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Effect of age and gender on carcass traits and meat quality of farmed brown hares

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A total of 48 sub-adult hares and adult reproducing farmed hares were used to characterize carcass and meat traits according to the age and gender of animals. With respect to carcass traits, when age increased, the carcass weight significantly increased (2022 to 3391 g; $P < 0.001$*), but dressing out percentages did not change. The dissectible fat (1.3% to 2.2%;* $P < 0.05$*) and* Longissimus lumborum *(LL) proportions (13.5% to 14.5%;* $P < 0.001$*) and muscle-to-bone ratio of hind legs (5.11 to 6.23;* $P < 0.001$*) increased, whereas the hind leg proportions decreased (37.3% to 36.3%;* $P = 0.01$*). As for the meat quality, the pH of hind leg (5.74 to 5.83;* $P < 0.001$*) and LL (5.53 to 5.69;* $P < 0.001$*) increased with age, while the* L^* *index decreased in both cuts (42.9 to 34.4 in hind leg; 45.1 to 40.3 in LL;* $P < 0.001$*). The redness index increased at the hind leg (4.07 to 5.76;* $P < 0.001$*), while it decreased at LL (3.03 to 1.46;* $P < 0.001$*). In the case of the hind leg, meat thawing losses decreased (1.58% to 1.02%), and shear force increased (2.97 to 4.02 kg/g). In the case of LL, thawing losses decreased (8.79% to 4.91%;* $P < 0.001$*) in the adult hares compared with the sub-adult ones. Meat water and protein contents decreased in the hind leg and LL of the adult hares compared with the sub-adult ones, whereas ether extract increased in a restricted range in LL only (0.92% to 1.11%;* $P < 0.001$*). In the case of the hind leg, the rate of the saturated fatty acids (SFA) decreased (41.0% to 26.7%), and the rate of the polyunsaturated fatty acids (PUFA) increased (34.0% to 45.3%) (*$P < 0.001$*). In the case of LL, SFA (38.6% to 42.9%) and monounsaturated fatty acids (19.4% to 27.2%) increased, whereas PUFA decreased (42.0% to 30.1%) when the age increased (*$P < 0.001$*). Gender affected only the slaughter results and carcass traits. In conclusion, farmed hares have favourable slaughter results (high dressing percentage), carcass traits (high hind legs and loins rates), and meat nutritional value (high-protein, low-fat meat). This fact would offer additional commercial opportunities, in addition to restocking, to hare farmers.*

Keywords: hares, slaughter results, meat rheological traits, chemical composition, fatty acid composition

Implications

Game meat has gained consumers' attention in recent years for several reasons: its particular taste and flavour, the absence of drug residue, and the attraction some people have for new foods. Game meat usually comes from hunting, but according to our results, hares farmed for restocking purposes may be used for meat production due to their favourable slaughter results (high dressing percentage) and carcass traits (high proportion in hind legs and loins), as well as the high nutritional value of meat and favourable fatty acid composition. This fact would offer additional commercial opportunities, in addition to restocking, to hare farmers.

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Introduction

Game meat has gained consumers' attention in recent years for several reasons: its particular taste and flavour, the absence of drug residue, and the attraction some people have for new foods (Fajardo *et al.*, 2010; Santos *et al.*, 2012). Game meat usually comes from hunting, but animals reared for restocking purposes could also be used, thus offering additional commercial opportunities to farmers as well as meeting the demand of consumers who are against hunting. The brown hare (*Lepus europaeus* Pallas) is one of the most popular small game species (Fettinger *et al.*, 2010) and is reared all over Europe for the restocking of hunting and protected areas (Strauß *et al.*, 2008; Sánchez-García *et al.*, 2012; Rigo *et al.*, 2015). Some authors have investigated the potential of adding hare meat from hunting into the human

