PASTURE AVAILABILITY AND GENOTYPE EFFECT IN RABBIT: 3. PERFORMANCE, CARCASS AND MEAT CHARACTERISTICS

Mugnai C.[1], Finzi A.[2], Zamparini C.[1], Dal Bosco A.[1*], Mourvaki E.[1], Castellini C.[1]

[1]Department of Applied Biology, University of Perugia, Borgo XX Giugno 74, 06121 Perugia, Italy
[2]Rabbit and Guinea Pig Unconventional Keeping Experimental Centre, Animal Production Department, University of Tuscia, 01100 Viterbo, Italy
*Corresponding author: dalbosco@unipg.it

ABSTRACT

To verify the effect of pasture availability and genotype on performance and meat quality, 80 weaned rabbits (40 Leprino of Viterbo and 40 New Zealand White) were assigned to two homogeneous groups (sex, weight and genotype): Control (C), reared in standard bicellular cages, and Pasture (P), kept in a wired pen provided of an external grassed pasture area. To evaluate fatty acid composition and tocopherol content of feed and pasture two sampling were carried out and grass was taken from different areas of external paddock. Live weights, feed intake and feed:gain ratio were recorded. At 90 days of age 20 rabbits per group were sacrificed. Respect to feed, pasture showed higher percentage of saturated fatty acids (28.41 vs. 19.67%) and lower of monounsaturated fatty acids (8.00 vs. 19.55%). Regarding polyunsaturated fatty acids, great differences were observed in relation to linoleic and linolenic acids (13.89% vs. 47.25% and 47.72% vs. 11.93%, respectively). Productive performance, carcass traits and fatty acid composition of meat were strongly affected by genotype and housing system. In particular, the possibility of performing movement and ingesting grass caused lower daily gain (Leprino 29.6 vs. 31.9 g; NZW 40.0 vs. 44.2 g) and slaughter weight (Leprino 2418 vs. 2563 g; NZW 2650 vs. 2902 g). Chilled carcasses of pasture reared rabbits followed trend of live weight; bone (Leprino 14.0 vs. 11.6 kg/cm^2; NZW 14.0 vs. 10.0 kg/cm^2) and meat (Leprino 3.4 vs. 2.9 kg/cm^2; NZW 3.4 vs. 2.5 kg/cm^2) shear force were higher and meat fatty acid profile was richer in n-3 and total polyunsatured fatty acids. Regarding genotype effect, Leprino showed lower daily gains, live and carcass weights. Pasture availability improved the meat nutritional quality and in particular the n-6/n-3 ratio was optimal and the total tocopherols content was suitable to assure a good oxidative stability.

Key words: Rabbit, Pasture, Performance, Carcass traits, Fatty acids.

INTRODUCTION

According to recent surveys of public opinion, extensive livestock production systems are perceived to offer higher welfare standards; furthermore they are reputed more sustainable and environmental friendly. In this context organic system seems to be a good alternative mainly if a wide grass pasture area is available, but the few investigations regarding adaptability of different genotypes are available; in fact fast-growing animals (i.e. commercial hybrids) show a low adaptation to poor environment conditions. On the contrary, rustic genotypes are recommended and some pure breeds in danger of extinction could be used in order to assure their preservation.

Concerning the rabbit, few studies exist about the effect of the organic system on performance and meat quality (Margarit *et al*., 1999; Lebas *et al*., 2002; Combes *et al*. 2003; Combes and Lebas, 2003; Gondret, 2005) accounting also for genotype reared (Dalle Zotte and Ragno, 2005).

The aim of this study was to verify the effect of the space and pasture availability on the performance and meat quality of two rabbit genotypes.

