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Effect of Different Raising Techniques on *In vivo* Performance and Carcass and Meat Traits of Ischia Grey Rabbit

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ABSTRACT : One-hundred and twenty Ischia grey rabbits, traditionally raised in pits, were equally divided after weaning (32 days) into three groups: group C, housed in cages (4 rabbits/cage) and fed a commercial concentrate; group GF, housed as C group and fed grasses collected on the island and crushed faba beans supplemented with an appropriate mineral vitamin mix; group P, housed in pits (8 rabbits/pit) and fed as GF group. Feed intake was recorded daily and live weight monthly up to slaughter (92 days). At slaughter, 10 rabbits per group were used to measure carcass and meat traits. The carcasses were weighed and measured according to the standard procedures and meat samples from the *Longissimus dorsi* and left hind leg were analysed for water holding capacity and chemical composition, respectively. During the entire trial, group C consumed significantly ($p<0.01$) a higher quantity of feed than the other groups (126.1 vs. 63.4 and 66.5 g/d, resp. for groups C, GF and P) and at slaughter showed a significantly ($p<0.01$) higher body weight (2,529.7 vs. 1,324.4 and 1,375.4 g, resp. for groups C, GF and P). Significant differences ($p<0.01$) were found also for dressing out percentage (68.6 vs. 66.6 and 66.9%, resp. for groups C, GF and P) and for meat chemical composition, in particular lipid percentage (4.13 vs. 1.84 and 1.93%, resp., for groups C, GF and P, $p<0.01$) and moisture (73.7 vs. 76.4 and 76.3%, resp. for groups C, GF and P, $p<0.01$). The results suggest the opportunity to obtain heavier animals raised in the pits if their diets were integrated with commercial feed. (**Key Words :** Ischia Grey Rabbit, Raising Technique, Carcass Characteristics, Meat Quality)

INTRODUCTION

In the last decades, increasing the attention on the quality of foods of animal origin, intensive farming is considered as a negative condition because of irrespective of animal welfare. In fact, focusing the attention on meat production, it is known that the stress can cause undesirable effects on the end quality of meat such as pale, soft, exudative meat and dark firm dry meat. In this context, meat produced with "alternative" raising technique arouses a very great interest, also from the researchers. In the alternative raising systems one or more factors, in particular the breed or hybrid raised, management and nutrition, differ from the conventional raising model (D'Agata et al., 2007).

On the Ischia island (Napoli, Italy), the raising of rabbits in "pits" was re-introduced some years ago. The system differs in all the three above indicated factors from the conventional raising systems (in cage feeding commercial concentrates). The animals raised in pits are a local genetic type called Ischia grey rabbit and classified as a slow-growing breed (Nizza and Barbato, 2003). The pits are about 2 metres deep with a surface area of 3-4 m^2, and the offered feeds consisted in grasses collected on the island and products or by-products homemade in the farm. On a wall of the pit, the farmer provides a tunnel that, later, the rabbits dig for several meters. The habitat into the pits is in perfect agreement with the natural behaviour of the species. To catch the rabbits there is a closure system of the tunnel. The pit rabbit, appreciated by consumers for its meat flavour, represents a very important economic resource for the island, where individual rabbit meat consumption is estimated as 40 kg/year. This makes the individual rabbit meat consumption in Campania region (where Ischia island is located) about 16 kg per year *versus* an average consumption in Italy of 4.5 kg/head/year. Awaiting a preparation of a specific protocol to regulate the production of Ischia pit rabbits, which could be designated as a PGI (protected geographical indication) product, Bovera et al. (2004) studied the carcass and meat characteristics of pit rabbits raised on Ischia island. Even if slaughtered, according to island traditions, at 16-20 weeks of age, the

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Table 1. Chemical and nutritional characteristics of the feeds used in the trial

	DM %	Ash % DM	CP % DM	EE % DM	CF % DM	NDF % DM	ADF % DM	ADL % DM	DE kcal/kg a.f.
Grasses	87.64	13.40	13.12	5.13	26.53	55.48	41.10	7.98	1,896
Faba	87.71	3.81	29.72	2.47	8.41	29.15	13.24	1.16	2,834
Concentrate*	87.00	10.92	18.97	3.79	18.97	32.12	21.73	3.57	2,295

DM = Dry matter, CP = Crude protein, EE = Extract ether, CF = Crude fibre, NDF = Neutral detergent fibre, ADF = Acid detergent fibre, ADL = Acid detergent fibre, DE = Digestible energy.