diet for its favourable sensory characteristics, high protein and low fat content (Škrivanko *et al*., 2008; Mertin *et al*., 2012). These traits, however, cannot be easily guaranteed in game meat procured from hunting because there is very little control of *ante-mortem* and *postmortem* factors. To the best of our knowledge, there is little available information, studying low numbers of animals, that has been collected on the effect of the age and gender of farmed hares on their slaughter traits, carcass traits and meat quality (Vicenti *et al*., 2003; Vizzarri *et al*., 2014). Under farming conditions, these factors could be controlled to guarantee product quality and farmers' income. Accordingly, the purpose of this study was to characterize carcass quality and meat traits in adult and sub-adult farmed hares of both genders.

Material and methods

Animals and housing

The hares were reared in a big commercial farm located in the province of Venice (Municipality of Santa Maria di Sala) at 13 m a.s.l. The farm housed a total of 720 outside roofed cages ($1.0 \times 1.60 \times 0.75$ m high), with wooden sides and back walls and a wire-net front side and floor, over an area of 4500 m^2. A total of 320 cages were for reproducing animals with their litters; the remaining cages were for growing hares (from weaning until 60 days) and sub-adult hares (from 61 days until release). The cages were equipped with feeders for the manual distribution of feed and automatic nipple drinkers. The reproducing hares were kept in pairs from the pair formation until their release for restocking purposes; the growing and sub-adult hares were housed collectively (three hares/cage) from weaning at 25 days of age until their release.

During 2014, 36 reproducing pairs at their first year of reproductive activity were identified by ear marks and monitored from the group formation until the end of their first reproductive period to measure reproductive performance. At the end of their reproductive cycle (October 2014), 24 adult reproducing hares (510 ± 9.4 days of age) (12 males and 12 females) were randomly selected to be slaughtered in a commercial slaughterhouse. The cage feed intake of the pairs was measured from the kindling of the first litter until the weaning of the third litter. Moreover, 72 leverets of both genders, born towards the end of July, were weaned, weighed, identified by ear marks and housed in groups of three animals in 24 collective cages. At the age of 73 days (±1.5 days), 24 sub-adult hares (12 males and 12 females) were weighed and submitted to commercial slaughter. The cage feed intake was measured from weaning until slaughter.

All animals were fed a commercial pelleted diet (dry matter: 89.9%; CP: 16.6% DM; ether extract: 3.3% DM; crude fibre: 21.9% DM; starch: 10.9% DM) *ad libitum*. The diet contained robenidine hydrochloride as coccidiostat.

Commercial slaughter and carcass and meat quality recordings

The hares (24 adult and 24 sub-adult hares) were slaughtered in a commercial rabbit slaughterhouse. The animals had free access to feed and water until they were individually weighed at the experimental farm, put into individual boxes, and transported for ~1 h to be processed at the slaughterhouse. At their arrival, the animals were weighed and stunned by electro-anaesthesia, which was followed by jugulation according to the current practice of the slaughterhouse. The skin, fore and hind distal legs, intestinal organs and bladder were removed to obtain the commercial carcass, which included the head, the thoracic organs, the liver and the kidneys. After 2.0 h cooling at 3°C to 4°C, the commercial carcasses were weighed to measure the individual dressing out percentage (commercial carcass/live weight at slaughterhouse $\times 100$). The carcasses were transported to the laboratory and stored at 3°C to 4°C until dissection, 24 h after slaughter.

The reference carcasses were obtained by removing the head, the thoracic organs, the kidneys and the liver according to harmonised procedures for meat rabbits (Blasco and Ouhayoun, 1996). The pH of the *Longissimus lumborum* (LL) and *Biceps femoris* (BF) muscles were measured in duplicate by a pH meter (Basic 20, Crison Instruments Sa, Carpi, Italy) equipped with a specific electrode (cat. 5232, Crison Instruments Sa). The $L^*a^*b^*$ colour indexes (Commission International de l'Eclairage (CIE), 1976) were measured in duplicate in the same muscles using a Minolta CM-508 C spectrophotometer (Minolta Corp., Ramsey, NJ, USA). The dissectible fat (perirenal, periscapular and external depots) was removed and weighed as an indicator of carcass fatness (Blasco and Ouhayoun, 1996). The hind legs and LL muscles were separated to measure their relative proportion on the carcass weight. The meat of the right hind leg was separated from the bones to measure the meat-to-bone ratio, as an indicator of carcass muscularity (Blasco and Ouhayoun, 1996).

