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INFLUENCE OF OPEN-AIR REARING ON FATTY ACID COMPOSITION AND SENSORY PROPERTIES OF RABBIT MEAT

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Abstract: A study was conducted to evaluate the fatty acid (FA) composition and sensory properties of meat from rabbits housed in the open-air in movable colony cages on pasture during the fattening period. A total of 60 rabbits were reared using conventional husbandry practises and subsequently divided into two groups at a live weight of about 2.0 kg and at 62 days old. The indoor group was kept in conventional bi-cellular cages (2 animals per cage, 0.07 m^2 per rabbit), while the open-air group was reared in movable colony cages (6 animals per cage, 0.17 m^2 per rabbit) on a polyphyta natural pasture. The grass was cut on the pasture prior to moving the cages so that the rabbits would not be able to eat the grass. Both groups were fed *ad libitum* a commercial diet for fattening rabbits. The rabbits were slaughtered when 13 weeks old. Fourteen carcasses from each experimental group were randomly collected and hind leg and loin meat were used to determine the intramuscular lipid content, FA composition and sensory attributes. Rabbits housed open-air in movable cages exhibited lower carcass weight (1110 *vs* 1243 g; $P<0.01$) and lipid content of the hind leg meat (3.61 *vs* 5.18%; $P<0.01$) as well as a higher content of PUFA (36.9 *vs* 32.5%; $P<0.05$) and arachidonic acid (5.9 *vs* 1.9%; $P<0.05$). However, no differences were found in the n-6/n-3 PUFA ratio. The quantitative descriptive analyses of the meat (*Longissimus lumborum* muscle) sensory properties did not show any differences between the experimental groups.

Key words: rabbit, open-air rearing, meat, fatty acid composition, sensory properties.

INTRODUCTION

There is an ever-growing consumer interest in the way in which farm animals are kept, transported and slaughtered. In the future, housing systems for meat

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production will have to consider the welfare of animals as well as the consumers' needs. Therefore, there is a need to change from current housing systems to systems which are closer to the natural behaviour of rabbits without impairing economic results and food safety. Several researchers have proposed housing systems in pens because they allow more freedom of movement for rabbits, an increase in group size and more available space. The first results from housing systems in floor pens or colony cages seem to indicate a reduction of stress and aggressive behaviour of the animals (Maertens and Van Herck, 2000; Lebas, 2001). However, they also highlight a higher mortality rate (mainly due to coccidiosis), lower growth rate, feed intake and feed efficiency as well as a poorer carcass dressing percentage and sometimes lower meat quality characteristics (Van Der Horst *et al.*, 1999; Cavani *et al.*, 2000; Dal Bosco *et al.*, 2000; Lambertini *et al.*, 2001).

Finzi and Margarit (1999) have proposed open-air housing in movable cages. This housing system provides more space for animals, which are reared in a recognisably 'natural' way compared to rabbits housed in conventional rabbitries. Furthermore, rabbits are kept away from faeces by changing the position of the cages on pasture. This practice reduces health problems as well as pharmacological control of enteric diseases mainly related to coccidiosis.

More recently, in order to determine the feasibility of pasturing as a means of production, McNitt *et al.* (2003) compared the productivity of fryer rabbits kindled in conventional hanging wire cages in a building and finished in a pasture pen (InOut), kindled and reared in a pasture pen (OutOut) or kindled and reared in the cages (OutOut).

The aim of this study was to evaluate the influence of an open-air housing system in movable cages on the fatty acid composition and sensory properties of rabbit meat.