* Ingredients: dehydrated alfalfa meal, wheat middlings, sunflower meal, alfalfa hay, maize, sugar cane molasses, toasted soybean meal, calcium carbonate, salt, soybean oil.

rabbits showed a low live weight at slaughter (1,285.9 g±16.18), poor hot dressing out (52.39%±3.47) and high incidence of the gastro-intestinal tract (26.42%±3.54). Nevertheless, the meat chemical characteristics did not greatly differ from those of rabbits of genetic types selected for meat production. In another study, Bovera et al. (2005) recorded interesting nutritional characteristics of pit rabbit meat, as a low ω6/ω3 ratio (3.08) and favourable atherogenic (0.68) and thrombogenic (0.72) indexes. What factor (genetic type, raising technique, feeding) more contributes to the particular characteristics of the Ischia grey rabbit carcasses and meat have to be investigated.

The raising technique in pits could represent a model for raising in developing countries, where not much technologies are available for rabbit production.

The aim of our study was to compare *in vivo* performance and carcass and meat traits of Ischia grey rabbits raised with three different techniques: in cages fed a commercial concentrate; in cages fed grasses collected on the island, crushed faba bean with mineral vitamin supplementation; in pits fed grasses, faba bean and mineral vitamin.

MATERIAL AND METHODS

The study was carried out on a rabbit farm located at the island of Ischia (Italy). At the end of February 2005 twenty pregnant Ischia grey does were placed in individual cages (0.5 m^2 area×50 cm height) and fed *ad libitum* a "unique cycle" commercial concentrate (Table 1). At litter weaning (32 day of age) 80 (sex ratio 50:50; average body weight 680.9 g±22.3) rabbits were homogeneously distributed in 20 cages (4 rabbits/cage) with the same characteristics as the does' cages and were divided into two groups: the first (group C, 10 cages, 40 rabbits) were fed *ad libitum* up to slaughter the same concentrate as the does; the second group (GF, 10 cages, 40 rabbits) were fed *ad libitum* grasses collected on the island (in particular: *Psoralea bituminosa*, *Avena fatua*, *Lupinus albus*, *Agropyrum repens*), appropriately sun-dried, crushed faba beans as protein source and an appropriate vitamin-mineral mix. Other 40 rabbits (group P) were housed in 5 pits (8 rabbits/pit) and fed as group GF. Grasses and crushed faba beans were offered in separated troughs. The feeds were analysed for chemical composition according to AOAC (2000) and, the content of Digestible Energy (DE) was estimated according to the equation proposed by Xiccato (1989).

The rabbits were weighed at weaning (32 days of age) and then each 30 days until slaughter (92 days), to calculate daily weight gain (DWG). Moreover, from weaning, the daily intake of concentrate, grasses and faba were recorded for each cage and for each pit by weighing the amounts of offered feeds and the corresponding refusals.

At 92 days, one animal per cage and two for pit (a total of 10 animals from each group) were slaughtered, after 12 hours' fasting. On the carcasses, according to Blasco et al. (1992) recommendations, the following weights were recorded: full and empty gastrointestinal tract; skin; distal legs and tail; urogenital tract with empty bladder. From the remaining carcasses (commercial carcasses or CC), weighed before and after refrigeration at 4°C for 24 h, the following were dissected and weighed: head; liver; the whole heart, lungs, oesophagus, trachea, thymus gland and kidney free of perirenal fat. From the resulting "reference carcass" (RC) the hind legs and the *Longissimus dorsi* (LD) muscle were separated.