The left hind legs and LL muscles were vacuum-stored in plastic bags at -18°C for a few days until analyses. Thawing and cooking losses were measured in both cuts. After thawing, the hind legs and LL were put into plastic bags and cooked for 2.5 and 1 h, respectively, in a water bath until an internal temperature of 80°C was reached. After 1 h cooling, three parallelepiped meat portions ($4 \times 2 \times 1$ cm) were separated from the lateral and hind parts of the hind leg, whereas the LL was cut into three parts (length: 4 cm; thickness: 1.0 to 2.5 cm). In these cooked cuts, the shear force was measured by TA-HDi dynamometer (Stable Micro System Ltd, Godalming, Surrey, UK) using the Allo-Kramer probe (10 blades) (load cell: 100 kg; distance between the blades: 5 mm; thickness: 2 mm; cutting speed: 500 mm/min).

Proximate analysis and fatty acid profile of meat

The meat of the hind leg and LL was minced by a Grindomix GM 200 (Retsch GmbH, Haan, Germany). Individual samples of the minced meat were freeze-dried, re-ground and analysed to determine the content of dry matter (934.01), ash

(967.05), CP (2001.11) and ether extract (991.36) (AOAC, 2000). Individual samples of fresh minced hind leg and LL meat were analysed for fatty acid composition. The fat was extracted by accelerated solvent extraction (Application Note 334; ASE®, Dionex, Sunnyvale, CA, USA) using two extraction cycles, with petroleum ether as a solvent, at a temperature of 125°C, a pressure of 10.3 Mpa, a 6-min heating phase, and a 2-min extraction phase. The extracted lipids were initially trans-methylated as fatty acid methyl esters (FAMEs), using a solution of 1 M sodium methoxide in methanol (1 vol), and a solution of oxalic acid in diethyl ether (Christie, 1982). An internal standard (13 : 1 methyl ester) was added to the extracts before methylation. After centrifugation, the surnatant was submitted to two-dimensional gas chromatography (GC × GC) by using an Agilent 7890 A Gas Chromatograph (Agilent Technologies, Santa Clara, CA, USA), with the split to 40 ml/min and rate set at 160 : 1. Supelco SP 2560 (Sigma-Aldrich, St. Louis, MO, USA) was used as the first capillary column (75 m × 0.18 mm internal diameter, 0.14 μm film thickness), with hydrogen as carrier at 0.25 ml/min. J&W HP 5 ms (Agilent Technologies) was used as the second capillary column (3.8 m × 0.5 mm internal diameter, 0.25 μm film thickness), with hydrogen as the carrier at 22 ml/min for 2 min and then 0.18 ml/min to 35 ml/min. The oven temperature was 45°C, held for 2 min, raised to 170°C at the rate of 50°C/min, held for 25 min, raised at 240°C at the rate of 2°C/min and held for 16 min, while the injector and the detector temperatures were set at 270°C and 250°C, respectively. The fatty acids were identified by comparing the retention time of 52 standard FAMEs mixture (GLC reference standard: 674; Nu-Chek Prep Inc., MN, USA). Individual FAMEs were expressed as the percentage of the total area of eluted FAMEs.

