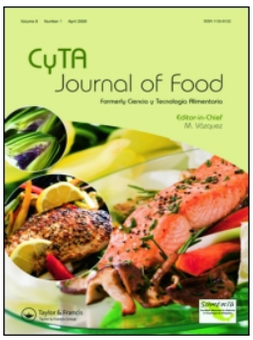

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Characterization of meat from two game birds: thrush (*Turdus philomelos*) and turtle dove (*Streptopelia turtur*) Caracterización de la carne de dos aves de caza: zorzal (*Turdus philomelos*) y tórtola (*Streptopelia turtur*)

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Characterization of meat from two game birds: thrush (*Turdus philomelos*) and turtle dove (*Streptopelia turtur*)

Caracterización de la carne de dos aves de caza: zorzal (*Turdus philomelos*) y tórtola (*Streptopelia turtur*)

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The chemical and fatty acid composition and color of wild thrush (*Turdus philomelos*) and turtle dove (*Streptopelia turtur*) meat were investigated. No significant differences in the chemical composition were observed between the meat of thrush and that of turtle dove. However, significant differences ($p < 0.05$) in the fatty acid composition of the three fractions (glycerides, phospholipids, and free fatty acids) and in color parameters were observed. The main fatty acid in thrush meat was oleic acid (around 30%), and the high content of docosahexaenoic acid (C-22:6n-3) (more than 10% in the three fractions) was remarkable. There was a high content of polyunsaturated fatty acids (PUFA) (more than 50%) in the turtle dove meat; the main PUFA were linoleic (C-18:2n-6) and arachidonic (C-20:4n-6) acids.

Keywords: game; thrush; turtle dove; meat; lipids; fatty acids; color

Se ha estudiado la composición química, de ácidos grasos y el color de la carne de zorzal (*Turdus philomelos*) y tórtola (*Streptopelia turtur*). No se observaron diferencias significativas en la composición química entre la carne de ambas especies; sin embargo, sí se detectaron diferencias significativas ($p < 0{,}05$) en la composición de ácidos grasos de las tres fracciones lipídicas (glicéridos, fosfolípidos y ácidos grasos libres) y en los parámetros de color. El principal ácido graso en la carne de zorzal fue el ácido oleico (alrededor del 30%), siendo remarcable el alto contenido de ácido docosahexaenoico (C-22:6n-3) (mayor del 10% en las tres fracciones). La carne de tórtola presentó un alto contenido de ácidos grasos poliinsaturados (mayor del 50%), siendo los principales ácidos grasos poliinsaturados el linoleico (C-18:2n-6) y el araquidónico (C-20:4n-6).

Palabras clave: caza; zorzal; tórtola; carne; lípidos; ácidos grasos; color

Introduction

Hunting has been practiced since ancestral times as a mean of survival and a way to obtain food. Meat from these animals is traditionally consumed in some European countries such as Spain. Game is distinguished by the characteristic texture, taste and color of its meat, which differs from poultry and farmyard animals; it is normally darker, presents a stronger taste, and is often tougher, depending to the age and type of animal (Cobos, De La Hoz, Cambero, & Ordóñez, 1995). Moreover, the meat from wild animals has a good nutritional value due to its low muscle fat content and its high levels of polyunsaturated fatty acids (PUFA) (Cobos, Veiga, & Díaz, 2000; Cobos et al., 1995; Hoffman & Wiklund, 2006; Polak, Rajar, Gasperlin, & Zlender, 2008). However, the research about the quality of meat from wild animals is mainly on mammals (rabbit, hare, deer, etc.). Little research has been conducted on the quality of wild game bird meat. Cobos et al. (2000) studied the chemical and fatty acid composition of wild ducks and observed that wild duck meat is also a good source of PUFA. However, the characteristics of the meat from other wild birds could be different. No information is available about other wild game bird meat such as thrush (*Turdus philomelos*) and turtle dove (*Streptopelia turtur*).