MATERIALS AND METHODS

Animals and experimental design

The trial was carried out at the experimental farm of the Deaprtment of Applied Biology (University of Perugia, Italy). Eighty weaned (35 d) rabbits of both Leprino di Viterbo and New Zealand White (NZW) genotypes were divided in two groups (sex, weight and genotype) and placed into two different housing systems:
- bicellular cages (17 rabbits/m^2) under standard fattening conditions with temperatures ranging from 15 to 25°C and relative humidity from 60 to 75% (Control, C);
- wire pen (10 rabbits/m^2) in the same environmental conditions of C group, but with free access to a external grassed paddock (1 rabbit/20 m^2), after a week of gradual adaptation (Pasture, P).

Live weights were recorded weekly and individually, while the feed intake was also registered, but collectively. The average feed consumption of the group was used to calculate individual feed:gain ratio. At 90 d, 20 rabbits per group, with a weight close to the average of the group ($\pm$10%), were selected and slaughtered by cutting the carotid arteries and jugular veins after electrical stunning.

Feeding

Rabbits fed *ad libitum* an organic diet, bought from a national agency. No medical treatment was performed. The composition of feed was: crude protein 16%, crude fibre 13%, fat 3% and digestible energy 11.0 MJ/kg.

Slaughter traits and muscle sampling

Handling and dissection of chilled carcasses (24 h at 4°C) were performed as proposed by Blasco and Ouhayoun (1996). The *Longissimus dorsi* (between the 1st and 7th lumbar vertebrae) and *Biceps femoris* muscles were excised from both sides and legs, respectively trimmed of all external fat and epimisyal connective tissue and then frozen until analyses.

Analytical determinations

To evaluate fatty acid composition and tocopherol content of feed and pasture two sampling were carried out and grass was taking from different area of external paddock. Ultimate pH (after 24 hours at 4°C) of *Longissimus dorsi* muscle were measured with a Knick digital pHmeter (Broadly Corp., Santa Ana, CA, USA) after homogenising 1 g of muscle for 30 sec in 10 ml of 5nM iodoacetate (Korkeala *et al*., 1986).

Meat lipids of feed, grass and meat (samples of about 5 g) were extracted in a homogeniser with 20 ml of 2:1 chloroform-methanol (Folch et al., 1961), followed by filtration through Whatman No. 1 filter paper. Fatty acids were measured as methyl esters (FAME) with a Mega 2 Carlo Erba Gas Chromatograph, model HRGC (Milano, Italy), using a D-B wax capillary column (25 mm ∅, 30 m long). The fatty acid percentage was calculated with the Chrom-Card software.

TBARs (Thiobarbituric Reactive substances) were quantified using the modified method of Tarladgis et al. (1960). Ten grams of minced muscle were homogenised for 2 min with 95.7 ml of distilled water and 2.5 ml of 4N HCl. The mixture was distilled until 50 ml were obtained. Five ml of the distillate and 5 ml of TBA reagent (15% trichloroacetic acid, 0.375% thiobarbituric acid) were heated in a boiling water bath for 35 min. After cooling under running tap water for 10 min, the absorbance was measured at 538 nm against a blank. TBARs values were obtained by multiplying optical density by 7.843. Lipid oxidation products were quantified as malondialdehyde equivalents (mg/kg of muscle). Tocopherol content (α-tocopherol and its isoform β, γ, δ) of feed, grass and meat was quantified by HPLC according to Hewavitharana *et al*. (2004).

Table 1: Main fatty acids (%) and tocopherols content (mg/kg) of feed and pasture (mean of two sampling, at the start and the end of rearing period)

Fatty acid profile	Feed	Pasture
Σ Saturated	19.67	28.41
Σ Monounsaturated	19.55	8.00
C18:2n-6	47.25	13.89
C18:3n-3	11.93	47.72
Σ Polyunsaturated	60.78	63.59
Σ Tocopherols	3.43	26.80

Statistical Analysis

A linear model (STATA, 2005 - procedure GLM) was used to evaluate the interactive effect of housing system (cage vs. pasture) and genotype (Leprino vs. New Zealand White). Statistical significance of differences was assessed by the t-test (SAS/GLM option PDIFF).

