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Chemical and lipid composition of deboned pieces of dry-cured pork forelegs as affected by desalting and boiling: The effects of vacuum packaging

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Abstract

The effects of desalting and boiling, with or without vacuum packaging, on the composition (mainly in relation to lipids) of the muscles of deboned pieces of dry-cured pork forelegs were investigated. The muscles of boiled, desalted, dry-cured foreleg pieces showed lower ash, chloride, nitrates and nitrites contents and higher protein contents than those of dry-cured forelegs. No significant changes were observed in lipid content and in lipid fraction proportions (glycerides, phospholipids and free fatty acids). The culinary treatment (desalting and boiling) caused a decrease of thiobarbituric acid values and an increase in polyunsaturated fatty acids proportions of the three fractions (glycerides, phospholipids and free fatty acids), especially at C-18:2 and C-20:4. Only the ash contents were significantly different between samples boiled with and without vacuum packaging.

Keywords: Meat products; Culinary treatment; *Sous-vide*; Lipolysis; Oxidation; Fatty acids

1. Introduction

Dry-cured pork forelegs are manufactured in the northwest of Spain (Galicia) following the same steps as dry-cured ham, (salting, washing, standing or post-salting and drying or curing), but for a shorter time. The length of the curing process varies and may take from 15 to 45 days. This influences the average value of dry matter for the final product (39–50%) (Marra, Salgado, Prieto, & Carballo, 1999; Veiga, Cobos, Ros, & Díaz, 2003). This product is also characterised by a high content of sodium chloride (16–19 g/100 g of dry matter on average) (Marra et al., 1999; Veiga et al., 2003). Hence, it is usually eaten after a process in which it is desalted and boiled. Traditionally, during this process, the whole forelegs are desalted for 48–72 h (the water is changed after 24 h) and afterwards, they are placed into boiling water where they cook for 3–4 h. The effects of this culinary treatment on the composition (mainly in relation to lipids) of the muscles of dry-cured pork forelegs have already been studied by Cobos, Veiga, and Diaz (2004). In this study, it was shown that the culinary treatment decreased ash, NaCl and cholesterol content and increased lipid and protein content but did not affect thiobarbituric acid (TBA) values; moreover, a significant increase in free fatty acids (mainly in polyunsaturated fatty acids) and an important decrease in phospholipids were observed, but no significant changes were recorded for glycerides.

However, the culinary treatment of whole forelegs is inconvenient in that it is a hard, time-consuming method. Some people cut the dry-cured pork forelegs into deboned portions and desalt and cook these pieces at home because they are easier to handle than an entire leg. The desalting and cooking of dry-cured pork forelegs in pieces (vs. whole forelegs) decreases the total time necessary to desalt and

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boil them. The cooking temperature is reached in a shorter time in the muscles, while the surface area in contact with water during desalting and boiling is increased. These modifications could result in the loss of water and other components, in the hydrolysis of lipids, and in the oxidation of fatty acids.

The *sous-vide* cooking technology involves vacuum packaging in plastic pouches, an adequate pasteurisation heat treatment is followed by rapid cooling and chilled storage (Creed & Reeve, 1998). This technology is being used for a wide variety of products (namely, chicken *ballotine*, spaghetti and meat sauce products, seasoned beef) and is especially interesting for traditional products that require labour-intense preparation (Jang & Lee, 2005; Schafheitle & Light, 1989; Simpson, Smith, Simpson, Ramaswamy, & Dodds, 1994). The *sous-vide* packaging technology allows for the possibility of developing ready-to-eat desalted and cooked dry-cured forelegs. On a retail level, the only product that can be bought is the dry-cured foreleg, whole or in pieces; thus, the development of a ready-to-eat product would enhance its acceptance for home consumption. However, due to their high salt content, the process should also involve an additional step of desalting before heat treatment. Besides preventing contamination, *sous-vide* cooking retains components of food flavour, nutrients and moisture, while it excludes oxygen and avoids its effects on the oxidation processes; thus, product quality and safety are preserved for a much longer time (Creed & Reeve, 1998; Nyati, 2000). The availability of oxygen can influence the state and fatty acid composition of meat via oxidation, polymerisation and pyrolysis (Ramamurti, 1986). Hence, vacuum packaging before boiling probably reduces or annuls the oxidation processes that can occur in unpackaged pieces of dry-cured pork forelegs leading to the oxidation of unsaturated fatty acids and formation of aldehydes, ketones, etc.