Statistical analyses

The individual data of sub-adult performance were analysed by ANOVA with gender as the main effect. The individual data of carcass traits and meat quality of adult and sub-adult hares were analysed by ANOVA with age, gender and their interaction as factors of variability. The PROC GLM of the Statistical Analysis System (SAS, 2013) was used for all analyses. Differences between the means, with $P \leqslant 0.05$, were accepted as statistically significant differences. The probability of the interaction age × gender never reached the statistical significance and is this not provided in the tables.

Results and discussion

Performance results

The reproducing pairs monitored during their first year of production gave birth 4.50 ± 2.31 times, produced 10.9 ± 6.5 live leverets and weaned 7.00 ± 5.46 leverets (average data of 36 pairs; data not reported in tables). These data are consistent with previous results recorded in the same farm during 2010 to 2011 on all fertile pairs (4.8 kindling, 11.4 live leverets, 8.4 weaned leverets per fertile pair per year) (Rigo *et al*., 2015). In the present trial, the feed intake of the reproducing hares (including the intake of the litters when present) from the first kindling until the third weaning was 578 ± 82 g/day per pair (average data of 36 pairs; data not reported in tables). The live weight of leverets was not affected by gender ($P > 0.05$), and averaged 855 ± 121 g at weaning and 2054 ± 237 g at slaughter (average data of 24 hares; data not reported in tables). The feed intake averaged 128 ± 22 g/day per hare from weaning to slaughter (average data of 24 collective cages; data not reported in tables).

Slaughter results, carcass and meat quality

Effect of age. As expected, the live weight at slaughter and commercial carcass weight were significantly ($P < 0.001$) lower in sub-adult hares compared with adult hares. No differences in dressing out percentages were measured because the full gut proportion was higher (+2.4 percentage points), and the skin and distal leg proportion lower (−1.6 percentage points) in the sub-adult hares compared with the adult hares ($P < 0.001$) (Table 1). At dissection of the chilled carcass, the proportion of head, liver and thoracic organs decreased from the sub-adult to the adult hares (Table 1). At dissection of the reference carcass, the proportion of dissectible fat ($P < 0.05$) and LL ($P < 0.001$), and the meat-to-bone ratio of hind legs ($P < 0.001$), increased with age, whereas the hind leg proportions decreased ($P < 0.01$) (Table 1).

To our knowledge, there is no available data on the effect of age on carcass traits in hares. There are some data showing that when slaughter age increased, meat rabbits showed improved dressing out percentage, increased proportion of LL and decreased proportion of hind legs (Parigi-Bini *et al*., 1992; Gondret *et al*., 1998a; Hernández *et al*., 2004), as found in the present trial. In black-tailed jack rabbits (*Lepus californicus*), the post-natal development of the locomotor system at the hind leg is achieved early and the hares are effective at escape when they reach only 20% of adult body size (Carrier, 1983). This fact may explain the higher hind leg proportion and the lower LL proportion that we observed in sub-adult hares compared with adult hares.

The average dressing percentage we measured in farmed hares was consistent with previous data recorded both in hunted (66.5%; Škrivanko *et al*., 2008) and farmed hares (62.8% to 68.3% in Vicenti *et al*., 2003; 63.7% to 66.9% in Vizzarri *et al*., 2014). In farmed hares slaughtered at 118 days and an average live weight of 2088 g, Vicenti *et al*. (2003) found that hind legs accounted for 38.5% of reconstituted carcass, consistent with our results and loins for 18.65%. The lower value for loins observed in our trial depended on the different dissection method used by Vicenti *et al*. (2003) that included bones. The average dressing out percentage was considerably higher in hares (67.2%) than in rabbits (55% to 61%), and similarly, the proportions of LL and hind legs were more favourable in the former than in the latter (Dalle Zotte, 2002; Xiccato *et al*., 2013).

