EFFECT OF OUTDOOR REARING SYSTEM, IN FLOOR CAGE, ON MEAT QUALITY OF SLOW GROWING RABBITS

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ABSTRACT

The present work investigated the effect of two housing systems (Indoor vs. Outdoor) on the qualitative characteristics of meat deriving from "Grigia Rustica" rabbits, a slow growing local population. Forty eight growing females were divided into two groups: Indoor group, housed in indoor colony cages (cm 65x40x32 h, 4 animals per cage), and Outdoor group, in wire net floor colony cages (cm 100x150x76 h, 8 animals per cage), in outdoor pen in a wooded area. The animals received *ad libitum* a commercial pelleted diet plus alfa-alfa hay and were slaughtered at 103±2 days (19 animals/group). About one hour after slaughter, carcasses were put in a ventilated cold room (+4°C) and chilled for 24 hours and the loin region and the right hind leg were excised from each carcass. The following variables were measured: pH_u, L* a* b* colour, water holding capacity (filter paper press method, M/T ratio) of *Longissimus lumborum* and *Biceps femoris* muscles; drip loss and cooking loss of *L. lumborum* muscle; chemical composition and fatty acids (FA) profile of hind leg meat. The muscles pH_u values were similar within groups. The *L. lumborum* and *B. femoris* muscles of Outdoor rabbits had lower lightness (55.59 vs. 59.15 and 53.02 vs. 55.50 respectively, $P<0.01$) and slightly higher a* value than those derived from rabbits reared in Indoor cages, probably due to increased movement. The M/T ratio of *L. lumborum* and *B. femoris* and drip loss of *L. lumborum* were similar among groups; cooking loss was significantly lower in Outdoor group (15.9% vs. 18.1%). The housing system significantly affected the dry matter (25.5% vs. 24.9%), protein (22.9% vs. 22.6%) and fat contents (1.4% vs. 1.2%) that were higher in Outdoor group. The hind leg meat of the Outdoor rabbits was significantly lower in saturated fatty acids (SFA, 36.4% vs. 37.9%) and higher in monounsaturated fatty acids (MUFA, 23.2% vs. 21.9%), while no difference was observed for polyunsaturated fatty acids (PUFA) contents. PUFA/SFA and MUFA+PUFA/SFA were similar in both groups. The meat showed similar n-6/n-3 ratio between experimental groups (10.5) and slightly higher than the recommended value in human. In conclusion, meat from outdoor rabbit appeared less pale, showed a significant higher fat content that was probably positively related to lower cooking loss, and a positive lower content of SFA and a higher content of MUFA. Outdoor rearing seems to be a possible alternative housing system that satisfies the ethical concern of modern consumer, even furnishing good meat quality.

Key words: Rabbit, Rearing system, Meat, Physical characteristics, Chemical composition.

INTRODUCTION

The recent interest on the rabbit welfare and on the housing system that respects the rabbit's fundamental biological characteristics and can produce a reduction of stress, has led to the implementation of alternative housing system (Cavani *et al.*, 2004). The alternative rearing system requires breed or population that can adapt to various environments, leading to favourable productive performance. In recent years, some studies were carried out on "Grigia Rustica" rabbits, a local population characterized by slow growing and a good capacity to adapt to the alternative rearing system. In fact, this population, reared also in unfavourable environmental conditions, showed always its rusticity and good productive performance (Paci *et al.*, 2004; D'Agata *et al.*, 2007).

The aim of this work was to investigate the effect of two housing systems (Outdoor vs. Indoor) on the qualitative characteristics of "Grigia Rustica" rabbit population meat.

MATERIALS AND METHODS

Animals and experimental design

Forty eight growing females of a slow growing rabbit population (Grigia Rustica) were divided into two groups: Indoor group housed in indoor wire colony cages (cm 65x40x32h, 4 animals per cage) and Outdoor group, in colony cages with wire net floor (cm 100x150x76h, 8 animals per cage). The floor colony cages were located on wheat straw litter, restored with fresh litter every week and were equipped with 4 feeders (20 cm length) and with 4 nipple drinkers, as reported more in detail in a previous note (D'Agata *et al.*, 2007). At 103±2 days, 19 animals for each experimental group were slaughtered according to the recommendations of the WRSA Commission (Blasco and Ouhayoun, 1996). After one hour from slaughtering, carcasses were put in a ventilated cold room (+4°C) and chilled for 24 hours; the loin region (between the 1st and the 7th lumbar vertebra) and the right hind leg were excised from each carcass and analyzed for meat quality assessment.

