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FATTENING RABBITS IN MOBILE ARKS: EFFECT OF HOUSING SYSTEM ON *IN VIVO* OXIDATIVE STATUS AND MEAT QUALITY

MATTIOLI S.*, MARTINO M.*, RUGGERI S.*, ROSCINI V.*, MOSCATI L.†, DAL BOSCO A.*, CASTELLINI C.*

*Dipartimento di Scienze Agrarie, Alimentari e Ambientali, Università degli Studi di Perugia, Perugia, Italy.
†Istituto Zooprofilattico Sperimentale dell'Umbria e delle Marche, Perugia, Italy.

Abstract: The aim of this trial was to study the effect of an alternative housing system on the oxidative status and meat quality of fattening rabbits. From May to June 2014, 60 rabbits of 35 d of age were reared in Mobile Arks (MA) placed on alfalfa grass and frequently moved for 40 d. To assess the health status of animals, blood samples were collected at slaughter in MA and in conventional cages (C). Meat quality parameters were also evaluated. Concerning the *in vivo* oxidative status, ark-reared rabbits showed higher thiobarbituric reactive substances values than C ones, probably for the higher motor activity due to the larger living area. The lipid percentage of *Longissimus lumborum* muscle was lower (1.22 *vs.* 1.48%) in the ark group. There were no significant differences in the muscle pH, colour, water holding capacity and cooking loss. Given the higher intake of grass, rich in vitamins, carotenes, polyphenols and polyunsaturated fatty acids, the antioxidant content of meat was higher in ark-reared rabbits (7.42 *vs.* 6.82 µg/g of retinol, 719.2 *vs.* 683.3 ng/g of α-tocopherol, respectively). Even the fatty acid profile of MA rabbits reflected the higher intake of essential fatty acids from grass and the n-3 long chain polyunsaturated fatty acids (arachidonic acid, eicosapentaenoic acid and docosahexaenoic acid) were almost doubled. Our study suggested that the fattening of rabbits in ark system could be a possible alternative system to improve the meat quality of rabbits.

Key Words: rabbit, mobile arks, meat quality, oxidative status, housing, grass.

INTRODUCTION

Rabbit meat production is widely developed in Mediterranean countries of the European Union. Meat sensory proprieties are crucial in the consumers' choice. Consumers consider rabbit meat to have positive sensory proprieties, being tender and delicately flavoured (Dalle Zotte, 2002). Even the nutritional traits of rabbit meat are highly valued, as it is a meat with a low fat and low amounts of saturated fatty acid (SFA) and cholesterol (Dalle Zotte and Szendrő, 2011). In addition, the manipulation of rabbits' diet is very effective; some bioactive compounds such as vitamins, polyphenols and polyunsaturated fatty acids (PUFA), can easily be incorporated into the meat (Dalle Zotte and Szendrő, 2011).

The quality is affected by several factors including the conditions under which the meat is produced, the management, breed, genotype, feeding, pre-slaughter handling and stunning, slaughter method, chilling and storage conditions (Andersen *et al.,* 2005). Current changes in the market require high standards of quality assurance and also involve respecting environmental ethics and animal welfare (Combes *et al.,* 2010). Searching for housing conditions able to improve the animal welfare aspects, several authors have compared the behaviour and performance of rabbits reared in small cage or large pens (Jordan *et al.,* 2006; Szendrő and Luzi, 2006; Verga *et al.,* 2006). At the same time, an alternative rearing system allows us to differentiate rabbit meat production and satisfy consumer demands for a more 'natural' product (Dalle Zotte *et al.,* 2009). Different outdoor or indoor housing systems were studied to compare the effect on the productive performance, welfare and meat quality of rabbit (D'Agata *et al.,* 2009). Dal Bosco *et al.* (2002)

Correspondence: S. Mattioli, simona.mattioli@hotmail.it. Received *September 2015* - Accepted *June 2016.*
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compared rabbits slaughtered at the same age and found that pen-reared rabbits showed a lower growth rate, lower pH and redness value and lower maturity than those reared in cages. Paci *et al.* (2013) suggested that the proper combination of animal density (5 rabbit/m^2), group size (4 rabbit/cage) and total available surface (0.8 m^2) afforded the best production and carcass traits.

