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Fatty acid composition of lipid fractions in Parma ham obtained from pigs fed on different levels of vitamin E (α-tochopherol acetate)[†]

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SUMMARY - The fatty acid composition of intramuscular lipids and adipose covering tissue was studied on 45 Parma hams obtained from Duroc x Cotswold heavy pigs (carcass weight 129.5±8.0 kg). Prior to slaughtering, which took place at an average liveweight of about 160 kg, the animals were fed on a diet integrated with 8 mg/kg of vitamin E for 95 days (C), 200 mg/kg for 65 days (T1) or 200 mg/kg for 95 days (T2). The intramuscular lipids, amounting to a total of 3.38%, contained, on average, 35.6% of saturated (SFA), 48.5% of monounsaturated (MUFA) and 15.9% polyunsaturated (PUFA) fatty acids. The dietary level of vitamin E had no statistically significant effect on fatty acid composition of intramuscular lipids, although the animals of groups T1 and T2 showed lipids tendentially richer in PUFA. The neutral fraction of intramuscular lipids comprising 35.5% of SFA, 56.5% of MUFA and 8.0% of PUFA, was found to be richer in PUFA in hams from pigs with higher vitamin E integration. However, there was no effect of the treatment on the composition of polar lipids, which were found to consist of 31.9% of SFA, 20.6% of MUFA and 47.5% of PUFA. The lipids in the adipose covering tissue, comprising an average of 36.9% SFA, 46.0% MUFA and 17.1% PUFA, were tendentially more unsaturated in animals with higher integration of the diet. The length of the treatment did not have a significant effect on any of the parameters examined.

Key words: Heavy pig, Parma ham, fatty acid composition, dietary vitamin E.

RESUME - *"Composition en acides gras des fractions lipidiques du jambon de Parme provenant de porcs alimentés avec différents niveaux de vitamine E (α-tocophérol acetate)". On a étudié la composition en acides gras des lipides intramusculaires et du tissu adipeux sous-cutané de 45 jambons secs de Parme de porcs Duroc x Cotswold (poids de la carcasse 129,5±8,0 kg). Avant l'abattage trois lots d'animaux ont reçu un aliment du commerce avec une supplémentation en vitamine E de 8 mg/kg pendant 95 jours (Lot C), 200 mg/kg pendant 65 jours (Lot T1) et 200 mg/kg pendant 95 jours (Lot T2). La composition des lipides intramusculaires (teneur de 3,38%) a montré des taux d'acides gras saturés (AGS), monoinsaturés (AGM) et polyinsaturés (AGP) respectivement de 35,6%, 48,5% et 15,9%. La supplémentation en doses élevées de vitamine E n'a pas significativement influencé la composition des lipides intramusculaires, même si les lots T1 et T2 ont montré des lipides fondamentalement plus riches en AGP. La fraction neutre des lipides intramusculaires, constituée par 35,5% de AGP, 56,5% de AGM et 8,0% de AGP, a montré une quantité plus élevée de AGP dans les jambons des porcs qui ont reçu l'aliment supplémenté avec 200 mg/kg de vitamine E. La supplémentation n'a eu aucun effet sur la composition des lipides polaires, constitués par 31,9% de AGS, 20,6% de AGM et 47,5% de AGP. Les lipides du tissu adipeux sous-cutané du jambon, ont montré une composition moyenne de AGS, AGM, et AGP respectivement de 36,9%, 46,0% et 17,1%. Cependant ces lipides se sont révélés fondamentalement plus insaturés dans les lots T1 et T2, qui ont reçu l'intégration vitaminique plus élevée. Par contre la période du traitement n'a pas significativement influencé les paramètres considérés.*

Mots-clés : *Porc lourd, jambon de Parme, composition en acides gras, vitamine E alimentaire.*

Introduction

In the last few years, Parma ham has been the subject of numerous studies aimed at determining its chemical and nutritional features (Baldini *et al*., 1993; Monin *et al*., 1996), clarifying the relationships between the characteristics of the raw material and those of the cured product (Virgili *et al*., 1998), checking the effect of the Halothane genotype (Santoro and Lo Fiego, 1987) and the lean content of the carcass (Russo *et al*., 1990; Nanni Costa *et al*., 1993; Lo Fiego *et al*., 1994) on qualitative features. The acidic composition of lipids was, however, taken into consideration mainly in French (Buscailhon *et al*., 1994), Corsican (Coutron

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et al., 1995) and Spanish (Flores *et al*., 1987) ham. The aim of this study was to examine the acidic composition of the lipid fractions in Parma ham and to check the effect exercised on this by an integrated diet containing high doses of vitamin E during the fattening period.