These species are two of the main game birds hunted in Spain. Both are migratory birds with different migratory patterns. The thrush spends the winter in Spain and migrates to Central Europe during the summer, whereas the turtle dove is in Spain during summer and spends the winter in sub-Saharan Africa. They also have different feeding patterns. The thrush is omnivorous, and eats a variety of food like fruits, earthworms, insects and snails; in Spain olives form a

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very important part of its diet (González-Solís & Ruiz, 1990; Muñoz-Cobo & Moreno Montesino, 2004). The turtle dove is essentially a granivorous bird that eats seeds of cereals, sunflower and wild species (Jiménez, Hodar, & Camacho, 1992). The fatty acid composition of both glycerides and phospholipids in poultry meat is influenced by diet (Ahn, Wolfe, & Sim, 1995; Asghar, Lin, Gray, Buckley, Booren, & Flegal, 1990; Meyner, Genot, & Gandemer, 1999); thus, the fatty acid composition of thrush and turtle dove meat will probably be different.

The objective of this study was to ascertain the chemical and fatty acid composition and to characterize the color of wild thrush and turtle dove meat.

Materials and methods

Animals

Six wild thrushes (*T. philomelos*) and five wild turtle doves (*S. turtur*) caught in the south of Spain (Ciudad Real, Castilla La Mancha) were analyzed. The thrushes were caught in November and the turtle doves were caught in September. The animals were frozen and stored at a temperature of -20 °C for 14 days and sent to the laboratory of Food Technology (Faculty of Sciences, Lugo). Firstly, the animals were defrosted at 4 °C for 24 h and weighed; afterwards, the feathers were removed and the meat from breast (m. *pectoralis major*) was obtained by carefully dissecting flesh from skeleton. The rest of the carcass and viscera were discarded. The weights of the birds were 67.29 $\pm$ 3.96 g for thrushes and 136.79 $\pm$ 6.74 g for turtle doves.

Analytical methods

Color measurements were taken on the external side of the *pectoralis major* muscle and were made in triplicate. Color was recorded using a Spectro-Color Dr. Lange chromameter (Dr. Bruno Lange GmbH & Co., Düsseldorf, Germany). All measurements were made in the CIE $L^*a^*b^*$ color space using the D65 illuminant and the 10° standard observer. The instrument was standardized with the white and black tiles provided by the manufacturer before sample measurements. The color values were expressed as L^* (lightness), a^* (redness/greenness), and b^* (yellowness/blueness). From these values, chroma and hue angle were calculated as follows (Hunt, 1991):

$$C^* = (a^{*2} + b^{*2})^{1/2}$$

$$H^* = \tan^{-1}(b^*/a^*).$$

Afterwards, the meat samples were finely minced in a blender (Polytron PT 10-35). AOAC methods (1995) were used for the dry matter, protein, and ash determination. The lipids were extracted and purified from the samples with chloroform/methanol according to the Bligh and Dyer method (Hanson & Olley, 1963). The total lipids were gravimetrically determined. All analyses were made in triplicate.

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). The neutral lipid fraction is mainly composed of glycerides and this term will be used throughout the text. Amounts of glycerides, phospholipids and free fatty acids were quantified by weighing (Vaghela & Kilara, 1995) and the results were expressed as a percent of the total weight obtained. The fatty acid compositions of glycerides, free fatty acids, and phospholipids were determined by liquid gas chromatography of methyl esters, which were 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, St. Louis, MO). Amounts of fatty acids from the three fractions (glycerides, free fatty acids, and phospholipids) were expressed as a percent of the total area of injected methyl esters.

Statistical analyses

The means were compared by *t*-test for independent samples. A significance level of $p < 0.05$ was used for all means evaluations (SPSS version 10.1. for Windows, 2000).