Concerning hare meat quality, all of the traits changed significantly according to age: meat pH raised both at BF

Table 1 *Effect of age and gender on slaughter traits and carcass quality in 24 h chilled carcasses of brown hares*

	Age (A)		Gender (G)		*P*-value		
	Sub-adults	Adults	Females	Males	A	G	RSD
Hares (*n*)	24	24	24	24			
Slaughter age (days)	73	510	293	290	–	–	–
Slaughter weight (SW) (g)	2022	3391	2783	2629	***	*	229
Transport losses (% SW)	1.58	0.62	1.17	1.03	***		0.3
Full gut (% SW)	14.5	12.1	13.7	12.9	***	*	1.3
Skin and distal legs (% SW)	12.9	14.5	13.3	14.0	***	**	0.8
Dressing out at 24 h (% SW)	66.8	67.5	66.7	67.6		0.06	1.7
Chilled carcass (CC) (g)	1350	2288	1857	1781	***		167
Head (% CC)	8.13	6.62	7.45	7.30	***		0.62
Liver (% CC)	3.35	2.88	3.14	3.09	***		0.34
Thoracic organs (% CC)	4.07	3.18	3.59	3.65	***		0.43
Reference carcass (RC) (g)	1130	1980	1585	1525	***		153
Dissectible fat (% RC)	1.34	2.17	1.34	2.17	*	*	1.39
Longissimus lumborum (% RC)	13.5	14.5	14.3	13.8	***	*	0.9
Hind legs (% RC)	37.3	36.3	37.2	36.4	**	0.06	1.4
Hind leg meat/bone ratio	5.11	6.23	5.52	5.81	***		0.64

*$P \leqslant 0.05$, **$P \leqslant 0.01$, ***$P \leqslant 0.001$.

($P < 0.001$) and LL ($P < 0.001$), and L^* index decreased (−8.5 units at hind leg and −4.8 units at LL; $P < 0.001$). Conversely, Mertin *et al*. (2012) did not report significant differences in meat lightness and final pH in young or old shot hares. In our trial, from sub-adult to adult hares, the yellow index decreased in the two cuts (−1.11 units and −3.17 units, respectively; $P < 0.05$ and <0.001); the redness index increased at the hind leg (4.07 to 5.76; $P < 0.001$), while it decreased at LL (3.03 to 1.46; $P < 0.001$) (Table 2). The high redness value of hare meat likely depends upon hare muscle fibre characteristics, since their fast fibres have a biochemical and histochemical enzyme pattern typical of slow red muscles (Bass *et al*., 1973). Nevertheless, the differences in redness with age may be explained by the differentiation of muscle fibres during growth, similar to rabbits. Slow fibres (largely present at the hind leg) are already oxidative at birth and increase their oxidative metabolism during growth, thus increasing the redness of the meat index (Gondret *et al*., 1998b). Otherwise, fast fibres (prevalent in LL) move from oxidative to glycolytic metabolism from birth until adult age, thereby reducing the redness index (Gondret *et al*., 1998b).

In our study, the meat thawing losses (for hind leg and LL) and cooking losses (for LL) decreased from sub-adult to adult hares, whereas the shear force increased for hind leg meat ($P < 0.001$) (Table 2), consistent with the changes in meat pH (Hulot and Ouhayoun, 1999). When age raises, the shear force may increase because of the change in protein quality and the increase and change in connective tissue. In a small set of hunted hares (eight young animals and four old animals), however, Slamecká *et al*. (1997) did not measure significant differences in collagen content according to hare age and found a decrease of meat shear force in older animals.

Concerning the effect of age on the meat chemical composition, water and protein contents of both hind leg and LL decreased ($P < 0.001$) in the adult compared with the sub-adult hares (Table 3). Ether extract content was not affected at the hind leg, whereas it increased at LL even though it was in a very narrow range (Table 3). Other authors (Slamecká *et al*., 1997; Mertin *et al*., 2012) did not find significant differences in the chemical composition of hunted hares according to their age. Differently, the fat content of LL in rabbits slaughtered at 11 and 18 weeks of age (Gondret *et al*., 1998b) and the protein and fat contents of hind legs in rabbits slaughtered at 9 and 13 weeks of age (Hernández *et al*., 2004) increased with age.