RESULTS AND DISCUSSION

Fatty acid profile of feed and pasture showed relevant differences on the proportion of main classes of fatty acids (Table 1). Pasture showed higher percentage of saturated fatty acids (28.41 vs. 19.67%) and lower of monounsaturated fatty acids (8.00 vs. 19.55%). Regarding polyunsaturated fatty acids even if total amount was similar (63.59 vs. 60.78%), great differences were observed in relation to linoleic and linolenic acid (13.89 vs. 47.25% and 47.72 vs. 11.93%, respectively) in agreement with Aurousseau *et al*. (2004). Total tocopherols content, was higher than feed confirming grass as good source of vitamin E (Castellini *et al*., 2006).

As expected, both genotypes reared in cages showed better performance in terms of slaughter weight, daily gain and feed intake, due to the lower movement that increased the time spent to eating simultaneously reducing the energy dispersion (Table 2). However, a part feed efficiency, the performance of NZW was always superior. These animals when reared at pasture showed a great grass eating activity (Mugnai *et al*., 2008) with increase of gastrointestinal tract (Cardinali *et al*., 2008) that probably favoured an higher concentrate ingestion. The feed efficiency showed an interactive behaviour: Leprino rabbits had the better value under organic conditions and NZW under cage rearing systems.

Chilled carcass weight had the same trend of slaughter weight; the dressing out percentage was slightly lower in pasture animals in consequence to higher pasture intake.

Table 2: Effects of genotypes and rearing system on rabbit performance, carcass and meat characteristics

Genotype	Leprino		New Zealand White		
Rearing system	C	P	C	P	SEM
Slaughter weight (g)	2563^{b}	2418^{a}	2902^{d}	2650^{c}	154
Average daily gain (g)	31.9^{b}	29.6^{a}	44.2^{d}	40.0^{c}	5.2
Feed intake (g/d))	126^{b}	98.7^{a}	132^{b}	142^{c}	21
Feed efficiency	3.9^{d}	3.3^{b}	3.0^{a}	3.6^{c}	0.9
Chilled carcass weight (g)	1561^{b}	1465^{a}	1763^{c}	1580^{b}	121
Dressing out (%)	60.9	60.2	60.8	59.6	5.9
Bone shear force (kg/cm^2)	11.6^{a}	14.0^{b}	10.0^{a}	14.0^{b}	2.1
pH_u	5.9^{b}	5.6^{a}	5.8^{ab}	5.7^{ab}	0.5
Meat shear force (kg/cm^2)	2.9^{ab}	3.4^{b}	2.5^{a}	3.4^{b}	0.4

n=20 per group; a..d: P<0.05

Bone and meat shear force were both affected by housing system reaching the higher values in organic rabbits of both genotypes. Ultimate pH of *longissimus dorsi* was significantly affected only Leprino rabbits by housing system. In our previous investigation (Dal Bosco *et al*., 2002a), the final pH value was lower in pen-raised animals in spite of the enhancement of the aerobic catabolism of pyruvate.

Regarding meat shear force, pasture reared rabbits showed the greater values according to our previous findings (Dal Bosco *et al*., 2001). Lipid levels of meat were affected by genotype and housing systems according to our previous investigations (Dal Bosco *et al*., 2002b) (Table 3).

Table 3: Lipid content (%), fatty acid composition (%), TBARs (mg malondyaldeide/kg) and tocopherol (mg/kg) contents in *Longissimus dorsi* and *Biceps femoris* muscles