Results

Table 1 shows the chemical and lipid composition of thrush and turtle dove breast meat. The contents of dry matter (271–275 g/kg), protein (216 g/kg), ash (13 g/kg), and lipids (40–44 g/kg) of breast meat were similar in both species.

No significant differences were observed in the level of glycerides (709–756 g/kg of total lipids), phospholipids (135–174 g/kg of total lipids) and free fatty acids (109–117 g/kg of total lipids) between the meat lipids of thrush and turtle dove.

Table 1. Chemical and lipid composition (means ± SD) of thrush and turtle dove meat.

Tabla 1. Composición química y lipídica (medias ± DE) de carne de zorzal y tórtola.

	Thrush	Turtle dove	*p*
Dry matter (g/kg meat)	271.16 ± 5.68	274.62 ± 9.44	NS
Protein (g/kg meat)	216.52 ± 7.03	216.26 ± 8.54	NS
Ash (g/kg meat)	13.41 ± 0.88	13.50 ± 0.16	NS
Lipids (g/kg meat)	40.23 ± 9.94	43.86 ± 3.94	NS
Glycerides (g/kg lipids)	709.06 ± 82.67	756.50 ± 23.93	NS
Phospholipids (g/kg lipids)	173.98 ± 64.69	134.62 ± 19.68	NS
Free fatty acids (g/kg lipids)	116.98 ± 22.80	108.88 ± 10.63	NS

Notes: NS, not significant.
$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

Notas: NS, no significativo.
$^{*}p < 0{,}05$; $^{**}p < 0{,}01$; $^{***}p < 0{,}001$.

Table 2. Fatty acid profiles (% of total fatty acids) (means ± SD) of glyceride fraction of thrush and turtle dove meat.

Tabla 2. Perfil de ácidos grasos (% del total de ácidos grasos) (medias ± DE) de la fracción de glicéridos de carne de zorzal y tórtola.

	Thrush	Turtle dove	*p*
C-14:0	0.36 ± 0.10	0.40 ± 0.10	NS
C-15:0	0.30 ± 0.08	0.28 ± 0.14	NS
C-16:0	17.40 ± 3.07	10.19 ± 1.54	**
C-16:1 n-9	0.13 ± 0.05	0.12 ± 0.03	NS
C-16:1 n-7	0.19 ± 0.04	0.98 ± 0.50	**
C-17:0	0.15 ± 0.02	0.18 ± 0.04	NS
C-18:0	16.53 ± 1.93	17.96 ± 4.00	NS
C-18:1 n-9	30.48 ± 4.84	11.75 ± 3.24	***
C-18:1 n-7	1.84 ± 0.28	1.38 ± 0.27	*
C-18:2 n-6	12.69 ± 2.68	43.69 ± 1.45	***
C-18:3 n-3	0.32 ± 0.10	0.33 ± 0.18	NS
C-20:1 n-11	0.18 ± 0.04	0.17 ± 0.43	NS
C-20:3 n-6	0.09 ± 0.03	0.37 ± 0.10	**
C-20:4 n-6	5.31 ± 1.18	9.03 ± 2.36	*
C-20:5 n-3	0.23 ± 0.11	0.12 ± 0.37	NS
C-22:4 n-6	0.20 ± 0.06	0.63 ± 0.30	*
C-22:5 n-6	0.46 ± 0.13	0.29 ± 0.13	NS
C-22:5 n-3	0.69 ± 0.24	1.03 ± 0.28	NS
C-22:6 n-3	13.11 ± 1.97	1.12 ± 0.28	***
SFA	34.74 ± 4.56	29.01 ± 3.00	NS
MUFA	32.83 ± 4.98	14.41 ± 3.98	**
PUFA	33.11 ± 5.50	56.59 ± 1.09	***
n-6	18.76 ± 3.89	54.00 ± 1.56	***
n-3	14.35 ± 2.26	2.59 ± 0.60	***
(n-6)/(n-3)	1.31 ± 0.23	21.91 ± 6.25	***
PUFA/SFA	0.95 ± 0.06	1.96 ± 0.16	***

Notes: NS, not significant; SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids.
$^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

Notas: NS, no significativo; SFA, ácidos grasos saturados; MUFA, ácidos grasos monoinsaturados; PUFA, ácidos grasos poliinsaturdos.
$^{*}p < 0{,}05$; $^{**}p < 0{,}01$; $^{***}p < 0{,}001$.