Meat analyses

The ultimate pH (pH_u) was determined *in situ* on the right *L. lumborum* muscle at the level of the 5th lumbar vertebra and on the *B. femoris* muscle; a portable pH-meter (Hanna) having a glass electrode with a 3 mm diameter conic tip, suited for meat penetration, was applied. Instrumental meat colour expressed as L* (Lightness), a* (redness), b* (yellowness) according to CIELab system (CIE, 1976) was measured with a Minolta CR300 apparatus with a light source D_{65} on a transversal section of *L. lumborum* muscle and on the *B. femoris* muscle surface. Water holding capacity (WHC) was measured according to filter paper press method on both muscles (Grau and Hamm, 1957) and expressed as the ratio of muscle area to total area (M/T ratio) after compression (50 kg/cm^2) of 300±5 mg of intact meat for 5 min.; on 6 samples of *L. lumborum* muscle for each group, WHC was even measured as drip loss and cooking loss (AMSA, 1995; Honikel, 1998).

The meat from the hind leg was removed, weighed, minced and scanned by Near Infrared Reflectance Spectroscopy (NIRS), then frozen and freeze-dried. The freeze-dried samples were ground through a 1mm screen and scanned again by NIRS. Measurement of the NIR spectra was performed using a Foss NIRSystems 5000 system, with small ring cup cells. Measurements were made in reflectance mode between 1,100 and 2,498 nm every 2 nm. All samples were scanned in duplicate. Ten samples were selected by NIR, on the basis of the global Mahalanobis and neighborhoods distances, for further chemical analysis.

The chemical analysis concerned the moisture, fat and ash contents and fatty acids profile analyzed by GC, after Folch extraction (Folch *et al.*, 1957). Protein was calculated by difference in accordance with standards of the A.O.A.C. (1990). Chemical data were used by the WINISI software to improve a previous calibration set and to predict the chemical composition and fatty acids profile of the not chemically analyzed samples (Berzaghi *et al.*, 2005; Dalle Zotte *et al.*, 2006).

Statistical analysis

The meat quality parameters were analyzed by least squares means considering rearing system as main categorical factor nested within cage; statistical significance of differences was assessed by the t-test (SAS, 2002).

RESULTS AND DISCUSSION

Meat physical quality traits of rabbits kept Indoor and Outdoor are shown in Table 1. The pH_u values of *L. lumborum* and *B. femoris* muscles were similar between groups: this result is not in agreement with other authors who found significant differences ascribed to exercise, age and open-air system on meat pH_u (Dalle Zotte and Ouhayoun, 1995; Cavani *et al.*, 2000; Dal Bosco *et al.*, 2002, Combes *et al.*, 2005: Paci *et al.*, 2005). The *L. lumborum* and *B. femoris* muscles derived from rabbits reared in Outdoor pens exhibited lower lightness (P=0.01) and more coloured meat (higher redness, a*) than those of rabbit reared in Indoor cages, as observed in our previous research (Paci *et al.*, 2005). These results are in agreement with Pla (2007) and may be explained by the fact that in the Outdoor pens more movement is possible. As animal movement increases the number of mitochondria in αW fibres also increases, converting their predominant glycolytic energy metabolism into oxidative energy metabolism and then, part of the αW fibres turn into αR fibres, more rich in myoglobin. In contrast, reduced movements increase the muscle glycogen storage used for the anaerobic energy metabolism (Ouhayoun, 1998; Gregory, 2003).

In *L. lumborum* muscle the cooking loss was significantly lower in the Outdoor group (15.9 vs. 18.1%; P<0.05) and probably related to the higher dry matter and fat contents of the meat,

Table 1: Meat physical quality traits

	Indoor group	Outdoor group	Prob.	MSE
L. lumborum muscle				
pH_u	5.70	5.83	0.07	0.04
Colour:				
- L*	59.15	55.59	0.01	4.06
- a*	2.08	2.46	0.29	1.11
- b*	1.63	1.81	0.49	0.60
WHC:				
- M/T[(1)]	0.46	0.51	0.27	0.01
- Drip loss (%)	2.52	2.47	0.87	0.36
- Cooking loss (%)	18.14	15.86	0.04	4.06
Biceps femoris muscle				
pH_u	5.92	5.90	0.79	0.02
Colour:				
- L*	55.50	53.02	0.01	4.84
- a*	2.20	2.79	0.07	0.84
- b*	2.02	2.28	0.17	0.29
WHC:				
- M/T[(1)]	0.45	0.49	0.37	0.01

