chicken), dry-cured (ham, loin), fermented (salami, sausages), marinated (beef, pork) and raw (carpaccio) meat products is increasing worldwide (Campus, 2010; Hereu, Dalgaard, Garriga, Aymerich, & Bover-Cid, 2012; Vercammen et al., 2011). Microorganisms are killed by HPP through damage of the cell membrane and inactivation of key enzymes (Hoover, Metrick, Papineau, Farkas, & Knorr, 1989). HPP, at pressure levels of 400 MPa or higher, also reduces the activity of meat endogenous proteases such as calpains and cathepsins (Campus, 2010), and affects characteristics of meat and meat products such as tenderness, colour, drip loss, and lipid oxidation (Cheftel & Culioli, 1997; Sun & Holley, 2010).

Volatile compounds of traditional dry-cured "lacón" have been investigated, with aldehydes as the most abundant chemical group (Purriños, Bermúdez, Franco, Carballo, & Lorenzo, 2011a; Purriños et al., 2012). However, there is no available information on the volatile compounds of low-salt cured–cooked "lacón". The aroma of cooked meat products mostly originates from heating effects linked to fatty acid oxidation and Maillard reactions (Leroy, Vasilopoulos, Van Hemelryck, Falcony, & De Vuyst, 2009; Mottram, 1998), but it is also influenced by the brine and the spices added during manufacture.

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http://dx.doi.org/10.1016/j.ifset.2014.09.009
1466-8564/

Bacterial growth during refrigerated storage generally results in acidity and production of volatile compounds, some of which are responsible for off-flavours (Leroy et al., 2009; Montel, Masson, & Talon, 1998). The microbiological and flavour characteristics of the vacuum-packaged (VP) cured–cooked “lacón” throughout a 120-day refrigerated-storage period, as well as the use of modified-atmosphere-packaging (MAP) and HPP to extend its shelf-life, were reported in a previous work (del Olmo et al., 2014).

In the present study, we have investigated the volatile compounds and odour characteristics of the sliced low-salt cured–cooked “lacón” throughout a 120-day refrigerated-storage period. In addition, we studied the effect of MAP and HPP at 500 or 600 MPa on the generation of volatile compounds and the odour characteristics of the sliced low-salt cured–cooked “lacón” during refrigerated storage.

2. Materials and methods

2.1. Manufacture and processing of “lacón”

The manufacture of the two batches of low-salt cured–cooked “lacón” from the hind legs of Duroc × Landrace pigs was described in a previous work (del Olmo et al., 2014). Cured–cooked “lacón” was hand-sliced to 6–10 g pieces and dispensed in expanded polystyrene trays (250 g per tray). Overall composition of “lacón” was 19.5% protein, 3.1% fat, 2.0% NaCl and 73.6% moisture. Treatments applied to the sliced “lacón” were VP, MAP in 80% N_2 and 20% CO_2, HPP at 500 MPa for 5 min (P500) or HPP at 600 MPa for 5 min (P600). The temperature of “lacón” before HPP was 4 °C. The initial temperature of water was 9 °C and it did not exceed 16 °C during HPP. Compression and decompression rates were 3.57 and 71 MPa/s. After treatments, “lacón” trays were held at 4 °C for 120 days.

2.2. Determination of volatile compounds

Volatile compounds were determined in triplicate by gas chromatography coupled to mass spectrometry (GC–MS), after solid-phase microextraction (SPME), according to the method described by Calzada, del Olmo, Picon, Gaya, and Nuñez (2014) with slight modifications here described. Cyclohexanone (1 mg/ml) was used as the internal standard. Fifty μl was added to the 10-g “lacón” sample prior to homogenization with 20 g sodium sulphate. The 5-g analytical sample was equilibrated in a 15-ml headspace vial for 20 min and extracted for 30 min at 37 °C. A 2 cm × 50/30 μm StableFlex divinylbenzene/carboxen/polydimethylsiloxane (DVB/CAR/PDMS) coated fibre (Supelco, Bellefonte, PA, USA) was used. Desorption of the inserted fibre was performed by using an automated CTC CombiPAL system (GC autosampler 80, Agilent, Palo Alto, CA, USA). Levels of volatile compounds were expressed as relative abundances, which were calculated by dividing the peak area of each compound by the peak area of the internal standard and multiplying the obtained quotient by 10^3.