MATERIAL AND METHODS

The animals used in the present study were 60 rabbits (both males and females) of the "Leprino of Viterbo" synthetic breed reared using conventional husbandry practises at the Unconventional Rabbit Breeding Experimental Centre - University of Tuscia. At the live weight of about 2.0 kg (62 days old), the rabbits were divided into two groups. The first group (indoor or control group) was kept indoors in conventional bi-cellular cages (2 animals per cage, 0.07 m^2 per rabbit), while the second group (open-air group) was reared outdoors in movable colony cages (6 animals per cage, 0.17 m^2 per rabbit) on a polyphyta natural pasture. Grass was cut to a height of about 3 cm before moving the cages, in order to avoid the consumption of grass by the rabbits. The trial was carried out in spring (from May 16th to June 10th). Mean temperatures indoors were 21.3 ±1.5°C and 14.4±1.4°C (maximum and minimum) and R.H 75.2 ±10%. Mean temperatures outdoors were 25.0±2.8°C and 12.4±2.1°C (maximum and minimum) and R.H. 90.7 ±10%. Animals reared outdoors were protected against direct sun and rain since the movable cages were partially covered (Margarit *et al*., 1999). Both groups were fed *ad libitum*, with a non-medicated commercial diet for fattening rabbits (crude protein 16.5%; crude fibre 15.3%) and had free access to water. The animals from both the indoor and open-air group were slaughtered at 13 weeks old and the carcasses were prepared as recommended by Blasco and Ouhayoun (1996). Fourteen carcasses from each experimental group were randomly collected and used to determine the lipid content and FA composition of the hind leg meat as well as the sensory characteristics of the loin meat. After 24 h chilling at 4°C, the loin region (between the 1st and 7th lumbar vertebra) and the hind region (from the 7th lumbar vertebra backwards) were excised from each carcass, vacuum-packed and stored at –18°C pending analysis.

The hind regions were thawed at +4°C for 24 h and each right hind leg was subsequently deboned and carefully trimmed to remove visible adipose tissue, aponervosis and tendon. The meat was minced in a food processor after adding 0.01% of butyl hydroxy toluene (BHT) in order to avoid lipid degradation. The total lipid content was determined using a modification of the method initially proposed by Folch *et al*. (1957), according to the procedure described by Toschi *et*

al. (2003) and expressed as g of lipid/100 g of meat.

Total lipids for FA analysis were extracted by using an accelerated solvent extraction system (ASE 200, Dionex, Salt Lake City, Utah, U.S.A.) and a chloroform/methanol (2:1) mixture as solvent (TOSCHI *et al.*, 2003). The FA composition of total lipid was determined by gas chromatography. Fatty acid methyl esters (FAME) were prepared by sodium methoxide-catalysed transesterification (CHRISTIE, 1989) and analysed using a capillary gas chromatograph (Carlo Erba Instruments, Milan, Italy) equipped with a 50m×0.25mm i.d. fused silica capillary column CP-SIL88 (Chrompack Ltd®, Middelburg, The Netherlands) coated with a stationary non-bonded phase of 100% cyanopropylpolysiloxane (0.2 mm film thickness). Helium was the carrier gas (1.5 ml/min). The oven temperature was programmed from 50 to 120°C at 10°C/min and from 120 to 220°C at 2.5°C/min. A flame ionisation detector (FID) working at 240°C was used. FAME were identified by reference to standards from Nu-Check-Prep, Inc (Elysian, MN, USA). The results were processed by using a "TurboChrom Workstation" (Perkin-Elmer, USA) and expressed as weight percent (wt%) of the total identified FAME.The unsaturation index (U.I.) was calculated according to BORDONI *et al*. (1999), whereas atherogenic (A.I.) and thrombogenic (T.I.) indexes were calculated as indicated by ULBRICHT and SOUTHGATE (1991) as follow:

$$U.I. = \sum_{1}^{n} \%\ fatty\ acid_i \times number\ of\ double\ bounds\ in\ the\ fatty\ acid_i$$

$$A.I. = \frac{lauric + 4 \times miristic + palmitic}{PUFA\ n-3 + PUFA\ n-6 + MUFA}$$

$$T.I. = \frac{miristic + palmitic + stearic}{0.5 \times MUFA + 0.5 \times PUFA\ n-6 + 3 \times PUFA\ n-3 + {}^{n-3}\!/_{n-6}\ ratio}$$