The aim of this study was to investigate the effect of an alternative outdoor housing system (mobile arks on grass) in comparison to the standard rearing system (in cage) on the rabbit *in vivo* oxidative status and meat quality.

MATERIAL AND METHODS

Animals and housing

The trial was carried out on a private farm (Brachino Patrizia - Bagnoregio, VT, Italy), from May to June 2014. The experimental design was planned according to the Italian directives (Gazzetta Ufficiale, 2014) on animal welfare for experimental and other scientific purposes.

Sixty weaning rabbits (35 d old), selected by Martini group (Budrio di Longiano, FC, Italy), were randomly assigned to different rearing systems: 20 rabbits in bicellular wire net cages (C; 60×25×33 cm, length×width×height); 40 rabbits in 2 Mobile Arks (MA; 250×200×50 cm, length×width×height) with a small covered shelter (50×200×50 cm, length×width×height; 20 rabbits/ark).

The respective stocking densities were 13.3 rabbits/m^2 per cage and 4 rabbits/m^2 per ark. The environmental parameters of rabbitry were the following: 15-18°C temperature, 16 light/8 dark schedule and 60% humidity. The rabbitry was equipped with ventilators for air circulation.

Arks were placed outdoor on alfalfa pasture, where they were moved frequently to make fresh grass available. The temperatures ranging from 18 to 30°C and humidity from 40 to 65%. Water was supplied *ad libitum*. The feeding schedule was adjusted according to the voluntary feed intake. At 75 d, 10 rabbits per group were selected and slaughtered by cutting the carotid arteries and jugular veins, after electrical stunning.

Blood sampling

Blood samples were collected from each animal (10 rabbits/groups) immediately before slaughter. Five mL blood samples from the marginal ear vein were collected in vacutainers and transported to the laboratory of the Department of Agricultural, Environmental and Food Science at the University of Perugia. Serum was obtained from blood samples coagulated at room temperature for 2 h and then the collection tubes were rimmed and refrigerated at 4°C for 24 h before analysis. Plasma was obtained from blood samples collected into tubes containing Na_2-EDTA and immediately centrifuged at 2500 *g* for 10 min at 4°C to determine the haematic parameters.

Blood oxidative parameters

The assessment of the antioxidant power (AP) and reactive oxygen molecular substances (ROMs) in blood serum was carried out using the Oxy-adsorbent kit and the d-ROMs test produced by Diacron (Italy) (Cesarone *et al.,* 1999), respectively.

The blood lipid peroxidation was evaluated on plasma using a spectrophotometer (set at 532 nm, Shimadzu Corporation UV- 2550, Kyoto, Japan), which measured the absorbance of thiobarbituric acid reactive substances (TBARs), and a 1,1,3,3-tetraethoxypropane calibration curve in sodium acetate buffer (pH=3.5) (Dal Bosco *et al.,* 2009). The results were expressed as nmol of malondialdehyde (MDA) per mL of plasma.

The α-tocopherol and retinol levels of plasma were assessed according to Schüep and Rettenmaier (1994) with high-performance liquid chromatography (HPLC) method (Jasco, pump model PU-1580, equipped with an autosampler system, model AS 950-10, Tokyo, Japan) on a Sinergy Hydro-RP column (4 µm, 4.6×100 mm; Phenomenex, Bologna, Italy). Tocopherols were identified using an FD detector (model Jasco, FP- 1520) set at excitation and emission wavelength of 295 nm and 328 nm, respectively, and were quantified using external calibration curves prepared with increasing amounts of pure tocopherols in ethanol. Retinol was identified using a UV-VIS spectrophotometer detector

(Jasco UV2075 Plus) set at λ 325 nm and quantified by comparing the sample with a pure commercial standard in ethanol (Sigma-Aldrich, Steinheim, Germany; Extrasynthese, Genay, France).