The objective of this study was to determine the influence of desalting and boiling with or without vacuum packaging on the chemical and lipid composition of the muscles of deboned pieces of dry-cured pork forelegs.

2. Materials and methods

2.1. Processing of forelegs and sampling

Five dry-cured pork forelegs were manufactured, as described by Cobos et al. (2004), by a local industry. Three deboned portions of similar size and shape (c. 500 g) including the skin, subcutaneous adipose tissue and *pectoralis profundus*, *coracobrachialis*, *biceps brachii* and *triceps brachii* muscles were obtained from each dry-cured pork foreleg and weighed. One portion was analysed as a dry-cured sample and the other two were desalted. The desalting was done in water at 4 °C for 24 h (4 l of water/kg piece) and the water was changed after 10 h. Afterwards, one of the desalted portions was vacuum-packed in a polypropylene/polyamide laminated pouch using a Stephan Alval vacuum packer (mod. 190). Both desalted portions were inserted directly into boiling water (11 l of water/kg piece) and cooked for 2.5 h. After they were cooled, the packed piece was extracted from the pouch and then both cooked pieces were weighed. All these steps were repeated five times (one for each dry-cured foreleg). The percentage weight loss of the pieces was calculated by the following equation:

$$\%\ \text{weight loss} = [(A - B)/A] \times 100$$

where A is the weight (g) before the culinary treatment and B is the weight (g) after the culinary treatment.

Samples were taken from each portion and were composed of the muscles mentioned above.

2.2. Analytical methods

The meat samples were finely minced in a blender (Polytron PT 10-35). AOAC methods (1995) were used for dry matter, protein, ash and nitrite (colorimetric method) determinations. Chloride (Carpentier-Volhard method) and nitrates (brucine method) were determined according to the official standards for Spain (Presidencia del Gobierno, 1979). The lipids were extracted and purified from the former homogenised sample according to the method of Bligh and Dyer (Hanson & Olley, 1963). The lipid contents of the samples were measured by weighing them after solvent evaporation. The extent of lipid oxidation was assessed by the thiobarbituric acid (TBA) method described by Pikul, Leszczynski, and Kummerow (1983). The results of the TBA value were expressed on a lipid weight basis (mg malonaldehyde/kg lipids) thus reducing the effect of variability of concentrations of lipids among samples.

Total intramuscular lipids (100 mg) were separated into neutral lipids, free fatty acids and phospholipids in NH_2-aminopropyl minicolumns according to the method described by Kaluzny, Duncan, Merritt, and Epps (1985). Since the neutral lipid fraction is mainly composed of glycerides, this term will be used throughout the text. Contents of glycerides, phospholipids and free fatty acids were quantified by weighing (Vaghela & Kilara, 1995) and the results were expressed as a percentage of the total weight obtained. The fatty acid compositions of glycerides, free fatty acids and phospholipids fractions were determined by gas liquid chromatography of methyl esters, prepared in basic conditions (KOH:methanol) for glycerides and phospholipids and acidic conditions (H_2SO_4:methanol) for the free fatty acids. The gas chromatograph was a Hewlett–Packard apparatus (HP 5890) equipped with a dual flame ionization detector. The fused silica capillary column (30 m, internal diameter 0.25 mm) was packed with OV-225 (0.1 μm). Analyses were performed using an initial isothermic period (150 °C, 2 min), thereafter the temperature was increased to 210 °C at an increasing rate of 4 °C/min and finally held at 210 °C for 15 min. The injector and detector were maintained at 250 °C. For quantitative analyses, a Hewlett–Packard HP3394A integrator was

used. The identification of different fatty acid methyl esthers was performed by comparison of the retention times with those of authentic standards (Sigma Chemical Co., St. Louis, MO). Fatty acid proportions from the three fractions (glycerides, free fatty acids and phospholipids) were expressed as a percentage of the total area of injected methyl esters.

2.3. Statistical analyses

The means were compared by *t*-test for dependent samples (three pieces obtained from each dry-cured pork foreleg). A significance level of $p < 0.05$ was used for all means evaluations (SPSS version 10.1. for Windows, 2000).