A descriptive test, conventional profiling (ISO, 1985) was carried out by a trained panel (9 members) very experienced in tasting both rabbit meat and beef. A preliminary session was carried out for discussion and sensory assessment of rabbit

meat samples from commercial rabbit carcasses. The panel members selected the following sensory parameters to be used during the sensory evaluation: colour, aroma, rabbit aroma, tenderness, fibrous trait, coating trait, taste, taste persistency and off-flavours (Table 1). Most of these parameters were described and adopted by other authors for sensory evaluation of rabbit meat (GONDRET *et al*., 1998; JEHL and JUIN, 1999). The sensory analysis was conducted in a certified sensory laboratory (ISO, 1989). A total of 12 rabbit carcasses from open air and 12 carcasses from the indoor group were used during three replicate trials (4 carcasses/trial from the open-air and 4 carcasses/trial from the indoor group). After 2 months storage at -18°C, the loin regions from each carcass were thawed at 4°C for 24 h and both the right and left *Longissimus lumborum* (LL) muscles were dissected. Two meat samples were

Table 1: Description and scale of sensory attributes.

Descriptors	**Description/scale**
Colour	Colour evaluation of a transversal section of the meat Scale: 0 = white-yellow colour – 10 = white-grey colour
Aroma	The intensity of total aroma perceived by sniffing Scale: 0 = low aroma intensity – 10 = high aroma intensity
Rabbit aroma	The intensity of aroma with which a meat sample is recognized as distinctly rabbit meat rather than another species Scale: 0 = low rabbit aroma intensity – 10 = high rabbit aroma intensity
Tenderness	The force needed to cut a meat sample with a knife Scale: 0 = little force – 10 = much force
Fibrous trait	The perception of meat fibres Scale: 0 = little fibrous – 10 = very fibrous
Coating trait	The abundance of sawdust-like particles coating the mouth Scale: 0 = little coating – 10 = much coating
Taste	The intensity of meat taste Scale: 0 = low intensity – 10 = high intensity
Taste persistency	The persistency of meat taste after swallowing Scale: 0 = low persistency – 10 = high persistency
Off-flavours	The presence of off-flavours Scale: 0 = not perceptible – 10 = very perceptible

obtained from each LL muscle (4 samples/rabbit) by cutting the meat perpendicularly to the direction of the fibre. The samples were steamed for 20 minutes without salt or spices and served to the panel members who scored the meat samples (one indoor *vs* one open-air) for the nine descriptors described in Table 1 using a 10 cm long scale.

Data were analysed by using the GLM (General Linear Models) procedure (SAS Institute, 1988) using a model which included the rearing system (indoor *vs* open-air) as fixed effect.

RESULTS AND DISCUSSION

Rabbits housed open-air in movable cages showed a lower growth rate so that their carcasses exhibited a lower weight (1110 *vs* 1243g; $P<0.01$) and a lower lipid content (3.61 *vs* 5.18%; $P<0.01$) compared to their conventionally reared counterparts (Table 2). These results could be due to the higher energy expenditure for exercise and thermoregulation as reported by several authors in outdoor rearing systems (Lebas and Ouhayoun, 1987; Margarit *et al.*, 1999; Verga, 2000). In previous studies, with the same open-air rearing system it took two more weeks to gain a slaughter weight similar to the one obtained with indoor rearing (De Lazzer and Finzi, 1992; Finzi *et al.*, 1993).

The FA composition of the hind leg meat is reported in Table 2. Rabbits reared open-air had meat with higher saturated fatty acid (SFA) content (40.3 *vs* 37.5%; $P<0.05$) mainly due to the stearic (C18:0) (9.66 *vs* 6.78%; $P<0.01$), nonadecanoic (C19:0) and eicosanoic (C20:0) acids. This group exhibited a lower monounsaturated fatty acids (MUFA) content (22.8 *vs* 29.9%; $P<0.01$), mainly due to oleic (C18:1 n-9) (18.2 *vs* 24.0%; $P<0.01$), palmitoleic (C16:1) and heptadecenoic (C17:1) acids. On the other hand, the polyunsaturated fatty acids (PUFA) level was higher (36.9 *vs* 32.5%; $P<0.05$) because of the higher content of both n-6 (32.6 *vs* 28.6%; $P<0.05$) and n-3 PUFA (4.4 *vs* 3.9%; $P=0.07$). The higher PUFA n-6 content was determined