Table 2 shows the fatty acid profiles (expressed as % of total fatty acids) of glyceride fraction of thrush and turtle dove breast meat. In thrush meat, the main fatty acid was oleic (30.5%), followed by palmitic (17.4%), stearic (16.5%), docosahexaenoic (13.1%), and linoleic (13.7%) acids. The total content of saturated, monounsaturated and PUFA were similar (around 33% in each group). Significant differences were observed in the fatty acid composition of thrush and turtle dove meat glycerides. Turtle dove glycerides showed higher contents of C-16:1n-7, C-18:2n-6, C-20:3n-6, C-20:4n-6 and C-22:4n-6 and lower of C-16:0, C-18:1 and C-22:6n-3 than thrush glycerides. In turtle dove meat, linoleic (43.7%), stearic (18.0%), oleic (11.7%), palmitic (10.2%), and arachidonic (9.0%) were the main fatty acids; the PUFA were the most abundant (57%) followed by saturated fatty acids (SFA) (29%) and monounsaturated fatty acids (MUFA) (14%). Significant differences were also observed in the ratios n-6/n-3 and PUFA/SFA. Thrush glycerides showed significantly lower values of both ratios than those in turtle dove meat: in thrush meat, the values were 1.31 (n-6/n-3) and 0.95 (PUFA/SFA) while for turtle dove meat the values were 21.91 and 1.96, respectively.

Table 3 shows the fatty acid profiles (expressed as % of total fatty acids) of phospholipid fraction from thrush and turtle dove breast meat. In thrush meat, SFA were the main group (41.9%). Oleic (27.0%), palmitic (25.3%), stearic (16.5%), docosahexaenoic (11.3%), and linoleic (10.5%) acids were the main fatty acids of the phospholipids. Significant differences were also observed between the fatty acid composition of phospholipids from thrush and turtle dove meat. Phospholipids from turtle dove meat showed higher contents of C-18:0, C-18:2n-6, C-20:3n-6, C-20:4n-6, C-22:4n-6 and C-22:5n-3 and lower of C-16:1, C-18:1n-9, C-18:3n-3, C-20:1n-11 and C-22:6n-3 than phospholipids from thrush meat. In turtle dove meat, PUFA were the main group (47.5%) followed by SFA (46.8%). Stearic (33.7%), linoleic (25.6%), arachidonic (15.6%), and palmitic (12.9%) were the main fatty acids. The ratio n-6/n-3 in thrush was 1.40, while in turtle dove, it was 12.5. Significant differences were also observed in the ratios n-6/n-3 and PUFA/SFA, since turtle dove meat was significantly higher than thrush meat.

Table 4 shows the fatty acid profiles (expressed as % of total fatty acids) of free fatty acid fraction from thrush and turtle dove breast meat. In thrush meat, MUFA were the most abundant (39.8%) followed by the PUFA (33.3%). Oleic (35.8%), palmitic (15.6%), linoleic (14.6%), and docosahexaenoic (11.0%) were the main fatty acids. Significant differences were also observed between the fatty acid composition in free fatty acids from thrush and turtle dove meat. Free fatty acids in turtle dove meat showed higher contents of

Table 3. Fatty acid profiles (% of total fatty acids) (means ± SD) of phospholipid fraction of thrush and turtle dove meat.

Tabla 3. Perfil de ácidos grasos (% del total de ácidos grasos) (medias ± DE) de la fracción de fosfolípidos de carne de zorzal y tórtola.