3. Results and discussion

3.1. Chemical composition

Table 1 shows the chemical composition of meat from dry-cured pork forelegs pieces (DF) and from dry-cured forelegs pieces subjected to culinary treatment by desalting and boiling (BDF) and by desalting and vacuum-packed boiling (VBDF). Meat from BDF and VBDF showed similar average values of dry matter (45–46%) to that of DF (45.3%). However, the culinary treatment (desalting and boiling) caused a significant decrease in the ash content. The changes in ash content are mainly related to decreases in the sodium chloride content. The similar values of dry matter and the losses of ash imply that there is also water loss in the muscles during culinary treatment. However, the weight losses of VBDF pieces were lower that those of BDF pieces ($2.32 \pm 1.49\%$ vs. $16.36 \pm 2.60\%$). One must take into account the fact that the pieces were made up not only of muscular tissue, but also of adipose and connective tissues, including skin. During wet heating, collagen is solubilised and denatured. It swells and absorbs important amounts of water and turns into gelatine (Belitz & Grosch, 1999; Laroche, 1990). In VBDF pieces, deposits of gelatine were observed inside the plastic pouches, which could absorb water from muscle tissue. These deposits of gelatine caused the weight losses of VBDF pieces, although a certain amount of gelatine remained inside the pieces. In unpacked pieces, this gelatine probably dissolved in the cooking water and was eliminated along with the water from muscle tissue, which caused higher weight losses.

BDF showed significant lower values of ash content than VBDF. This implies that there was ash loss (chloride) during the boiling process, in the unpacked pieces, while the vacuum packaging of the pieces prevented this loss. The higher levels of chlorides in VBDF also imply that a longer desalting time might be needed if this product is going to be commercialised.

The culinary treatment caused a decrease in nitrates and nitrites but no significant differences were found between the vacuum-packed cooked pieces and the unpacked cooked pieces. This is probably because these compounds are more connected to the muscles than sodium chloride.

The culinary treatment caused an increase in protein content (from 25% to 29–30%) due to the decrease of ash content. However, the lipid content showed similar values before and after culinary treatment (9–10%). Thus, there was a loss of lipids during the culinary treatment (desalting and boiling) in muscles. In the boiling of pork meat, Hernández, Navarro, and Toldrá (1999) did not find significant changes in total lipid contents; however, lipid losses in the cooking of ground beef have been reported (Baggio & Bragagnolo, 2006; Ono, Berry, & Paroczay, 1985; Rodriguez-Estrada, Penazzi, Caboni, Bertacco, & Lercker, 1997). These different results are probably due to the differences in the cooking (method, temperature, time) and in the type of sample (muscles with or without fat, ground meat or not). In whole dry-cured forelegs (Cobos et al., 2004), the culinary treatment caused an increase in lipid content that was related to the absence of lipid loss in muscles. The smaller size of the pieces decreased the time needed to reach high temperatures in the muscles and the longer boiling time per kg of meat used in this study probably caused the decrease of the lipid content, due to melting and migration of intramuscular fat out of the meat. The boiling of unpacked pieces probably caused lipid loss since some of them dripped into the cooking water. The lipid loss in vacuum-packed pieces happened because a small amount of lipids accumulated on the surface of the portions under the pouches together with the gelatine.

Table 1
Chemical composition (average ± SD) of meat from dry-cured forelegs pieces (DF) and from dry-cured pieces subjected to culinary treatment by desalting and boiling (BDF) or by desalting and vacuum-packed boiling (VBDF) ($n = 5$)

	DF	BDF	VBDF
Dry matter (g/100 g meat)	45.3 ± 1.98	44.5 ± 3.61	46.0 ± 3.69
Ash (g/100 g meat)	11.2 ± 0.45a	5.46 ± 0.62b	6.47 ± 0.55c
Chloride (g/100 g meat)	7.85 ± 1.28a	3.31 ± 0.86b	4.64 ± 0.77b
Nitrates (mg/kg meat)	33.9 ± 19.2	18.3 ± 3.53	22.0 ± 8.77
Nitrites (mg/kg meat)	5.06 ± 1.44a	3.11 ± 1.65b	2.41 ± 1.07b
Protein (g/100 g meat)	24.9 ± 4.07	30.3 ± 4.46	29.2 ± 4.15
Lipids (g/100 g meat)	9.18 ± 3.22	8.70 ± 1.67	10.2 ± 2.70

Means with different letters on the same row differ significantly ($p < 0.05$).