by arachidonic (C20:4 n-6, 5.88 *vs* 1.92%; $P<0.05$) and docosatetraenoic (C22:4 n-6, 0.99 *vs* 0.49%; $P<0.05$) acids which were respectively three and two times higher compared with the indoor group. The higher level of n-3 PUFA was determined by the eicosatrienoic (C20:3 n-3) (0.40 *vs* 0.18%; $P<0.01$), docosapentaenoic (C22:5 n-3, DPA) (1.20 *vs* 0.44%; $P<0.01$) and docosahexaenoic (C22:6 n-3, DHA) (0.27 *vs* 0.10%; $P<0.05$) acids, whereas the linolenic acid (C18:3 n-3) was higher in meat from rabbit reared indoors (2.89 *vs* 2.11%; $P<0.05$).

The most interesting result was the higher level of PUFA in rabbit meat from the open-air group. It is generally recognized that when the lipid content of the muscle falls the proportion of phospholipids in the total lipid rises (Enser, 1999) so that the higher long chain PUFA content could be considered as a consequence of the lower muscle fat content in open-air reared rabbits compared with the indoor group. Alasnier *et al*. (1996) reported that phospholipids in rabbit meat are rich in PUFA, mainly in arachidonic acid.

Because of the increase in both n-6 and n-3 FA levels, the higher arachidonic acid (C20:4 n-6) content did not negatively unbalance the n-6/n-3 PUFA ratio in the open-air rabbit meat. The atherogenic and thrombogenic indexes were not affected by the type of rearing, whereas the unsaturation index was significantly higher in the open-air group as a consequence of the higher PUFA content.

Fatty acids are involved in many "technological" aspects of meat quality. The main problem associated with the enhancement of the PUFA content in the meat is due to the propensity of unsaturated fatty acids to oxidise, thus limiting the shelf-life of meat products mainly by modifying the sensory properties of the meat and causing a change in the colour of the meat during storage with detrimental effects on the appearance of the product (Bianchi *et al.*, 2004; Wood *et al.*, 2003; Enser, 1999).

The Quantitative Descriptive Analyses of meat sensory properties did not show any difference between the experimental groups (Figure 1).

Table 2: Carcass weight, lipid content and FA composition of hind leg meat.

	Rearing System			
	indoor	open-air	SEM	Significance
n°	14	14		
Carcass weight (g)	1243	1110	55	*
Lipid content (%)	5.18	3.61	0.42	**
Fatty acid (% total methyl esters)				
C12:0	Trace amounts[1]	Trace amounts[1]		
C14:0	2.06	1.65	0.24	NS
C14:1	0.25	0.19	0.04	NS
C15:0	0.51	0.46	0.05	NS
C16:0	27.1	27.3	1.10	NS
C16:1	3.32	2.16	0.42	*
C16:1 (r)[2]	0.36	0.32	0.05	NS
C17:0	0.63	0.68	0.03	NS
C17:1	0.35	0.24	0.03	**
C18:0	6.78	9.66	0.95	**
C18:1 n-7	1.14	1.18	0.07	NS
C18:1 n-9	24.0	18.2	2.0	**
C18:1 t	0.21	0.21	0.03	NS
C18:2 n-6	25.5	24.6	1.16	NS
C18:3 n-3	2.89	2.11	0.42	*
C18:3 n-6	Trace[1]	Trace[1]		
C19:0	0.21	0.26	0.03	*
C20:0	0.16	0.19	0.01	*

Continued Table 2.