	Thrush	Turtle dove	*p*
C-16:0	25.28 ± 1.92	12.93 ± 0.90	***
C-16:1 n-9	0.14 ± 0.06	ND	
C-16:1 n-7	0.15 ± 0.45	ND	
C-17:0	0.17 ± 0.02	0.23 ± 0.06	NS
C-18:0	16.47 ± 1.38	33.71 ± 5.67	***
C-18:1 n-9	27.03 ± 2.00	4.48 ± 0.76	***
C-18:1 n-7	1.49 ± 0.13	1.30 ± 0.43	NS
C-18:2 n-6	10.53 ± 1.37	25.62 ± 7.37	**
C-18:3 n-3	0.23 ± 0.04	ND	
C-20:1 n-11	0.20 ± 0.06	ND	
C-20:3 n-6	ND	0.44 ± 0.11	
C-20:4 n-6	5.52 ± 0.69	15.56 ± 1.59	***
C-20:5 n-3	0.26 ± 0.06	0.26 ± 0.14	NS
C-22:4 n-6	0.19 ± 0.05	0.83 ± 0.12	***
C-22:5 n-6	0.43 ± 0.12	0.61 ± .015	NS
C-22:5 n-3	0.63 ± 0.20	1.72 ± 0.77	**
C-22:6 n-3	11.31 ± 2.49	2.41 ± 0.91	***
SFA	41.92 ± 1.92	46.78 ± 5.65	NS
MUFA	29.00 ± 2.01	5.77 ± 1.19	***
PUFA	29.09 ± 2.28	47.45 ± 6.26	***
n-6	16.66 ± 1.18	43.05 ± 7.03	***
n-3	12.43 ± 2.62	4.40 ± 1.68	***
(n-6)/(n-3)	1.40 ± 0.37	12.47 ± 8.90	*
PUFA/SFA	0.70 ± 0.08	1.04 ± 0.23	**

Notes: NS, not significant; ND, not detected; SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Notas: NS, no significativo; ND, no detectado; SFA, ácidos grasos saturados; MUFA, ácidos grasos monoinsaturados; PUFA, ácidos grasos poliinsaturdos.
*$p < 0{,}05$; **$p < 0{,}01$; ***$p < 0{,}001$.

Table 4. Fatty acid profiles (% of total fatty acids) (means ± SD) of free fatty acid fraction of thrush and turtle dove meat.

Tabla 4. Perfil de ácidos grasos (% del total de ácidos grasos) (medias ± DE) de la fracción de ácidos grasos libres de carne de zorzal y tórtola.

	Thrush	Turtle dove	*p*
C-14:0	0.56 ± 0.09	0.50 ± 0.29	NS
C-15:0	0.13 ± 0.08	ND	
C-16:0	15.62 ± 1.62	10.00 ± 0.50	**
C-16:1 n-9	0.97 ± 0.21	0.29 ± 0.06	**
C-16:1 n-7	0.47 ± 0.15	1.01 ± 0.35	*
C-17:0	0.17 ± 0.04	0.15 ± 0.06	NS
C-18:0	10.45 ± 2.72	10.62 ± 1.35	NS
C-18:1 n-9	35.80 ± 7.13	9.05 ± 1.05	***
C-18:1 n-7	1.68 ± 0.20	1.22 ± 0.32	*
C-18:2 n-6	14.63 ± 5.97	51.35 ± 1.76	***
C-18:3 n-3	0.52 ± 0.16	0.53 ± 0.20	NS
C-20:1 n-11	0.85 ± 0.14	ND	
C-20:3 n-6	0.17 ± 0.05	0.36 ± 0.07	**
C-20:4 n-6	5.19 ± 1.13	11.52 ± 1.10	***
C-20:5 n-3	0.68 ± 0.24	0.62 ± 0.25	NS
C-22:4 n-6	0.25 ± 0.06	0.11 ± 0.06	*
C-22:5 n-6	0.23 ± 0.12	ND	
C-22:5 n-3	0.82 ± 0.26	0.87 ± 0.24	NS
C-22:6 n-3	10.97 ± 2.97	1.82 ± 0.35	**
SFA	26.89 ± 3.96	21.27 ± 0.95	NS
MUFA	39.77 ± 7.16	11.57 ± 1.33	***
PUFA	33.34 ± 5.12	67.17 ± 0.72	***
n-6	20.36 ± 6.34	63.33 ± 1.53	***
n-3	12.99 ± 2.98	3.84 ± 0.86	**
(n-6)/(n-3)	1.71 ± 0.99	17.13 ± 4.19	***
PUFA/SFA	1.26 ± 0.22	3.16 ± 0.14	***