3.2. TBA values and lipids fractions

The TBA values and the lipid fraction composition of meat from forelegs are shown in Table 2. The TBA values in lipids were significantly lower in BDF and VBDF than in DF. No significant differences were observed between BDF and VBDF. The studies about the effects of boiling meat on TBA values are contradictory. Badiani et al. (2002) also observed that the cooking of meat, especially boiling, led to significant decreases in TBA values in lipids. Sakai, Shimizu, and Kawahara (2006) observed that the malonaldehyde contents of pork meat did not change by boiling while Hernández et al. (1999) reported that the boiling of

Table 2
TBA values and lipids fraction composition (average ± SD) of meat from dry-cured forelegs pieces (DF) and from dry-cured pieces subjected to culinary treatment by desalting and boiling (BDF) or by desalting and vacuum-packed boiling (VBDF) ($n = 5$)

	DF	BDF	VBDF
Glycerides (g/100 g lipids)	72.2 ± 2.33	73.3 ± 3.02	73.7 ± 0.84
Free fatty acids (g/100 g lipids)	12.4 ± 1.81	11.7 ± 3.69	11.8 ± 0.99
Phospholipids (g/100 g lipids)	15.4 ± 1.53	14.9 ± 1.80	14.5 ± 1.35
TBA value (mg MDA/kg lipids)	94.1 ± 17.2a	54.0 ± 14.8b	62.3 ± 11.1b

Means with different letters on the same row differ significantly ($p < 0.05$).
TBA: thiobarbituric acid; MDA: malonaldehyde.

pork meat produced an increase of TBA values. No significant changes were observed in TBA values in lipids when the culinary treatment was done on whole forelegs (Cobos et al., 2004). The significant decreases in TBA values in lipids during the culinary treatment of the pieces of dry-cured forelegs probably occurred because the exposition of the muscles to heat treatment was more intense in the smaller pieces than in the whole forelegs. This might have produced the degradation of aldehydes (reaction with the intermediates and products of Maillard and Strecker reactions during cooking) and/or possibly the denaturation caused by the heat made the TBA reactive substances less assessable for measurement (Nuernberg et al., 2006). It is also possible that when the pieces are boiled, part of the malonaldehyde dissolves in the water lost by the muscles during culinary treatment. In any case, the low levels of TBA could be related to low oxidation during culinary treatment. Hydrolysis of phospholipids during the processing of dry-cured forelegs has been observed (Veiga et al., 2003) and it has been reported that this hydrolysis might protect the long chain polyunsaturated fatty acids (PUFA) from oxidation (Gandemer, 2002).

There were no significant differences in the levels of glycerides, free fatty acids and phospholipids between the different batches (DF, BDF and VBDF). Boiling of pork meat increases the content of free fatty acids due to thermal hydrolysis as well as the action of endogenous lipase (Hernández et al., 1999). Cobos et al. (2004) observed that whole dry-cured forelegs subjected to culinary treatment showed significant higher values of free fatty acid content than dry-cured forelegs, which was probably also due to thermal hydrolysis and to the action of endogenous lipases. The fact that there was no increase in the content of free fatty acids during the culinary treatment, of the deboned pieces, of dry-cured forelegs was probably due to several reasons. Firstly, the shorter time of desalting (24 h in pieces of dry-cured forelegs and 48 h in whole dry-cured forelegs) allowed less time for lipases to hydrolyse sterified fatty acids. Secondly, the higher degree of heat penetration in the boiled pieces of dry-cured forelegs probably caused the lipases to lose their activity quicker than in whole dry-cured forelegs. Moreover, thermal hydrolysis may not

Table 3
Fatty acid profiles (% of total fatty acids) (average ± SD) of glycerides, phospholipids and free fatty acids fractions of meat from dry-cured forelegs pieces (DF) and from dry-cured pieces subjected to culinary treatment by desalting and boiling (BDF) or by desalting and vacuum-packed boiling (VBDF) ($n = 5$)