Materials and methods

The study was conducted on 45 hams from 45 different heavy pigs (carcass weight 129.5±8.0 kg) Duroc x Cotswold (23 castrated males and 22 females) divided into three groups of 15 pigs each (C, T1, T2) and fed *ad lib* throughout the test period (95 days) on a diet integrated with 8 mg/kg (C) or 200 mg/kg (T2) of vitamin E. Group T1 was given the same feed as group C for the first 30 days and as group T2 for the next 65 days. The iodine value of lipids in the fresh adipose covering tissue (Wijs method) was measured. Fatty acid composition, after methylation (IUPAC, 1979), was determined by means of capillary gas chromatography, on both fresh and cured covering fat tissues from each left ham.

At the end of the curing process (12 months), a sample of the *Biceps femoris* muscle was taken from each ham in order to determine the total lipids (Folch *et al.,* 1957). A quantity of these and the neutral and polar fractions separated from them (Kaluzny *et al*., 1985) were subjected, after methylation (Joseph and Ackman, 1992), to determination of the acidic composition. The general averages were calculated from the data obtained and were subjected to variance analysis according to sex and treatment. The two degrees of freedom of the latter effect were split up *a priori* in orthogonal contrasts T1 *vs* T2 and the average of (T1+T2) *vs* C.

Results and discussion

The content of intramuscular lipids in *Biceps femoris*, which was 3.38%, was found to be more or less the same as that reported by Baldini *et al*. (1993) for both Parma (3.35%) and San Daniele (3.65%) hams.

Table 1 shows the fatty acid composition of total intramuscular lipids and the neutral and polar fractions in cured ham.

Total lipids were found to consist of 35.6% SFA, 48.5% MUFA and 15.9% PUFA. The main constituents were C16:0 (22.3%) and C18:0 (11.4%) among SFA, C16:1 (3.6%) and C18:1 (43.8%) among MUFA, C18:2 (11.6%) and C20:4 (3.1%) among PUFA. The other components were found to be present in very low quantities, varying from a minimum of 0.1% of C20:0 to a maximum of 1.4% of C14:0.

The neutral lipids are characterized by a high content of MUFA (56.5%), due to a high content of C18:1 (51.1%) and C16:1 (4.4%) and a reduced content of PUFA (8.0%), relative to both total lipids and phospholipids. The SFA content does not differ between total lipids (35.6%) and neutral lipids (35.5%); whereas, it is lower in phospholipids (31.9%). The latter consist of a large quantity of PUFA (47.5%), mainly C18:2 (27.7%) and C20:4 (16.5%) and a low quantity of SFA (31.9%) and MUFA (20.6%).

The adipose covering tissue from fresh ham (Table 2), which showed an average iodine value of 71.5, was found to consist of 36.9% SFA (23.2% C16:0 and 11.5% C18:0), 46.0% of MUFA of which 42.5% C18:1 and the remaining 17.1% PUFA represented mainly by C18:2 (15.1%). During the curing phase, there was a reduction of all SFA, all PUFA, with the exception of C20:3 and C20:4 which were found to have increased, along with an increase in all MUFA.

There was no difference between the two treatment times with vitamin E (T1 *vs* T2), thus the tables only give, for each parameter, the comparison between the averages of groups T1 and T2 and that of group C. Integration of the diet with 200 mg/kg of vitamin E had no effect on the fatty acid composition of total and polar lipids (Table 1), with the exception of a slight but significant increase in C18:3 in the former. The neutral fraction, however, showed a higher quantity of PUFA, especially C18:2, C18:3 and C20:3.

Table 1. Fatty acid composition of *Biceps femoris* intramuscular lipids of Parma ham and dietary vitamin E effect

Fatty acids (%)	Mean ± S.D.			Dietary vitamin E effect (Mean T1+T2 *vs* C)†		
	Total lipids	Neutral lipids	Phospholipids	Total lipids	Neutral lipids	Phospho-lipids
C14 :0	1.38 ± 0.15	1.60 ± 0.14	0.78 ± 0.45	-0.04 NS	-0.01 NS	+0.23 NS
C16 :0	22.28 ± 0.91	22.85 ± 1.02	18.37 ± 2.32	-0.28 NS	-0.14 NS	-0.38 NS
C17 :0	0.18 ± 0.04	0.14 ± 0.02	0.42 ± 0.09	+0.01 NS	0.00 NS	-0.04 NS
C18 :0	11.40 ± 1.17	10.53 ± 0.99	11.81 ± 1.32	-0.03 NS	-0.57 NS	-0.57 NS
C20 :0	0.13 ± 0.13	0.11 ± 0.04	0.24 ± 0.15	-0.06 NS	0.00 NS	-0.04 NS
SFA	35.58 ± 1.71	35.46 ± 1.71	31.86 ± 3.39	-0.43 NS	-0.72 NS	-0.73 NS
C16 :1	3.63 ± 0.51	4.38 ± 0.61	2.84 ± 0.77	-0.18 NS	-0.26 NS	+0.04 NS
C17 :1	0.16 ± 0.03	0.16 ± 0.03	0.28 ± 0.16	0.00 NS	+0.01 NS	-0.07 NS
C18 :1	43.84 ± 2.39	51.08 ± 1.44	17.00 ± 3.74	-0.62 NS	-0.19 NS	+0.74 NS
C20 :1	0.89 ± 0.10	0.93 ± 0.11	0.50 ± 0.13	+0.01 NS	-0.03 NS	+0.08 NS
MUFA	48.55 ± 2.68	56.55 ± 1.67	20.63 ± 3.92	-0.80 NS	-0.47 NS	+0.79 NS
C18 :2	11.58 ± 1.95	6.74 ± 1.27	27.69 ± 4.34	+0.98 NS	+1.00*	-0.41 NS
C18 :3	0.40 ± 0.06	0.37 ± 0.08	0.33 ± 0.11	+0.08**	+0.08**	-0.05 NS
C20 :2	0.41 ± 0.13	0.36 ± 0.07	1.23 ± 0.26	+0.06 NS	+0.04 NS	+0.04 NS
C20 :3	0.41 ± 0.12	0.11 ± 0.03	1.80 ± 0.39	+0.01 NS	+0.03*	-0.17 NS
C20 :4	3.06 ± 0.81	0.40 ± 0.11	16.47 ± 2.90	+0.09 NS	+0.04 NS	+0.47 NS
PUFA	15.86 ± 2.87	7.98 ± 1.45	47.50 ± 6.15	+1.21 NS	+1.17 *	-0.05 NS