Notes: NS, not significant; ND, not detected; SFA, saturated fatty acids; MUFA, monounsaturated fatty acids; PUFA, polyunsaturated fatty acids.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Notas: NS, no significativo; ND, no detectado; SFA, ácidos grasos saturados; MUFA, ácidos grasos monoinsaturados; PUFA, ácidos grasos poliinsaturdos.
*$p < 0{,}05$; **$p < 0{,}01$; ***$p < 0{,}001$.

C-16:1n-7, C-18:2n-6, C-20:3n-6 and C-20:4n-6 and lower of C-15:0, C-16:0, C-16:1n-9, C-18:1, C-20:1n-11, C-22:4n-6, C-22:5n-6 and C-22:6n-3 than free fatty acids in thrush meat. In turtle dove meat, PUFA were the main group (67.2%) followed by SFA (21.3%). Linoleic (51.3%), arachidonic (11.5%), stearic (10.6%), and palmitic (10.0%) were the main fatty acids. As in glycerides and phospholipids, significant differences were also observed in the ratios n-6/n-3 and PUFA/SFA between free fatty acids from turtle dove and thrush meat.

Table 5 shows the color parameters in thrush and turtle dove meat. Significant differences were observed between the color parameters found in thrush and turtle dove meat. The meat from thrushes showed lower values of L^*, a^*, b^*, C^* and H^* than the meat from turtle doves.

Discussion

The lipid content of both thrush and turtle dove breast meat was higher than that observed in chicken breast meat (Castellini, Mugnai, & Dal Bosco, 2002; De Marchi, Cassandro, Lunardi, Baldan, & Siegel, 2005; Wattanachant, Benjakul, & Ledward, 2004). The explanation is that chicken breast muscle (pectoralis muscle) is glycolitic (Currie & Wolfe, 1977) while the pectoralis muscle in thrushes and turtle doves is a flight muscle, and thus has a high percentage of oxidative fibres (Sokoloff & Goslow Jr., 1999). The oxidative muscles have a higher lipid content than glycolitic muscles (Cassens & Cooper, 1971). This result differs from what has previously been observed in wild mammal meat where the content of meat lipids is lower than that of farmyard animal meat.

The lipid content of both thrush and turtle dove breast meat was also higher than that observed in wild ducks (Cobos et al., 2000) and farm pigeons (Dal Bosco, Castellini, & Cardinali, 2005). This is probably because the thrush and the turtle dove are migratory birds and these birds accumulate large amounts of lipids as the prime energy source for their long-distance flights (Bairlein, 2002).

Table 5. Color coordinates (means ± SD) in thrush and turtle dove meat.

Tabla 5. Coordenadas de color (medias ± DE) en carne de zorzal y tórtola.

	Thrush	Turtle dove	*p*
*L**	9.63 ± 11.49	19.38 ± 7.33	**
*a**	7.10 ± 2.63	18.93 ± 7.87	**
*b**	1.70 ± 0.56	8.65 ± 4.90	**
*C**	7.31 ± 2.68	20.85 ± 9.16	**
*H**	13.53 ± 1.52	23.17 ± 4.34	***
*a**/*b**	4.20 ± 0.53	2.41 ± 0.52	***

Notes: NS, not significant.
*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$.