	Glycerides			Phospholipids			Free fatty acids		
	DF	BDF	VBDF	DF	BDF	VBDF	DF	BDF	VBDF
C-14:0	1.98 ± 0.36	1.74 ± 0.45	1.64 ± 0.25	0.31 ± 0.07	0.24 ± 0.07	0.29 ± 0.04	1.24 ± 0.22	1.06 ± 0.27	1.02 ± 0.30
C-16:0	28.63 ± 1.95	26.1 ± 2.28	25.9 ± 1.02	28.5 ± 2.54	25.5 ± 2.66	27.1 ± 1.25	21.1 ± 1.29	22.3 ± 2.41	23.5 ± 2.47
C-16:1$n-9$	0.53 ± 0.08	0.50 ± 0.12	0.52 ± 0.07	0.31 ± 0.12	0.22 ± 0.06	0.23 ± 0.03	1.05 ± 0.32	0.96 ± 0.29	0.97 ± 0.35
C-16:1$n-7$	3.21 ± 0.60	2.73 ± 0.29	2.71 ± 0.51	0.70 ± 0.24	0.63 ± 0.24	0.69 ± 0.20	2.60 ± 1.08	1.85 ± 0.36	1.84 ± 0.31
C-17:0	0.27 ± 0.07	0.26 ± 0.07	0.27 ± 0.05	0.43 ± 0.06	0.38 ± 0.06	0.38 ± 0.04	0.29 ± 0.04	0.34 ± 0.09	0.30 ± 0.04
C-17:1$n-7$	0.27 ± 0.05	0.27 ± 0.05	0.31 ± 0.10	0.11 ± 0.05	0.23 ± 0.16	0.10 ± 0.02	0.30 ± 0.07	0.25 ± 0.07	0.21 ± 0.05
C-18:0	11.8 ± 3.21	11.2 ± 1.92	12.0 ± 2.97	11.2 ± 0.80a	10.0 ± 0.66b	9.62 ± 1.09b	7.57 ± 1.01	7.92 ± 1.01	7.44 ± 1.09
C-18:1$n-9$	37.4 ± 2.79	38.1 ± 3.84	38.0 ± 2.52	14.6 ± 1.27	13.4 ± 1.01	13.4 ± 1.31	26.2 ± 6.32a	19.1 ± 2.14b	18.7 ± 1.14b
C-18:1$n-7$	3.31 ± 0.45	3.60 ± 0.43	3.32 ± 0.40	4.40 ± 0.48	4.01 ± 0.40	4.08 ± 0.55	3.50 ± 0.27	3.15 ± 0.34	3.04 ± 0.24
C-18:2$n-6$	10.2 ± 2.08	12.5 ± 2.00	12.5 ± 1.91	28.5 ± 1.87a	31.2 ± 1.36b	31.2 ± 1.62b	24.8 ± 3.72a	29.3 ± 0.69b	29.9 ± 2.05b
C-18:3$n-3$	0.57 ± 0.13	0.71 ± 0.08	0.72 ± 0.11	0.56 ± 0.09	0.55 ± 0.08	0.54 ± 0.09	1.27 ± 0.14	1.29 ± 0.17	1.27 ± 0.16
C-20:1$n-9$	0.68 ± 0.11	0.62 ± 0.09	0.66 ± 0.15	0.33 ± 0.10	0.25 ± 0.07	0.23 ± 0.05	0.60 ± 0.18a	0.39 ± 0.12b	0.38 ± 0.03b
C-20:2$n-6$	0.40 ± 0.09	0.48 ± 0.06	0.49 ± 0.08	0.76 ± 0.27	0.80 ± 0.31	0.61 ± 0.06	0.57 ± 0.15	0.62 ± 0.13	0.45 ± 0.17
C-20:3$n-6$	nd	nd	nd	0.88 ± 0.19	1.04 ± 0.22	0.96 ± 0.12	0.69 ± 0.25	0.91 ± 0.14	0.86 ± 0.20
C-20:4$n-6$	0.71 ± 0.19	1.20 ± 0.58	1.05 ± 0.46	6.46 ± 0.85a	9.17 ± 1.54b	8.39 ± 1.19b	6.55 ± 2.37	8.81 ± 0.88	8.42 ± 1.08
C-22:4$n-6$	nd	nd	nd	1.15 ± 0.33	1.35 ± 0.51	1.21 ± 0.17	0.78 ± 0.18	0.68 ± 0.20	0.75 ± 0.16
C-22:5$n-3$	nd	nd	nd	0.79 ± 0.22	0.97 ± 0.31	0.91 ± 0.16	0.78 ± 0.23	1.01 ± 0.12	1.00 ± 0.27
SFA	42.7 ± 3.01	39.3 ± 2.12	39.8 ± 2.49	40.5 ± 2.21a	36.1 ± 2.74b	37.4 ± 1.21b	30.2 ± 2.06	31.6 ± 3.30	32.2 ± 3.02
MUFA	45.4 ± 3.47	45.8 ± 4.19	45.5 ± 2.90	20.4 ± 1.98	18.8 ± 1.51	18.7 ± 1.89	34.3 ± 7.57a	25.8 ± 2.81b	25.1 ± 1.43b
PUFA	11.9 ± 2.39	14.9 ± 2.57	14.7 ± 2.32	39.2 ± 2.36a	45.1 ± 2.45b	43.8 ± 2.35b	35.5 ± 6.50a	42.6 ± 1.60b	42.6 ± 3.35b