Muscle sampling

The slaughtering and carcass dissection procedures followed the World Rabbit Science Association (WRSA) recommendations described by Blasco and Ouhayoun (1996). The *Longissimus lumborum* muscles (LL) (between the 1st and 7th lumbar vertebrae) were excised from the 2 sides of refrigerated carcasses (24 h at 4°C), trimmed of all external fat and epimysial connective tissue, and frozen at –80°C for analyses of lipid profile, oxidative state and antioxidants content.

Analytical determinations of feed and meat

The chemical composition of the feed was determined according to the method of the AOAC (1995). Neutral detergent fiber (NDF), acid detergent fiber (ADF) and acid detergent lignin (ADL) content were determined according to Van Soest *et al*. (1991). Ultimate pH (pHu) of LL meat was measured after 24 h of carcass refrigeration with a Knick digital pH meter (Broadly, Santa Ana, CA, USA) by stabbing at the 7th-8th thoracic vertebra. The colour parameters (L^*, a^*, b^*) were measured using a tristimulus analyser (Minolta Chroma Meter CR-200), with the CIELAB Colour System (1976), on LL muscle surface as reported for the pH. The cooking loss was measured on samples of about 20 g of LL muscle placed in open aluminium pans and cooked in an electric oven (pre-heated to 195°C) for 15 min to an internal temperature of 80°C. The water holding capacity (WHC) was estimated (Nakamura and Katoh, 1985) by centrifuging 1 g of the LL muscles placed on tissue paper inside a tube for 4 min at 1500 *g*. The water remaining after centrifugation was quantified by drying the samples at 70°C overnight. WHC was calculated as: (weight after centrifugation–weight after drying)/initial weight×100.

The fatty acid profiles of the feed and meat were determined by gas chromatography following lipid extraction according to the method described by Folch *et al.* (1957). One mL of lipid extract was evaporated under a stream of nitrogen and the residue was derived by adding 3 mL of sulphuric acid (3% in methanol). Following incubation at 80°C for 1 h, the methyl esters were extracted with petroleum ether, and 1 µL was injected into a gas chromatograph (Mega 2 - model HRGC; Carlo Erba, Milan, Italy) equipped with a flame ionisation detector. The fatty acid methyl esters (FAMEs) were separated with an Agilent (J&W) capillary column (30 m lenght×0.25 mm inner diameter; CPS Analitica, Milan, Italy) coated with a DB-wax stationary phase (film thickness of 0.25 mm). The operating conditions used during the column injection of the 1 µL sample volume were as follows: the temperatures of the injector and detector were set at 270 and 280°C, respectively, and the detector gas flows were H_2 at 50 mL/min and air at 100 mL/min. The oven temperature was programmed as follows: the initial oven temperature was set at 130°C; this temperature increased at a rate of 4.0°C/min to 180°C and was held for 5 min; the temperature was then increased at a rate of 5.0°C/min to 230°C; the final temperature was held for 5 min. Helium was used as a carrier gas at a constant flow rate of 1.1 mL/min. Individual fatty acid methyl esters were identified by referring to the retention time of FAME pure standards and expressed as a percentage of total fatty acids.

The average amount of each fatty acid was used to calculate the sum of the total saturated (SFA), total monounsaturated (MUFA) and total polyunsaturated (PUFA) fatty acids.

The peroxidability index (PI) was calculated according to Arakawa and Sagai (1986): PI=(% monoenoic×0.025)+(% dienoic×1)+(% trienoic×2)+(% tetraenoic×4)+(% pentaenoic×6)+(% hexaenoic×8).