[(1)] M/T: muscle area/total area

The hind leg meat chemical composition is reported in Table 2. The housing system significantly affected the dry matter, protein and fat contents that were significantly higher in Outdoor groups. The higher fat content might be related to the productive performance of Outdoor rabbits that showed significantly higher live weights (2.5 vs. 2.0 kg), resulting in higher reference carcass (84.0 vs. 81.9% chilled carcass) and hind leg (35.3 vs. 35.1%) proportions (D'Agata *et al.*, 2007); this was probably due to the better environmental and consequently healthy conditions induced by this housing system, that could have increased the animal welfare (Cozzi *et al.*, 2000).

Table 2: Chemical composition of hind leg meat

	Indoor group	Outdoor group	Prob.	MSE
Dry matter (%)	24.88	25.54	0.01	0.19
Protein (%)	22.57	22.93	0.01	0.08
Fat (%)	1.12	1.40	0.02	0.08
Ash (%)	1.20	1.22	0.18	0.01

In Table 3 the fatty acid (FA) composition of the hind leg is reported. The meat of the Outdoor reared rabbits showed a significantly lower content in SFA and higher content in MUFA, while no difference was observed for PUFA.

The Department of Health and Social Security (1994, quoted in Pla, 2007) recommends a ratio for PUFA/SFA equal or higher than 0.45: in our study the meat showed higher PUFA/SFA ratio in both groups, approaching 1. Our results are supported by those recently found by Cavani *et al.* (2004), who affirms that this ratio is generally very high in the rabbit meat. The (MUFA+PUFA)/SFA ratio was similar in both groups and higher than that reported by Cavani *et al.* (2004) and Pla (2007). The n-6/n-3 ratio of hind leg meat was similar between experimental groups and slightly higher than that recommended in human (Crawford and Marsh, 1995).

Table 3: Fatty acid profile of hind leg meat

	Indoor group	Outdoor group	Prob.	MSE
C10:0	0.13	0.12	0.91	0.01
C12:0	0.13	0.13	0.90	0.01
C14:0	1.46	1.56	0.12	0.03
C15:0	0.52	0.51	0.01	0.01
C16:0	26.61	25.70	0.20	4.05
C17:0	0.74	0.72	0.09	0.01
C18:0	8.19	8.22	0.85	0.19
C20:0	0.13	0.12	0.62	0.01
SFA	37.85	36.42	0.05	4.19
C14:1	0.04	0.06	0.01	0.01
C16:1	1.55	1.83	0.04	0.14
C17:1	0.20	0.21	0.45	0.01
C18:1 n-9	18.13	19.31	0.01	1.70
C18:1 n-7	1.52	1.51	0.67	0.01
C20:1 n-9	0.22	0.22	0.69	0.01
MUFA	21.94	23.22	0.01	1.60
C18:2 n-6	28.07	27.77	0.57	2.26
C18:3 n-6	0.05	0.05	0.52	0.01
C18:3 n-3	1.73	1.75	0.90	0.15
C20:2 n-6	0.28	0.29	0.06	0.01
C20:3 n-6	0.33	0.32	0.28	0.01
C20:4 n-6	4.21	3.73	0.02	0.33
C20:3 n-3	0.08	0.08	0.61	0.01
C22:5 n-3	0.65	0.57	0.04	0.01
PUFA	34.74	34.18	0.37	3.19
PUFA/SFA	0.92	0.94	0.31	0.01
(MUFA+PUFA)/SFA	1.50	1.58	0.19	0.01
n-6/n-3	10.52	10.57	0.93	2.77

Note: SFA = saturated fatty acids; MUFA = monounsatured fatty acids; PUFA = polyunsatured fatty acids

CONCLUSIONS

Some variation in meat quality due to the different rearing system are noted: the meat from Outdoor reared rabbits appears less pale with a significantly higher content of intramuscular fat, that is positively related to the reduction in cooking loss. Moreover, Outdoor rearing system seems to reduce the content of SFA and increase that of MUFA in the hind leg meat. For these reasons, Outdoor rearing seems to be an alternative housing system that satisfy the ethical concern of modern consumer, even furnishing good meat quality.

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