Notas: NS, no significativo.
*$p < 0,05$; **$p < 0,01$; ***$p < 0,001$.

The ash contents from wild birds were similar to those observed in meat from wild ducks (Cobos et al., 2000) and farm pigeons (Dal Bosco et al., 2005) and higher than those observed in chickens (Castellini et al., 2002; Wattanachant et al., 2004).

Alasnier, Meyner, Viau, and Gandemer (2000a) reported lower percentages of free fatty acids in chicken breast meat than those found in thrush and turtle dove breast meat. The explanation might be related to the fact that thrush and turtle dove breast meat has oxidative muscles and chicken breast has glycolitic muscles. The high levels of free fatty acids are related to lipolysis of phospholipids and triacylglycerols and it has been reported after storage, lipolysis is higher in oxidative muscles than in glycolytic ones (Alasnier, David-Briand, & Gandemer, 2000b).

Diet has a considerable influence on the fatty acid composition in poultry meat because a great part of dietary fatty acids are unmodified during digestion and are incorporated into the fat deposits almost without modification. The thrush eats mainly olives (rich in oleic acid) whereas the turtle dove eats mainly cereal and sunflower seeds (rich in linoleic acid). This explains the higher oleic acid content in thrush meat and the higher linoleic acid content in turtle dove meat. The level of C-18:2n-6 in the diet also influences, to some extent, the concentration of other n-6 fatty acids. Diets rich in linoleic acid increase the levels of longer chain length n-6 fatty acids, mainly arachidonic acid (Lestingi, Laudadio, Marisco, Carola, & Vicente, 2004) because these fatty acids can be synthesized from dietary linoleic acid (Rosenthal, 1987). This effect may explain the higher levels of arachidonic acid in turtle dove meat. Schiavone, Romboli, Chiarini, and Marzoni (2004) suggested that the desaturation/elongation reactions and the mechanism implicated in the captation by peripherical tissue of long chain PUFA may be more efficient in wild animals.

The high content of docosahexaenoic acid (DHA, C-22:6n-3) (more than 10% in the three fractions) in thrush breast meat is remarkable. This content is higher than those reported in wild duck breast meat (Cobos et al., 2000), other wild animals (Hoffman & Wiklund, 2006; Polak et al., 2008), farm pigeons (Dal Bosco et al., 2005) and chickens (De Marchi et al., 2005; Wattanachant et al., 2004), as all of them show values between 0.25 and 2.50%. In fact, the content in thrush breast meat is even higher than in birds fed diets enriched with n-3 fatty acids (Ajuyah, Hardin, Cheung, & Sim, 1992; Cherian, Li, & Sim, 1995; Meyner et al., 1999; Schiavone et al., 2004). The high levels of DHA in thrush meat are probably due to the fact that thrush pectoral muscles are high-frequency contraction muscles. A high content of DHA has only been reported in animals with high-frequency contraction muscles: for example, a DHA content of 21% was reported in the total fatty acids portion of hummingbird breast muscle (Infante, Kirwan, & Brenna, 2001). The high-frequency contraction muscles are endowed with a high content of sarcoplasmic reticulum Ca^{2+}-ATPase and mitochondrial respiration enzymes with a high concentration of phospholipids with DHA; these phospholipids have specific physiological functions (Infante et al., 2001). As in our study, Infante et al. (2001) have also reported that triglycerides from these muscles also contain a high percent of DHA and these authors suggest that neutral lipids are used as a docosahexanoic reservoir for phospholipids synthesis, and also as a way to store energy.