Indexes of atherogenicity (AI) and thrombogenicity (TI) were calculated according to Ulbricht and Southgate (1991) and Santos-Silva *et al.* (2002).

In particular:

$AI = (C12{:}0+4\times C14{:}0+C16{:}0)/[(\Sigma MUFA+\Sigma n6)+\Sigma n3)]$;

$TI = (C14{:}0+C16{:}0+C18{:}0)/[(0.5\times\Sigma MUFA+0.5\times\Sigma n6+3\times\Sigma n3)+(\Sigma n3)/\Sigma n6)]$;

Lipid oxidation was evaluated with a spectrophotometer set at 532 nm (Shimadzu Corporation UV- 2550, Kyoto, Japan) that measured the absorbance of TBARs and a 1,1,3,3-tetraethoxypropane calibration curve (Ke *et al.,* 1977). Oxidation products were quantified as malondialdehyde equivalents (mg MDA/kg muscle).

The tocopherol (α-tocopherol and its isomers β+γ and δ) and retinol contents of the feed and meat were quantified by HPLC according to the method described by Hewavitharana *et al.* (2004). Five mL of distilled water and 4 mL of ethanol were added to 2 g of sample and vortexed for 10 s. After mixing, 4 mL of hexane containing BHT (200 mg/L) was added and the mixture was carefully shaken and centrifuged at 8000 *g* for 10 min. An aliquot of supernatant (3 mL) was dried under a stream of nitrogen and dissolved in 200 µL of acetonitrile; 50 µL were injected into the HPLC (pump model Perkin Elmer series 200, equipped with an autosampler system, model AS 950-10, Tokyo, Japan) on a Sinergy Hydro-RP column (4 µm, 4.6×100 mm; Phenomenex, Bologna, Italy). Tocopherols were identified using a FD detector (model Jasco, FP-1525 - excitation and emission wavelengths of 295 nm and 328 nm, respectively) and quantified using external calibration curves prepared with increasing amounts of pure tocopherols in ethanol. Retinol was identified using a UV-VIS spectrophotometer detector (Jasco UV2075 Plus) set at λ 325 nm and quantified by comparing the sample with a pure commercial standard in ethanol (Sigma-Aldrich, Steinheim, Germany; Extrasynthese, Genay, France).

Fatty acids and antioxidant compounds of feed and alfalfa grass were expressed as means of 3 repetitions±standard deviation.

Table 1: Formulation and chemical composition of feed and alfalfa grass (% of wet weight).

Ingredients	Feed	Grass
Alfa-alfa hay	30.00	
Corn meal	10.00	
Soybean meal	18.00	
Barley	25.00	
Wheat bran	12.00	
Calcium-phosphate	1.35	
Vitamin mineral premix*	1.20	
Molasses	1.00	
Salt	0.70	
Calcium-Carbonate	0.70	
DL-methionine	0.05	
Dry matter	89.0	35.6
Crude protein	17.3	4.12
Ether extract	2.02	0.89
Ash	7.24	8.91
Crude Fibre	12.8	10.9
Neutral Detergent Fibre	24.0	25.4
Acid Detergent Fibre	14.1	15.6
Acid Digestible Lignin	2.93	3.21
Hemicellulose	9.92	9.75
Digestible Energy** MJ/kg	10.5	3.52

*Added per kg: vit. A, 11000 U.I. ; vit. D_3, 2000 U.I.; vit. B_1, 2.5 mg; vit. B_2, 4 mg; vit. B_6, 1.25 mg; vit. B_{12}, 0.01 mg; vit. E, 25 mg; biotine, 0.06 mg; vit. K, 2.5 mg; niacine, 15 mg; folic acid, 0.30 mg; D-pantotenic acid, 10 mg; coline, 600 mg; Mn, 60 mg; Cu, 3 mg; Fe, 50 mg; Zn, 15 mg; I, 0.5 mg; Co, 0.5 mg; lysine, 50 mg; methionine, 40 mg.
**Estimated according to Maertens *et al.* (1988).