With a Hanna portable instrument, mod. HI 9025, equipped with electrode FC 230C, the pH of LD and *Biceps femoris* (BF) muscles was measured at 1 h and 24 h post mortem. The water holding capacity (WHC) was measured according to four different methods in order to evaluate the water losses of the meat under different condition of cooking (on hot plate, in bain-marie), conservation (refrigeration) or handling (pressure). The following procedures, normally used for bovine meat, were appropriately modified. On sections of LD muscles (size: 25×25×5 mm) the weight losses were evaluated after: i) refrigeration at 4°C for 48 h in a container with grate as indicated by Lundström and Malforms (1982); ii) cooking on a hot plate at 300°C until the core temperature of 70°C is reached (Wheeler et al., 1990); iii) cooking in a bain-marie in a polyethylene bag at 70°C for 15 minutes (Gault, 1985); iv) pressure for 10 minutes according to Grau and Hamm (1957), measuring the weight losses. The left hind leg was used to evaluate the percentage of meat (M), bone (B) and fat. The meat to bone ratio was calculated according to

Table 2. Individual intake of feeds and of digestible energy of the three groups

	C	GF	P	MSE
	---------- Individual feed intake (g/d) ----------			
32-62 days	105.1^{A}	53.2^{B} (28.5+24.7)*	55.4^{B} (29.6+25.8)*	6.12
63-92 days	147.2^{A}	73.8^{B} (45.0+28.8)*	77.6^{B} (47.2+30.4)*	7.54
Overall (32 to 92 days)	126.1^{A}	63.4^{B} (36.7+26.7)*	66.5^{B} (38.4+28.1)*	6.58
	---------- Individual intake of digestible energy (DE, kcal/d) ----------			
32-62 days	241.2^{A}	124.1^{B}	129.2^{B}	25.64
63-92 days	337.9^{A}	166.8^{B}	175.7^{B}	39.48
Overall (32 to 92 days)	289.5^{A}	145.5^{B}	152.4^{B}	19.54

C = Cage+concentrate group; GF = Cage+grass and faba group; P = Pit group; A, B = $p<0.01$; MSE = Mean square error; * Enclosed in parenthesis separate intake of grass and crushed faba.

Parigi-Bini et al. (1992) as follows: M/B = (raw hind leg weight-bone weight)/bone weight. The meat from hind leg dissection was ground, freeze-dried, and analysed for water, fat and ash (AOAC, 1984). The percentage of protein was calculated by difference.

Data were processed by ANOVA (SAS, 2000) using the model: $Y_{ijk} = \mu+R_i+S_j+(R\times S)_{ij}+\varepsilon_{ijk}$ where: Y is the single observation; μ is the general mean; R is the raising technique effect (i = cage+concentrate; cage+grass and faba; pit+grass and faba); S is the sex effect (j = male or female); R×S is the interaction between effects; ε is the error.

RESULTS AND DISCUSSION

Table 2 shows the average intake of the feeds and of digestible energy recorded from weaning to 62 days, from 63 days to slaughter and along the entire trial. As expected, the group raised in cage and fed the commercial concentrate (C) showed higher feed intake than groups GF and P. The recorded values are in agreement with the findings of Nizza et al. (2001) and Di Meo et al. (2004). The authors, in New Zealand White rabbits, found, respectively, at the first and second week post weaning feed intake of 110.5 and 108.4 g/d, and intake of 111.2 g/d from 35 to 77 days. However, the feed intake recorded in the present trial is lower than that reported by other authors in commercial hybrid selected for meat production: Piattoni et al. (1998), 120.5 g/d between 42 and 56 days of age; Gidenne et al. (2004), 142.3 g/d between 49 and 70 days; Xiccato et al. (1999) 162.5 g/d between 45 and 80 days, Chang et al. (2007) 143.5 g/d within 30 days after weaning. The groups GF and P showed a similar feed intake, significantly lower than C group. This result, is probably due to the "encumbrance" effect of the grasses. As a consequence of lower feed intake, daily weight gains during the entire trial were significantly ($p<0.01$) lower for the rabbits of groups GF (10.79 g/d) and P (11.57 g/d) than the rabbits of group C (30.75 g/d). On the other hand, subtracting from the digestible energy intake (Table 2) the DE for maintenance (102.8 kcal/d/kg $LW^{0.75}$, Parigi-Bini and Xiccato, 1998), the DE available for growth in groups GF and P was on average just below half than group C. As regards the "sex" effect, no significant differences were found for live weight and daily feed intake during the trial. However, considering only group C, the DWGs (Table 3) were much lower than those reported by Nizza et al. (2001) in NZW rabbits at the first and second week post weaning (an average 39.63 and 37.07 g/h/d), by Piattoni et al. (1998) in commercial hybrids between 32 and 56 days of age (an average 44.2 g/h/d), and by Piccolo et al. (2005) in NZW rabbits between 33 and 46 days (35.2 g/h/d). Also considering the entire period of the trial, daily weight gain resulted lower than the data recorded by Di Meo et al. (2007) in commercial hybrids (40.0 g/d/head). However, we have to take into account that in the trial of Di Meo et al. (2007) the rabbits were slaughtered at 84 days, one week before the animals of the present trial.

