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The changes in gliceridic fractions of sweaty fat and weight loss during ripening time of Iberian dry-cured ham

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ABSTRACT

In this contribution, we studied the weight loss of Iberian hams during dry-curing process and determined the composition of fatty acids, triacylglycerols, diacylglycerols (DGs), monoacylglycerols and free fatty acids in their sweaty fat collected during processing. Ten Iberian hams were used in the study and kept throughout all processes. Humidity, temperature and weight were measured and the sweaty fat of each ham was collected. During dry-curing process, Iberian hams underwent a weight loss with a logarithmic trend and the coefficients depended on the characteristics of the initial raw material and processing conditions. The percentage of weight that hams lost in dry-curing process ranges between 28.83 and 35.91% (mean 33.06%), whereas they lost between the 0.29 and 1.28% (mean 0.79%) of sweaty fat. Concerning the composition of sweaty fat, this was influenced by the composition of ham fat and by the different melting points of compounds sweated. The monounsaturated fatty acids were the most abundant in sweaty fat, especially C18:1 ω9, followed by the saturated and polyunsaturated fatty acids. Triacylglycerols represented 13.4–24.6% of the sweaty fat, characterized by a high amount of species with doubled bound number 2, especially POO. The free fatty acid species found were C18:1 and C16:0 and their percentage ranged similar in all periods, being between 14.45 and 26.94%. The only specie of monoacylglycerol detected was 1-monoolein, being present between 1.24 and 10.65%. The diacylglycerols (DGs) most abundant were 1,2-OP and 1,2-OO (O = oleic acid, P = palmitic acid). In the first period of sweating, there was a higher amount of 1,2-DGs, whereas similar amounts of 1,2- and 1,3-DG species were found in the second and third periods of sweating. When there was a higher amount of diacylglycerols, there were higher quantities of monoacylglycerols and free fatty acids in this fat.

1. Introduction

Dry curing of hams is practised in the south of Spain and Portugal and the length of such processing depends on the characteristics of the raw hams (white or Iberian pigs) and on the weather conditions (temperature and relative humidity) of the area where this is carried out. Dry curing is a typical way of manufacturing raw ham in the Mediterranean area, which includes a dry salting stage at low temperature and a long ripening stage at high temperature. Arnau, Gou, and Comaposada (2003) studied the effect of the relative humidity (RH) of drying air during the resting period on the composition and the appearance of Spanish dry-cured ham surface, and they found that it affects both of them, pH and also the appearance of ham surface at the end of ageing. Besides, they observed that the differences in moisture contents in the external zone and weight losses disappeared at the end of the processing. They explained that the differences in weight losses during ageing decreased with time due to the asymptotic tendency to attain the same equilibrium moisture content. Another explanation given in that work is that the oil layer formed on the surface could contribute to protecting the surface against excessive dehydration and that such effect could contribute to decreasing the differences in weight losses among treatments (Arnau et al., 2003). In another study, Comaposada, Gou, and Arnau (2000) observed a marked decrease in the equilibrium water content in salted fresh ham muscles at RH <75% and that the surface composition of the ham could affect the surface water content. Furthermore, mould growth is inhibited by a RH <60% (Leistner, Rödel, & Krispien, 1981) and mites on the surface are eliminated by a RH <55% (Schmidt, 1996).

Monin et al. (1997) studied the effect of the dehairing technique (scalded and singed), and no significant differences were observed in weight losses between these techniques, taking into account only four different times. They concluded that the use of singeing in place of scalding may well lengthen the processing time required to obtain a similar aroma quality, but this is undesirable on economic grounds.

Spanish dry-cured hams with a pale, soft and exudative (PSE) nature were studied by Arnau, Guerrero, Casademont, and Gou (1995), the weight loss of these hams being not significantly different from that of normal hams and these results did not concur with those found in other studies, which used different technologies. In the case of Parma hams classified as PSE, their weight losses were 4% higher than in

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normal hams (Maggi & Oddi, 1988). No study about the weight loss of Iberian dry-cured hams during processing is found in the literature.

Time reduction of post-salting period of dry-cured Spanish hams has been studied by using brine thawing–salting (Barat, Grau, Ibáñez, & Fito, 2005). The thawed pile salted hams exhibited a higher NaCl diffusion, implying that a shorter post-salting period could be attained when working with that kind of raw material. Post-salting stage could be reduced from the 50 days employed in the traditional fresh raw material salting, to 25 days when using frozen hams brine thawed/salted.

Drying of ham is generally accepted as a diffusive process that follows the Fick's law. Moisture diffusivity in the lean tissue of Spanish dry-cured ham at different processing times has been studied (Gou, Comaposada, & Arnau, 2004). The aim of such study was to determine the effective moisture diffusivity coefficient (D_e) during dry-cured ham processing in two muscles (Biceps femoris, BF and Semimembranosus, SM) at different temperatures. A simple diffusive model, with a unique and constant moisture diffusivity coefficient or with a coefficient depending only on temperature, did not explain the whole drying process correctly. Thus, the effects of moisture content and the gradient of NaCl/moisture ratio on D_e had to be considered. The effect of temperature on D_e decreased during the processing of dry-cured ham.

There have been a considerable number of publications concerning the characterization of the dry-cured ham (Narváez-Rivas, Vicario, Graciani Constante, & León-Camacho, 2007; Narváez Rivas et al., 2008; Narváez-Rivas, Vicario, Graciani Constante, & León-Camacho, 2008; Viera Alcaide et al., 2009; Narváez-Rivas, Vicario, Alcalde, & León-Camacho, 2010; Narváez-Rivas, Gallardo, Ríos, & León-Camacho, 2011; Narváez-Rivas, Pablos, Jurado, & León-Camacho, 2011), but no study about the composition of sweat fat of hams has been found in literature. The study of such fat could clarify the changes occurring in subcutaneous and intramuscular fats.