Statistical analysis

A linear model (STATA, 2005; procedure GLM) was used to evaluate the fixed effect of housing system (cage *vs.* Mobile Ark). Statistical significance of differences was assessed by the *t*-test for $P<0.05$.

RESULTS AND DISCUSSION

The solid feed intake of MA rabbits was lower than control (85±8 *vs.* 125±12 g/d respectively; data not shown), as the consequence of the intake of grass. Despite the low energy of fresh grass, the slaughter weight of ark-reared rabbits was almost the same as that of control rabbits (3326±120 and 3422±96 g, in C and MA, respectively).

Table 1 shows the chemical composition of feed and grass. Grass had a lower amount of dry matter, protein and digestible energy, whereas the amount of fibre and its components (neutral detergent fibre, acid detergent fibre, and acid detergent lignin) was comparable.

The fatty acid of feed (Table 2) and grass showed great differences in the essential fatty acids (linoleic acid [LA] and α-linolenic acid [ALA]) and in the saturated/unsaturated and n-6/n-3 ratios. The antioxidant contents were also very different, with a strong predominance of the α-tocopherol in the feed (due to addition of vitamin premix) and lutein and β-carotene in the grass. Carotenes are much higher in pasture than in feed, confirming grass as a relevant source of antioxidant (Mugnai *et al.,* 2009). It is known that carotenes in the

Table 2: Fatty acid (mg/100 g) and antioxidant compounds (µg/g) contents of feed and alfalfa grass.

Fatty acids	Feed	Grass
C16:0	326.6±21.4	299.0±35.2
C18:0	51.9±6.0	40.4±6.8
C18:1n-9	283.1±21.4	181.8±41.1
C18:2n-6	695.1±32.3	256.4±31.8
C18:3n-3	246.2±19.2	1342.9±199.2
Total saturated fatty acids	407.0±31.9	355.6±48.5
Total monounsaturated fatty acids	314.9±25.8	205.6±42.1
Total polyunsaturated fatty acids	953.1±62.2	1607.4±287.3
Saturated/unsaturated fatty acids	0.32±0.81	0.22±0.63
n-6/n-3	2.85	0.23
α-tocopherol	63.2±0.32	7.55±2.21
γ(+β)-tocopherol	0.70±0.003	0.05±0.01
δ-tocopherol	0.15±0.06	0.10±0.04
Lutein	2.23±0.70	20.38±8.72
Zeaxanthin	1.19±1.12	n.d.
β-Carotene	1.16±0.12	4.85±1.06

Each value represents the mean of 3 determinations.
n.d.: not detectable

diet may have a high scavenging power against free radicals (Osganian *et al.,* 2003) and have a strong inhibitory power against lipid *in vitro* peroxidation (Bub *et al.,* 2000).

The oxidative status of plasma was affected by the housing system (Table 3). The C group showed a lower plasma level of α-tocopherol than MA. On the other hand, the TBARs value was higher in plasma of rabbits reared in mobile arks compared to rabbits reared in cages, likely due to the different locomotor activity. The balance in the body between antioxidant protection and oxidative stability is unstable and depends on training and exercise (Dal Bosco *et al.,* 2010)

Oxidative stress, resulting from an increased production of free-radicals and ROS, damages biological macromolecules and disrupts normal metabolism and physiology (Tse *et al.,* 2004). In the present trial, rabbits reared in mobile arks showed higher values of AP and ROMs.

In agreement with Dalle Zotte *et al.* (2009), WHC and cooking loss of rabbit meat (Table 4) were not affected by housing system. The pH values of LL muscle were not significantly different in cage-housed rabbits compared with those in the ark, contrary to what is observed by other authors (Dal Bosco *et al.,* 2002; Dalle Zotte *et al.,* 2009). The colour values (L*, a* and b*) did not show any significant differences between groups.