2.3. Odour analysis

Nineteen panellists, with previous training for the sensory analysis of meat products (del Olmo, Calzada, & Nuñez, 2013), evaluated the odour of sliced “lacón” submitted to the four treatments on days 0, 30, 60, 90 and 120 of refrigerated storage. Slices from each tray, which were opened and held for 30 min at room temperature before analysis were presented to panellists on white ceramic plates under artificial light coded with random 3-digit numbers. Odour quality and intensity were evaluated on a 0- to 10-point scale using a horizontal line anchored in the middle and at both ends, where 0 indicates “dislike extremely” for quality and “extremely mild flavour” for intensity, and 10 indicates “like extremely” for quality and “extremely strong flavour” for intensity. In addition, acid, putrid and rancid odour attributes were evaluated on a 0- to 10-point scale using a horizontal line anchored in the middle and at both ends, where 0 indicates “absence” and 10 “maximum intensity” of the attribute.

2.4. Statistical analysis

Analysis of variance (ANOVA), which included treatment (VP, MAP, P500 and P600) and time of storage as main effects, and their interaction, was carried out using Statview version 5.0 (SAS Inst., Cary, N.C., USA). Pearson's correlation analysis, comparison of means by Tukey's test with the significance assigned at $P < 0.05$, and principal component analysis (PCA) were performed using the same program.

3. Results and discussion

3.1. Volatile compounds

One-hundred and forty-two compounds were identified in the volatile fraction of sliced cured–cooked “lacón”. Lower numbers of volatile compounds had been generally reported in previous works on cooked ham and similar meat products. Thus, 66 volatile compounds were found in MAP artisan-type cooked ham (Leroy et al., 2009), 126 volatile compounds were detected throughout the storage of VP sliced cooked pork shoulder for 28 days at 4 °C (Rivas-Cañedo, Juez-Ojeda, Nuñez, & Fernández-García, 2011), and 46 volatile compounds were identified in VP artisan-cooked ham held for 15 days at 5 °C (Comi & Iacumin, 2012). Regarding dry-cured “lacón”, 102 volatile compounds were found throughout manufacture and ripening, 62 of which were present at the end of the curing period (Purriños, Bermúdez, Franco, Carballo, & Lorenzo, 2011a).

The 142 volatile compounds found in cured–cooked “lacón” were grouped into acids, alcohols, aldehydes, benzenic compounds, esters, ethers, hydrocarbons, ketones, nitrogen compounds, sulphur compounds, terpenoids, and halogenated compounds. According to the ANOVA, treatment significantly influenced 11 of these 12 chemical groups at $P < 0.001$ and ethers at $P < 0.01$, while the time of storage influenced significantly 10 of the 12 chemical groups at $P < 0.001$, ethers at $P < 0.01$ and nitrogen compounds at $P < 0.05$.

The principal chemical group in the volatile fraction of sliced cured–cooked “lacón” was that of benzenic compounds, which accounted for 57.6% of the overall abundance of volatile compounds considering samples from all treatments and times of storage, followed by alcohols, esters and ketones which accounted for 25.4%, 12.7% and 2.2% of the overall abundance, respectively. Other chemical groups, in decreasing order of abundance, were acids, aldehydes, hydrocarbons, nitrogen compounds, terpenoids, sulphur compounds, halogenated compounds and ethers which accounted for 0.68%, 0.60%, 0.35%, 0.32%, 0.15%, 0.040%, 0.015% and 0.003%, respectively, of the overall abundance of volatile compounds in “lacón”. The volatile fraction of cooked meat products is influenced by factors such as meat composition, manufacturing process and additives like nitrites (Thomas, Mercier, Tournayre, Martin, & Berdagué, 2013), and also by the storage temperature, with more compounds being found at increasing temperatures (Leroy et al., 2009). Techniques used for the extraction of volatile compounds may also influence the volatile profile. Thus, linear aldehydes were the most abundant chemical group in refrigerated cooked pork shoulder when volatiles were extracted by dynamic head space and methylketones if SPME was used for extraction (Rivas-Cañedo, Juez-Ojeda, Nuñez, & Fernández-García, 2012).

Thirteen benzenic compounds were found in “lacón”, 12 of which were significantly ($P < 0.01$) influenced by treatment and all by the time of storage ($P < 0.01$). This chemical group may originate from lipid oxidation (Poligné, Collignan, & Trystram, 2001), microbial activity (Leroy et al., 2009), environmental contaminants or compounds of plant origin present in the diet (Théron et al., 2010). Benzenic compounds gradually increased in all samples during refrigerated storage. On days 60 and 120, they reached the highest levels in P600 “lacón” (Fig. 1).