On average, in our trial, hare meat exhibited 74.3% water, high crude protein content (22% and 23% in hind leg and LL, respectively), and low ether extract content (2.1% and 1.0% in hind leg and LL, respectively), with ash content averaging 1.35% in the hind leg and 1.44% in LL (Table 3). These values are consistent with previous reports by Škrivanko *et al*. (2008) in hunted hares (water: 75.3%; protein: 23.2%; ether extract: 1.12%; ash: 1.16%).

In our trial, the fatty acid composition was also significantly affected by hare age with a different pattern in the two cuts: in the case of the hind leg, the rate of saturated fatty acids (SFA) decreased ($P < 0.001$), whereas the rates of monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA) increased ($P < 0.001$) from sub-adult to adult hares (Table 4); in the case of LL, the rates of SFA ($P < 0.001$) and MUFA ($P < 0.001$) increased, whereas the rate of PUFA decreased ($P < 0.001$) (Table 5). The differences in muscle fibres between the two cuts and the differentiation of muscle fibres with age likely accounted for these results. In fact, lipids within slow and oxidative fibres (hind leg muscles) are generally less saturated than those within fast and

Table 2 *Effect of age and gender on rheological traits of hind leg meat and* Longissimus lumborum *of brown hares*

	Age (A)		Gender (G)		*P*-value		
	Sub-adults	Adults	Females	Males	A	G	RSD
Hares (*n*)	24	24	24	24			
Hind leg							
pH	5.74	5.83	5.79	5.78	***		0.09
*L**	42.9	34.4	38.7	38.6	***		2.7
*a**	4.07	5.76	4.92	4.91	***		0.95
*b**	4.09	2.98	3.42	3.65	*		1.95
Thawing losses (%)	1.58	1.02	1.25	1.35	***		0.41
Cooking losses (%)	21.5	21.4	21.6	21.3			1.1
Shear force (kg/g)	2.97	4.02	3.45	3.54	***		0.43
Longissimus lumborum							
pH	5.53	5.69	5.60	5.61	***		0.07
*L**	45.1	40.3	42.5	42.8	***		3.9
*a**	3.03	1.46	2.38	2.11	***		1.26
*b**	1.83	−1.34	0.51	−0.02	***		3.15
Thawing losses (%)	8.79	4.91	6.94	6.76	***		2.62
Cooking losses (%)	28.0	27.3	27.8	27.6	*		1.0
Shear force (kg/g)	3.67	3.49	3.60	3.56			0.43

*$P \leqslant 0.05$, **$P \leqslant 0.01$, ***$P \leqslant 0.001$.

Table 3 *Effect of age and gender on chemical composition of hind leg meat and* Longissimus lumborum *of brown hares*

	Age (A)		Gender (G)		*P*-value		
	Sub-adults	Adults	Females	Males	A	G	RSD
Hares (*n*)	24	24	24	24			
Hind leg							
Water (%)	75.5	73.3	74.7	74.2	***	<0.10	0.5
CP (%)	20.9	23.1	22.0	22.0	***		0.5
Ether extract (%)	2.20	1.97	1.91	2.25		**	0.40
Ash (%)	1.28	1.42	1.34	1.35	***		0.15
Longissimus lumborum							
Water (%)	75.1	73.3	74.2	74.1	***		0.5
CP (%)	22.2	23.6	22.9	22.9	***		0.5
Ether extract (%)	0.92	1.11	1.08	1.04	***		0.25
Ash (%)	1.43	1.44	1.44	1.49			0.20

*$P \leqslant 0.05$, **$P \leqslant 0.01$, ***$P \leqslant 0.001$.

glycolytic fibres (LL) (Alasnier *et al.*, 1996; Realini *et al.*, 2013). As observed by Gondret *et al.* (1998b), in rabbits, from sub-adult to adult hares, the differentiation of slow fibre muscles towards oxidative metabolism and of fast fibre muscles towards glycolytic metabolism determined the corresponding changes in FAs composition at the hind leg and LL. However, in rabbits from 35 to 90 days of age, other authors have observed that the FAs composition of total intramuscular lipid and phospholipids changed coherently in loins and hind legs muscles (Xue *et al.*, 2015). Further studies on the characterization, biochemical and histochemical enzyme patterns of muscle fibres in hares would be necessary to clarify our results and differences with rabbits.