The rearing condition affected only the lipid content of meat, which was lower in MA rabbits, probably due to the larger available living area, which allowed a greater movement, and also due to the lower intake of feed. Even Van der

Table 3: Plasma bioactive compounds and oxidative status.

		Control	Mobile ark	*P*-value	SEM
Antioxidant Power	µmol HClO neutralised	417.7[a]	548.0[b]	0.003	145.2
ROMs	mmol H_2O_2	0.66[a]	0.85[b]	<0.001	0.13
Retinol	nmol/mL	27.1	27.0	0.089	1.9
α-tocopherol	nmol/mL	3.70[a]	4.75[b]	<0.001	0.18
γ(+β)-tocopherol	nmol/mL	0.03	0.02	0.088	0.002
δ-tocopherol	nmol/mL	0.009	0.008	0.125	0.0003
α-tocotrienol	nmol/mL	0.07	0.03	0.062	0.006
TBARs	nmol MDA/mL	32.4[a]	43.7[b]	<0.001	2.3

SEM: standard error of means. n=10 per group; [a,b]Means not sharing superscript in the same row were significantly different at *P*<0.05. ROMs: reactive oxygen molecular substances; TBARs: thiobarbituric acid-reactive substances; MDA: malondialdehyde.

Table 4: Characteristics of *Longissimus lumborum* muscle.

	Control	Mobile ark	*P*-value	SEM
pH	5.80	5.88	0.546	0.08
Colour				
L*	58.1	55.3	0.301	1.52
a*	6.44	6.35	0.880	0.37
b*	–1.71	-1.04	0.067	0.38
WHC (%)	54.5	55.9	0.691	2.31
Cooking Loss (%)	26.8	29.3	0.429	2.31
Proximate composition				
Water (%)	74.56	74.90	0.967	0.63
Crude Protein (%)	22.71	22.54	0.179	0.31
Ether extract (%)	1.48[b]	1.22[a]	0.002	0.14
Ash (%)	1.25	1.34	0.076	0.10

SEM: standard error of means. n=10 per group. WHC: water holding capacity

[a,b]Means not sharing superscript in the same row were significantly different at $P<0.05$.

Horst *et al.* (1999) and Dal Bosco *et al.* (2000) found lower fat amount in meat of rabbits reared in pens compared to standard cages. The fatty acids profile of the meat (Table 5) did not show significant differences in SFA and MUFA proportion. The most abundant fatty acids were palmitic, stearic, oleic and LA. The ALA and the sum of n-3 of MA group were higher than those of the C one. In particular, MA rabbits showed a higher amount of long chain PUFA

Table 5: Fatty acid profile (% of total fatty acid) and fatty acid ratio of selected fatty acid-related indexes of *Longissimus lumborum* muscle.

	Control	Mobile ark	*P*-value	SEM
C14:0	0.33	0.24	0.139	0.03
C16:0	24.82	25.47	0.417	1.28
C18:0	10.15	12.10	0.105	0.66
C 20:0	0.26	0.05	0.344	0.10
SFA	35.56	35.85	0.889	1.34
C14:1n-6	0.05	0.07	0.409	0.01
C16:1n-7	2.44	2.47	0.060	0.25
C18:1n-9	26.80	25.28	0.118	1.22
MUFA	29.29	27.82	0.103	1.45
C18:2n-6	23.26	19.17	0.110	1.67
C20:2n-6	0.25	0.29	0.455	0.03
C20:3n-6	0.06	0.07	0.492	0.02
C20:4n-6	3.09	4.05	0.089	1.72
C18:3n-3	1.43[a]	2.48[b]	0.001	0.91
C20:3n-3	0.68[a]	1.45[b]	0.023	0.68
C20:5n-3	1.35[a]	3.06[b]	0.029	0.86
C22:5n-3	0.18[a]	0.31[b]	0.008	0.48
C22:6n-3	0.20[a]	0.93[b]	0.006	0.10
PUFA	30.29	31.53	0.229	1.70
Others	3.85	4.19	0.93	0.45
Σ n-3	2.83[a]	6.24[b]	0.019	0.90
Σ n-6	27.46	25.29	0.275	1.28
n-6/n-3	9.71[b]	4.05[a]	0.039	1.43
PUFA/SFA	0.83	0.85	0.440	0.12
Atherogenicity Index	0.90	0.87	0.290	0.02
Thrombogenicity Index	1.63[b]	1.25[b]	0.023	0.05
Peroxidability index	12.10[a]	30.64[b]	0.001	2.15
Δ^5- plus Δ^6 -desaturase	17.63[a]	29.73[b]	0.004	5.07