The aim of this work was to study the trend of the weight loss of Iberian dry-cured hams and the triacylglycerol, diacylglycerol, monoacylglycerol, free fatty acid and total fatty acid composition of their sweaty fat during processing. The data about the weight loss and sweat of different hams could help to elucidate the changes that the dry-curing process promotes in the composition of subcutaneous fat of Iberian ham.

2. Materials and methods

2.1. Reagents and standards

Standards of fatty acids and triacylglycerols: myristic (C14:0), palmitic (C16:0), palmitoleic (C16:1), margaric (C17:0), *cis*-10-heptadecenoic acid (C17:1), stearic (C18:0), elaidic (C18:1 ω9 *trans*), oleic (C18:1 ω9 *cis*), linoleic (C18:2), arachic (C20:0), linolenic (C18:3), *cis*-13-eicosenoic acid (C20:1), trimiristin (MMM), trilinolein (LLL), triolein (OOO), tripalmitin (PPP) and tristearin (SSS) were purchased from Sigma-Aldrich (St. Louis, MO). Standard solutions of 1.0% (m/v) of the triacylglycerols were prepared by dissolving them in analytical reagent grade n-hexane (Romil, Cambridge, United Kingdom).

1-palmitoil *rac*-glycerol, 1,3-dimiristin, 1,2-dimiristoyl-*rac*-glycerol, 1,3-dipalmitin, 1,2-dipalmitoyl-*rac*-glycerol, 1,3-distearin, 1,2-distearoyl-*rac*-glycerol, 1,2-dioleoyl-*rac*-glycerol and 1,3-diolein were purchased from Sigma-Aldrich (St. Louis, MO). To obtain 1,2-dilinolein an enzymatic hydrolysis of porcine pancreas was done using lipase according to a procedure previously described in the literature (Mancha, 1975). After a short reaction time, 1,2-dilinolein was isolated by thin layer chromatography in silica gel impregnated with boric acid to prevent the isomerization (Christie, 1982). 1,3-dilinolein was purchased from NUCHEK-PREP (Elysian MN). The solid-phase extraction cartridge (3 mL), packed with diol-bonded phase was purchased from Supelco (Bellefonte, PA). Silylating reagent was prepared by adding 3 mL of hexamethyldisilazane and 1 mL of trimethyl-chlorosilane to 9 mL of anhydrous pyridine.

All reagents were of analytical-reagent grade, unless otherwise specified.

2.2. Hams processing

Ten hams (between 10.80 and 12.83 kg, mean of 11.69 kg) from the origin designation of "Los Pedroches" were obtained from five castrated Iberian pure 19-month-old pig males, fattened extensively with acorns and pastured for 90 days prior to slaughter, and were processed in an industry for 35 months. The stages and the number of days from the beginning of the processing were as follows: after the slaughter (3-feb-2009), hams were removed from the carcasses after 24 h refrigerated storage at 1 °C. Then they were placed in piles completely covered only with marine salt (they were not in contact with each other) at low temperature (1.0 °C) and high relative humidity (about 80%) for 1 day kg^{-1} of weight (12 days, from5-feb-2009 to 18-feb-2009). After being washed to remove salt from the surface, the hams were hung at 3.0 °C and a relative humidity of 76% for 26 days, then at 4.0 °C and a relative humidity of 70% for 5 days. Next, they were kept at 6.0 °C and a relative humidity of 70% for 34 days and after this, they were kept at 7.0 °C and a relative humidity of 70% for 15 days. This postsalting period (from 19-feb-2009 to 25-may-2009) was completed raising to 12 °C at a rate of 1 °C each 3 days and a relative humidity of 70%, until 95 days.

Then, they were taken to a dryer at temperatures varying from 7 to 26 °C and a relative humidity ranging from 80% to 12% for 231 days (up to 11-Jan-2010).

Next, the hams were left to mature during 689 days in a cellar at temperatures ranging from 7 to 25 °C and 16–82% relative humidity.

The environmental conditions (temperature and relative humidity) were recorded continuously throughout the whole period of maturing (Fig. 1).

Before starting with the postsalting period, the hams were hung in a container and equipped with a system for recovering the sweaty fat. A datalogger with sensors of humidity, temperature and weight, as showed in Fig. 2, was placed in the container. The hams were thus kept during all processing.

2.3. Sampling

The sweaty fat was collected as it can be observed in detailed in Fig. 2 each month from the beginning of the dry-curing process (raw ham) until this finished (cured ham), as it is shown in Table 1. Samples were stored at −25 °C before analysis.

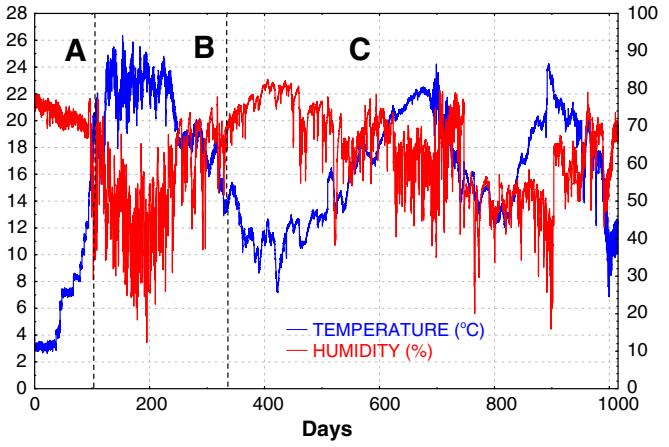

Fig. 1. Evolution of environmental temperature and relative humidity during ripening of Iberian ham. (A): Postsalting period; (B): Drying period; (B): Cellar period.