Means of a same fraction with different letters on the same row differ significantly ($p < 0.05$).
nd: not detected.
SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids.

play an important role when this product is boiled. Finally, boiling the pieces may cause migration of free fatty acids from muscles to other locations or into the cooking water. This fact matches the increase of levels caused by hydrolysis.

3.3. Fatty acid composition

Table 3 shows the fatty acid compositions in DF, BDF and VBDF of glycerides, phospholipids and free fatty acids.

In glycerides, the cooked pieces (BDF and VBDF) showed a lower content of saturated fatty acids (SFA) as compared with dry-cured pieces (DF), due to the decrease in the percentage of C-16:0 and showed a higher content of PUFA due to the increase in the percentages of C-18:2, C-18:3, C-20:2 and C-20:4. However, no significant differences in fatty acid composition of glycerides between dry-cured pieces and cooked pieces were found.

The culinary treatment caused changes in the fatty acid profiles of phospholipids of dry-cured pieces. The cooked pieces (BDF and VBDF) showed significantly higher values of PUFA and significantly lower values of SFA than DF. A significant increase was observed in the main polyunsaturated fatty acids (C-18:2$n-6$ and C-20:4$n-6$) and a significant decrease was observed in C-18:0.

The culinary treatment also caused changes in the fatty acid profiles of free fatty acids of pieces of dry-cured forelegs. The cooked pieces (BDF and VBDF) showed significantly higher values of PUFA (mainly of C-18:2) and significantly lower values of MUFA (of C-16:1, C-18:1$n-9$ and C-20:1$n-9$) than DF.

Thus, glycerides, phospholipids and free fatty acids of boiled desalted dry-cured forelegs pieces showed higher contents of PUFA (mainly linoleic and arachidonic acid) than those of dry-cured pork forelegs. In the culinary treatment of whole dry-cured pork forelegs, a higher content of PUFA was only reported in the free fatty acid fraction of cooked dry-cured forelegs, with no differences in glycerides and phospholipids fractions (Cobos et al., 2004). In this paper, the increase of PUFA in free fatty acids was because the free fatty acids came mostly from phospholipid hydrolysis. The increase of PUFA in the culinary treatment of pieces of dry-cured pork forelegs might be more related to the migration of lipids from muscles to other tissues or into cooking water during boiling. The lipid losses from the meat during the boiling of the pieces would contain triglycerides, phospholipids and free fatty acids with saturated and monounsaturated fatty acids.

The increase in the proportion of PUFA in total lipids has been also reported in the grilling of beef patties from meat of bulls (Scheeder et al., 2001) and in the cooking of hamburguers (Rodriguez-Estrada et al., 1997), ground beef (Ono et al., 1985; Ramamurti, 1986) and jerked beef (Correia & Biscontini, 2003). The explanation of these results was related to drip losses, containing mainly triglycerides of adipose tissue with relatively more saturated than unsaturated fatty acids (Ramamurti, 1986; Scheeder et al., 2001); in this sense, Ono et al. (1985) stated that unsaturated fatty acids were less affected by cooking because they belonged to the membrane structure, to a higher extent, than saturated fatty acids. Nevertheless, lipids were not fractionated in these studies. During the culinary treatment of dry-cured foreleg pieces, the proportions of the lipid fractions remained constant; so the lipid losses in the muscles were more related to the degree of saturation of the fatty acids than to their belonging or not to glycerides, phospholipids or free fatty acids.

Finally, no significant differences were found in fatty acid composition between BDF and VBDF batches. This is probably due to the fact that the lipids were not affected by oxidation during culinary treatment, as was observed in whole dry-cured forelegs (Cobos et al., 2004).

4. Conclusions

The desalting and boiling of pieces of dry-cured forelegs caused a decrease of ash and chloride contents and TBA values, an increase of protein contents and did not produce changes in the total lipids, glycerides, phospholipids and free fatty acids contents of the muscles. There were significant increases in polyunsaturated fatty acids of glycerides, phospholipids and free fatty acids in muscles of pieces with or without vacuum packaging before boiling.

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