A few studies on the fatty acid profile of hare meat are available that have evaluated the effect of diets, the rearing system and gender in farmed hares (Vicenti *et al.*, 2003; Vizzarri *et al.*, 2014). Literature data are consistent with those recorded in the present trial and show the prevalence of unsaturated fatty acids (ranging from an average value of 57.3% to 65.7% total FAs in Vizzarri *et al.*, 2014 and Vicenti *et al.*, 2003, respectively) over SFA (ranging from 42.7% to 32.3% total FAs), with also a large variability in the rate between PUFA and MUFA. This variability likely depends upon the cuts analysed in the two studies (homogenized meat from hind legs, loin and lean part in Vicenti *et al.*, 2003; only LL in Vizzarri *et al.*, 2014) as well as upon the FAs composition of diets fed to hares in the different studies. As in our trial, Vicenti *et al.* (2003) found that C16:0 (on average 19.8% total FAs) and C18:0 (11.0% total FAs) among SFA, C18:1n-9 (12.3% total FAs) among MUFA, and 18:2n-6

Table 4 *Effect of age and gender on fatty acid (FA) profile (% total FAs) of hind leg meat of brown hares*

	Age (A)		Gender (G)		*P*-value		
	Sub-adults	Adults	Females	Males	A	G	RSD
Hares (*n*)	24	24	24	24			
C12:0	0.89	0.16	0.56	0.50	***		0.20
C14:0	3.25	1.91	2.64	3.19	***		0.34
C16:0	26.8	16.9	22.2	21.4	***		1.7
C18:0	7.24	5.75	6.49	6.49	***		0.59
C16:1n-7	1.67	4.16	2.64	3.18	***	*	0.78
C18:1n-9	20.2	19.5	19.5	20.2	*	*	1.1
C18:2n-6	27.5	31.5	29.3	29.6	***		1.9
C20:4n-6	1.42	4.55	3.20	2.77	***	*	0.61
C22:4n-6	0.37	0.51	0.44	0.44	***		0.10
C18:3n-3	1.97	2.07	2.00	2.00			0.26
C22:5n-3	0.28	0.78	0.55	0.51	***		0.10
Total saturated FA	41.0	26.7	34.4	33.4	***	0.07	2.0
Total monounsaturated FA	25.0	27.9	25.7	27.2	***	**	1.6
Total polyunsaturated FA	34.0	45.3	39.9	39.4	***		2.5

*$P \leqslant 0.05$, ***$P \leqslant 0.001$.

Table 5 *Effect of age and gender on fatty acid (FA) profile (% total FAs) of* Longissimus lumborum *of brown hares*

	Age (A)		Gender (G)		*P*-value		
	Sub-adults	Adults	Females	Males	A	G	RSD
Hares (*n*)	24	24	24	24			
C12:0	0.58	0.17	0.36	0.39	***		0.21
C14:0	2.49	3.61	3.06	3.04	***		0.60
C16:0	25.2	28.9	27.5	26.6	***		2.4
C18:0	8.00	7.38	7.89	7.50			1.09
C16:1n-7	1.87	5.79	3.42	4.23	***		0.93
C18:1n-9	14.1	17.4	15.7	15.8	***		1.6
C18:2n-6	28.6	21.7	24.8	25.5	***		2.4
C20:4n-6	4.63	3.54	3.97	4.20	**		1.00
C22:4n-6	0.88	0.36	0.62	0.62	***		0.16
C18:3n-3	1.23	1.07	1.14	1.16	**		0.24
C22:5n-3	0.68	0.49	0.57	0.59	***		0.17
Total saturated FA	38.6	42.9	41.3	39.9	***		3.1
Total monounsaturated FA	19.4	27.2	22.8	23.8	***		2.1
Total polyunsaturated FA	42.0	30.1	35.9	36.3	***		3.8