	Rearing System			
	indoor	open-air	SEM	Significance
C20:1 n-9	0.31	0.29	0.02	NS
C20:2 n-6	0.26	0.26	0.01	NS
C20:3 n-3	0.18	0.40	0.09	**
C20:3 n-6	Trace[1]	0.10	0.02	
C20:4 n-6	1.92	5.88	1.82	*
C20:5 n-3 (EPA)	0.23	0.37	0.08	NS
C22:3 n-3	Trace[1]	Trace[1]		
C22:4 n-6	0.49	0.99	1.03	*
C22:5 n-3 (DPA)	0.44	1.20	0.32	**
C22:5 n-6	0.34	0.62	0.16	NS
C22:6 n-3 (DHA)	0.10	0.27	0.08	*
Total SFA	37.5	40.3	1.3	*
Total MUFA	29.9	22.8	2.1	**
Total PUFA n-6	28.6	32.6	1.6	*
Total PUFA n-3	3.87	4.39	0.3	0.07
Total PUFA	32.5	36.9	1.8	*
PUFA/SFA	0.87	0.93	0.06	NS
n-6 / n-3	7.39	7.52	0.28	NS
Atherogenic index	0.57	0.58	0.05	NS
Thrombogenic index	0.88	0.96	0.03	NS
Unsaturation index	117.2	136.1	11.2	*

** $P<0.01$; * $P<0.05$.
NS: not significant.
[1]: < 0.1% and = 0.05%.
[2]: C16:1 ramified (CHRISTIE, 1989)

These results are consistent with the findings of MARGARIT *et al.* (1999) who compared characteristics of meat from rabbits housed either indoors in bi-cellular cages or open-air in movable colony cages. However, AMICI *et al*. (1992), using an untrained panel, reported that rabbit housed open-air for 60 days produced a meat with a higher overall acceptance than those reared indoors.

In conclusion, the open-air rearing system in colony cages provided leaner meat with a higher PUFA content compared to a conventional indoor rearing system. These characteristics could be exploited by the food industry in order to promote "natural" rabbit meat products in line with consumer trends towards animal welfare and food safety.

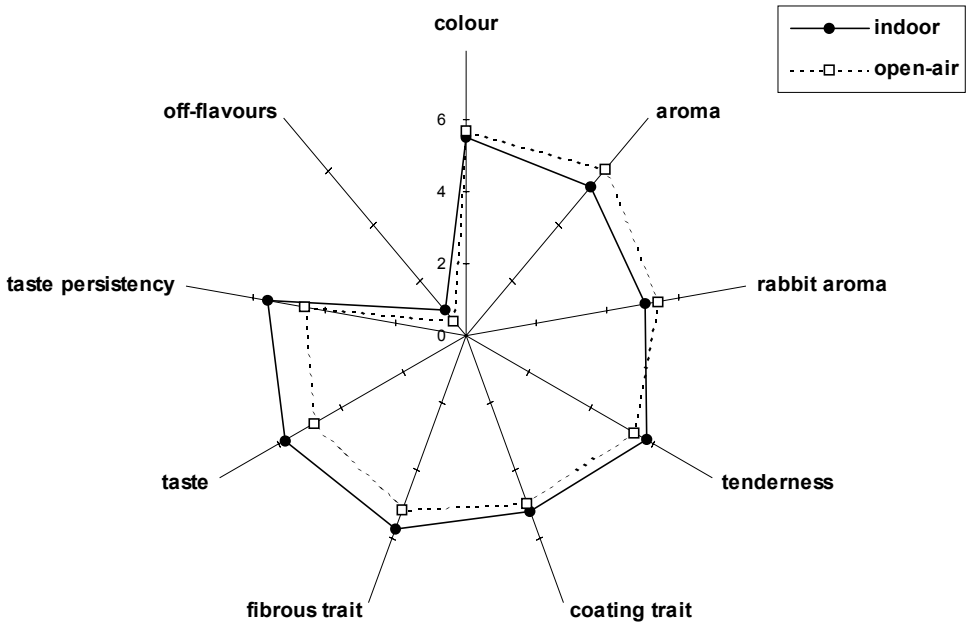

Figure 1: Spider plot for sensory traits of rabbit meat (least square means).

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