Muscle	*Longissimus dorsi*					*Biceps femoris*				
Genotype	Leprino		New Zealand White			Leprino		New Zealand White		
Rearing system	C	P	C	P	SEM	C	P	C	P	SEM
Lipids	1.40^{b}	1.23^{a}	1.58^{c}	1.43^{b}	0.55	2.32^{ab}	2.15^{a}	2.62^{b}	2.40^{ab}	0.47
Σ Saturated	41.99^{c}	41.08^{b}	38.81^{a}	38.17^{a}	2.63	37.87^{a}	39.78^{b}	39.09^{b}	41.21^{c}	1.35
Σ Monounsaturated	23.59^{b}	18.53^{a}	22.69^{b}	18.14^{a}	1.81	22.78^{b}	15.26^{a}	22.25^{b}	16.35^{a}	0.79
C18:2n-6	24.12^{a}	25.28^{b}	23.87^{a}	25.41^{b}	2.99	27.19	27.47	26.41	27.71	1.05
C18:3n-3	2.68^{a}	4.91^{c}	2.40^{a}	3.19^{b}	1.19	2.90^{a}	3.92^{b}	2.84^{a}	3.54^{ab}	0.72
Σ Polyunsaturated	34.42^{a}	40.39^{b}	38.50^{b}	43.69^{c}	3.48	39.35^{a}	44.96^{b}	38.66^{a}	42.44^{b}	1.93
Σ n-6 (C≥20)	5.40^{a}	7.31^{b}	8.87^{b}	8.71^{b}	1.85	6.52^{a}	10.08^{b}	6.78^{a}	7.51^{a}	1.74
Σ n-3 (C≥20)	1.50^{a}	2.38^{ab}	2.22^{ab}	3.20^{b}	1.06	1.66^{a}	3.08^{b}	1.77^{a}	2.98^{b}	1.14
n-6/n-3	6.90^{b}	4.53^{a}	6.67^{b}	4.72^{a}	1.28	6.51^{a}	5.40^{a}	6.74^{a}	5.51^{a}	1.34
TBARs	0.11^{a}	0.13^{a}	0.16^{b}	0.14^{ab}	0.04	0.13^{a}	0.18^{b}	0.22^{c}	0.20^{bc}	0.11
Σ Tocopherols	3.22^{a}	4.15^{a}	3.48^{a}	7.31^{b}	1.50	5.44^{a}	6.31^{ab}	5.48^{a}	8.46^{b}	1.09

N=20 (per group); a..c: P<0.05 (for each muscle)

The fatty acid profile of both muscles was affected by genotype and housing system. Concerning *Longissimus dorsi*, muscle of Leprino presented higher percentage of saturated fatty acids. In the same muscle, monounsaturated fatty acids, in agreement with other authors (Pla, 2007), lowered in both pasture reared genotypes, while that of polyunsatured fatty acids increased; at the same time the n-6/n-3 ratio lowered. Total content of tocopherol increased in pasture animals, but the difference was significant only for NZW rabbits, nevertheless TBARs values were quite the same. Leprino, although a lower tocopherol level had lower TBARs. The discrepancy between the theoretical assumption of a positive correlation between tocopherols and oxidative stability of meat could be explained by the differences in the fat level of the genotypes (higher in NZW) which in turn enhances the TBARs value.

Biceps femoris, compared to *Longissimus dorsi*, showed a higher TBARS and total tocopherols according to its higher oxidative metabolism and fat level. In this muscle the percentage of saturated fatty acids was higher in pasture rabbits, probably for their higher oxidative metabolism (Gondret et al., 2001; 2005).

As in *Longissimus dorsi* muscle, the effect of organic housing system caused lower percentage of monounsaturated fatty acids and higher of polyunsatured fatty acids. In NZW, nevertheless an increase of tocopherols and TBARs the trend observed in *Longissimus dorsi* are more pronounced. In general when increases in fibre size are overemphasized in response to selection for high daily gain, the capacity of fibres to adapt to oxidative stress seems to be reduced (Rehfeldt *et al*., 1999) and consequently oxidative stress increases as well as need of antioxidant.

CONCLUSIONS

In conclusion, the pasture housing system reduces the productive performance of both studied genotypes, but increased meat nutritional quality, in particular lowering lipid content, increasing polyunsaturated fatty acids, decreasing n-6/n-3 and with good vitamin E amount. These characteristics together with more animal friendly living conditions (Mugnai *et al*., 2008) could justify the higher price of this product.

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