**$P \leqslant 0.01$, ***$P \leqslant 0.001$.

(34.7% total FAs) and C20:4n-6 (8.4% total FAs) among PUFA, were the most represented FAs. These latter authors also found that the activity level of hares in different housing systems affected the SFA (lower in pens than in cages) and MUFA (higher in cages than in pens) rates. The FA profile of hare meat is also consistent with that measured in rabbits for the main FA classes (SFA, MUFA, PUFA, n-3 PUFA, n-6 PUFA) and single FA (Hernández and Dalle Zotte, 2010).

Effect of gender. Gender affected slaughter results and carcass traits (Table 1), whereas rheological meat quality traits were similar in the two genders (Table 2). In details, the females were heavier ($P < 0.05$), showed higher full gut ($P < 0.05$), lower skin and distal legs proportions ($P < 0.01$), and lower dressing out percentage ($P = 0.06$) than the males (Table 1). At the dissection of reference carcasses, the females exhibited lower dissectible fat ($P < 0.05$) and higher LL and hind legs proportion ($P = 0.06$) than the males (Table 1). Finally, meat rheological traits were not affected by gender (Table 2), whereas females showed lower meat ether extract content at the hind leg ($P < 0.01$) (Table 3). Similarly, differences in FA composition were limited to a lower monounsaturated FA content ($P < 0.01$) in meat hind leg of the females compared with the males (Tables 4 and 5).

A few literature data are available about the effect of gender in brown hares and have not reported any differences in slaughtering data or carcass dissection between females and males slaughtered at 118 days of age (Vicenti *et al.*, 2003).

In fact, in the wild, male and female hares (*Lepus europaeus*) are not distinguishable on the base of their weight or body traits (Trocchi and Riga, 2005). Otherwise, the hare BW is affected by individual, geographical and seasonal factors (with a reduction of fat depots during the reproductive season in both genders and an increase during autumn), in addition to their health status (Trocchi and Riga, 2005). On the other hand, despite the genetic variability of the different crossbreeds (Pla *et al*., 1998), in growing rabbits at commercial slaughter, the final live weight is usually lower and dressing out percentage less favourable in females than in males because of the higher full gut proportion in the former than in the latter ones (Parigi-Bini *et al*., 1992; Petracci *et al*., 1999; Trocino *et al*., 2003; Lazzaroni *et al*., 2009).

In hares, other authors did not find significant differences in meat rheological traits (Tărnăuceanu *et al*., 2015), protein and fat contents (Slamečka *et al*., 1997; Vicenti *et al*., 2003; Mertin *et al*., 2012) or FA profile (Vicenti *et al*., 2003) according to gender. In farmed rabbits, some minor differences in meat colour were reported between males and females (Carrilho *et al*., 2009; Lazzaroni *et al*., 2009, whereas water losses during storage or cooking showed similar results (Petracci *et al*., 1999).

Conclusion

Farmed hares may be used for meat production because of their favourable slaughter results (high dressing percentage) and carcass traits (high proportion in hind legs and loins), as well as the high nutritional value of meat and favourable FA composition. Among ontogenetic factors, the increase in age improves both the slaughter results and carcass quality, even if meat tenderness decreases in adult hares compared to sub-adult ones. Gender affected only slaughter results and carcass traits. A sensorial evaluation of hare meat quality would be necessary to complete the evaluation of hare meat from the consumer's perspective.

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