†Vitamin E supplementation (mg/kg of feed): C=8 mg for 95 d; T1=8 mg for 30 d and 200 mg for 65 d; T2=200 mg for 95 d
*P <0.05; **P<0.01; NS: Non significant

Table 2. Fatty acid composition of covering fat of raw and cured ham and dietary vitamin E effect

Fatty acids (%)	Mean ± S.D.		Dietary vitamin E effect (Mean T1+T2 *vs* C)†	
	Raw ham	Cured ham	Raw ham	Cured ham
C14 :0	1.48 ± 0.14	1.42 ± 0.16	-0.01 NS	+0.03 NS
C16 :0	23.22 ± 1.07	22.43 ± 1.08	-0.54 NS	-0.20 NS
C17 :0	0.24 ± 0.04	0.17 ± 0.03	-0.02 NS	-0.01 NS
C18 :0	11.52 ± 1.01	10.64 ± 0.91	-0.72 *	-0.60 NS
C20 :0	0.20 ± 0.14	0.11 ± 0.01	-0.08 NS	0.00 NS
SFA	36.87 ± 1.86	34.94 ± 1.58	-1.44*	-0.77 NS
C16 :1	2.47 ± 0.31	2.95 ± 0.37	+0.07 NS	+0.06 NS
C17 :1	0.19 ± 0.03	0.21 ± 0.04	-0.02 NS	-0.02 NS
C18 :1	42.48 ± 1.52	47.52 ± 1.42	+0.12 NS	-0.19 NS
C20 :1	0.86 ± 0.11	1.05 ± 0.22	-0.02 NS	-0.03 NS
MUFA	45.99 ± 1.63	51.73 ± 1.40	+0.16 NS	-0.16 NS
C18 :2	15.15 ± 1.90	11.22 ± 1.54	+1.06 NS	+0.61 NS
C18 :3	0.94 ± 0.13	0.68 ± 0.13	+0.13*	+0.08 NS
C20 :2	0.68 ± 0.11	0.64 ± 0.22	+0.08*	0.00 NS
C20 :3	0.15 ± 0.02	0.40 ± 0.46	+0.01 NS	+0.24 NS
C20 :4	0.22 ± 0.03	0.39 ± 0.72	0.00 NS	+0.03 NS
PUFA	17.14 ± 2.13	13.33 ± 1.84	+1.29 NS	+0.94 NS
Iodine value	71.52 ± 4.04	-	+2.54*	-

†Vitamin E supplementation (mg/kg of feed): C=8 mg for 95 d; T1=8 mg for 30 d and 200 mg for 65 d; T2=200 mg for 95 d
*P <0.05; **P<0.01; NS: Non significant

In the adipose covering tissue of fresh ham (Table 2) high vitamin E integration of the diet resulted in a significant reduction in the saturated fatty acid content, an almost equivalent increase in polyunsaturated acids, but significant only for C18:3 and C20:3 and an increase in the iodine value. A similar trend, but non statistically significant, was also observed in the covering fat of cured ham.

Conclusions

On the whole, Parma ham showed a reduced quantity of intramuscular fat and lipids with 64.4% of unsaturated fatty acids and 35.6% of saturated fatty acids. The latter, which could be a cause of concern from the nutritional point of view in human beings, comprises about 1/3rd of stearic acid, now considered as a fatty acid which plays the same biological role as oleic acid, since the organism is capable of converting it into the latter by a mechanism of desaturation (Klingenberg *et al*., 1995).

Integration of the diet with high doses of vitamin E, although generally tending to produce more unsaturated lipids, probably owing to the antioxidant action of the vitamin in the living animals, had no relevant effects on the acidic composition of fat depots in cured ham.

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