SEM: standard error of means. n=10 per group. [a,b]Means not sharing superscript in the same row were significantly different at $P<0.05$. SFA: saturated fatty acids; MUFA: monounsaturated fatty acids; PUFA: polyunsaturated fatty acids.

Table 6: Bioactive compounds and oxidative status of *Longissimus lumborum* muscle.

		Control	Mobile ark	*P*-value	SEM
Retinol	μg/g of meat	6.82[a]	7.42[b]	0.036	0.32
α-tocopherol	ng/g of meat	683.3[a]	719.2[b]	<0.001	22.1
γ(+β)-tocopherol	ng/g of meat	10.1	8.3	0.071	1.9
δ- tocopherol	ng/g of meat	6.30	5.65	0.119	0.93
α-tocotrienol	ng/g of meat	20.3	20.0	0.426	1.8
TBARs	mg MDA/g	0.12	0.14	0.056	0.09

SEM: standard error of means. n=10 per group; [a,b]Means not sharing superscript in the same row were significantly different at $P<0.05$. TBARs: thiobarbituric acid-reactive substances; MDA: malondialdehyde.

n-3 (eicosapentaenoic acid and docosahexaenoic acid) than the control. This fact also affected the n-6/n-3 ratio and the thrombogenic index, which were lower in ark-reared rabbits. The greater ALA content of MA was probably due to the lower n-6/n-3 ratio of the grass (Kouba and Mourot, 2011) and in turn, the higher ALA intake increased the desaturase/elongase activity towards the n-3 series (Brenner, 1971; Dal Bosco *et al.,* 2014).

The differences in the fatty acids profile observed in MA rabbits compared to C ones could be also due to the lower amount of intra-muscular fat and the greater percentage of phospholipids that are richer in PUFA and particularly in C20 and C22 (Enser *et al.,* 1988).

Relevant differences were also observed in the estimated $\Delta^5+\Delta^6$–desaturase activity, which was higher in MA group.

The PI index, given the higher amount of unsaturated fatty acid in meat of rabbit reared in arks, was higher than in control (Wood *et al.,* 2000). Despite the higher peroxidability of the meat, the good oxidative status of MA group (Table 6) was probably due to grass ingestion, as observed by Mugnai *et al.* (2014) and Dal Bosco *et al.* (2014) in organic rabbits.

The TBARs value of MA rabbits was not significantly different than control, although the greater amount of antioxidants, in particular the retinol and α-tocopherol (6.82 *vs.* 7.42 μg/g and 683.3 *vs.* 719.2 ng/g, respectively, in C *vs.* MA).

The greater activity negatively affected the oxidative status (TBARs) and consequently the meat quality. However, as already stated, the pasture availability in the MA group, providing a greater amount of antioxidant compounds, helped rebalance the lipid peroxidation with higher intake of antioxidants (mainly carotenes) contained in the grass.

In conclusion, it is possible to affirm that the mobile ark is a suitable alternative housing system to improve the quality of rabbit meat (increasing α-tocopherols and PUFA content). However, the plasma oxidative status was negatively affected by higher movement of animals, allowed by the large available space in the ark, as demonstrated by TBARS values. Further studies are in progress to verify the effect of this alternative housing system on rabbit performance, health status and welfare.

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