As observed in meat from other wild animals, turtle dove and thrush meats have a high proportion of PUFA. The content of PUFA in turtle dove meat is even higher than that observed in lipids from wild ducks (Cobos et al., 2000) and other wild animals (Cobos et al., 1995; Hoffman & Wiklund, 2006; Polak et al., 2008). The high level of PUFA in game meat has been directly linked to those species having very low muscle fat content consisting predominantly of phospholipids with high proportions of PUFA. In poultry meat, the level of PUFA in phospholipids is normally higher than in glycerides (Alasnier, Meyner, Viau, & Gandemer, 2000a). However, both turtle dove and thrush meat have a high content of fat and a high proportion of PUFA in both phospholipids and glycerides. The content of PUFA in phospholipids in turtle dove meat is similar to that reported in other poultry breast phospholipids such as turkey (Meyner et al., 1999) and broiler (Alasnier et al., 2000a) while the level of PUFA in glycerides of turtle dove meat is twice of that observed in triacilglycerols of lipids from broiler meat (Alasnier et al., 2000a).

From a nutritional point of view, both turtle dove and thrush meat are a good source of PUFA. Nutritional value is determined primarily by the ratio between SFA and PUFA and the balance between fatty acids of the n-6 and n-3 series. In general, a ratio of PUFA to SFA (PUFA/SFA) above about 0.45 and a ratio of n-6:n-3 below about 4.0 are required in a well-balanced diet (Simopoulos, 2004; Williams, 2000). In

relation to PUFA/SFA, both meats have a good value; however, only thrush meat shows a good n-6:n-3 ratio.

In recent years, there has been much interest in the beneficial effects of the very long chain n-3 PUFAs, particularly due to eicosapentaenoic acid (EPA, 20:5 n-3) and DHA (22:6 n-3) (Givens & Gibbs, 2008; Horrocks & Yeo, 1999). Whilst some EPA and DHA can be synthesized *in vivo* from α-linolenic acid, recent data indicate this source to be very limited. It is suggested that EPA and DHA should be classified as dietary essentials since, in many parts of Europe, the daily intake of EPA + DHA is very low (Givens & Gibbs, 2008). In view of the nutritional importance of DHA, wild thrush shows very good nutritional potential.

In relation to the color coordinates, the most distinctive is that the values of L^* for thrush and turtle dove breast meat (10-19) were lower than those observed in farm pigeon breast meat (Dal Bosco et al., 2005) and in breast meat from chickens (Castellini et al., 2002; De Marchi et al., 2005; Wattanachant et al., 2004) with values around 40–60. These results are probably due to the effect of the species but also to the higher content of haemoglobin in game meat caused by incomplete exsanguination. Moreover, it might also be due to differences in myoglobin content between farm animals and wild ones, in which a significant inverse correlation between lightness and myoglobin content has been observed (Onyango, Izumimoto, & Kutima, 1998). Higher myoglobin concentration is necessary in those muscles subjected to fast movements (Totosaus, Pérez-Chabela, & Guerrero, 2007), and the flight muscles of thrush and turtle dove fit these characteristics.

The value of a^* in turtle dove was very similar to those reported by Dal Bosco et al. (2005) in farm pigeon breast meat and higher than those observed in breast meat from chickens (Castellini et al., 2002; De Marchi et al., 2005; Wattanachant et al., 2004). These differences are due to the different type of muscles; oxidative muscles are redder than glicolytic ones (Valin, Touraille, Vigneron, & Ashmore, 1982).

The differences observed between meat from thrush and turtle dove in the color coordinates are probably due to simple variance in species but also to their different diets. In this sense, carotenes are responsible for the color of meat (Pérez-Álvarez & Fernández-López, 2006) and influence the yellowness parameter (b^* values); these compounds are probably more abundant in the turtle dove diet and thus, accumulate in a higher quantity in its meat more than in thrush meat.

Conclusion

We conclude that wild thrush and turtle dove are a good source of PUFA. More particularly, wild thrush meat shows a high content of DHA (C-22:6n-3) and turtle dove meat shows a high content of linoleic (C-18:2n-6) and arachidonic (C-20:4n-6) acids.

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