Table 4 and 5 show, respectively, the carcasses and meat

Table 3. Rabbit live weight (g) and daily weight gain (DWG, g/day)

n	C 40	GF 40	P 40	♂ 60	♀ 60	Inter.	MSE
	---------- Live weight (g) ----------						
32 days	684.5	677.0	681.2	680.0	681.8	NS	332.2
62 days	1,513.9^{A}	1,032.2^{B}	1,050.3^{B}	1,202.4	1,195.2	NS	3,627.8
92 days	2,529.7^{A}	1,324.4^{B}	1,375.4^{B}	1,745.1	1,741.2	**	10,546.8
	---------- Daily weight gain (g/d) ----------						
32-62 days	27.65^{A}	11.84^{B}	12.30^{B}	17.41	17.11	NS	3.32
63-92 days	33.86^{A}	9.74^{B}	10.84^{B}	18.09	18.20	NS	17.55
Overall (32 to 92 days)	30.75^{A}	10.79	11.57	17.75	17.66	**	22.19

C = Cage+concentrate group; GF = Cage+grass and faba group; P = Pit group; A,B = $p<0.01$; NS = Not significant; Inter. = Interaction; MSE = Mean square error.

Table 4. Carcass traits

n	C 10	GF 10	P 10	♂ 15	♀ 15	MSE
Skin (% LW)	17.1^{A}	15.4^{B}	15.5^{B}	15.9	16.1	0.87
Full GI (% LW)	15.5^{B}	20.9^{A}	20.8^{A}	17.6^{b}	20.5^{a}	2.87
Empty GI	7.58^{B}	9.35^{A}	9.31^{A}	8.61	8.83	0.30
Hot carcass (g)	1,597.1^{A}	768.0^{B}	811.0^{B}	1,090.6	1,026.8	23,362
Net HDO (%)	68.2^{a}	66.6^{b}	66.9^{b}	67.4	67.4	0.63
Chilled carcass (g)	1,557.5^{A}	740.4^{B}	782.6^{B}	1,057.9	992.9	22,727
Liver (% ChC)	5.20	4.46	4.50	4.60	4.84	0.66
TTOLH	1.21^{B}	1.68^{A}	1.62^{A}	1.38	1.45	0.05
Kidney	1.02	1.18	1.15	1.05	1.07	0.03
Head	8.64^{B}	11.61^{A}	11.63^{A}	10.07	9.84	0.95
Ref. carcass (g)	1,307.8^{A}	597.8^{B}	634.6^{B}	868.4	813.9	18,136
PF	1.67^{A}	0.23^{B}	0.21^{B}	0.78	0.68	0.23
CL (cm)	31.7	30.7	30.8	30.0^{b}	32.1^{a}	5.01
CC (cm)	19.9^{A}	12.9^{B}	13.0^{B}	15.7	14.8	1.33
Left hind leg (g)	172.5^{A}	85.9^{B}	89.3^{B}	123.6	108.2	436.2
Bone (g)	22.3^{A}	12.1^{B}	12.2^{B}	15.8	15.2	3.60
Meat (g)	146.7^{A}	72.3^{B}	75.3^{B}	114.2	92.0	379.9
Fat (g)	1.75^{A}	0.42^{B}	0.41^{B}	0.75	0.97	0.22
M/B	6.57	5.97	6.17	7.22^{A}	6.05^{B}	0.58
pH LD 1 h	6.45	6.45	6.45	6.48	6.42	0.014
pH BF 1 h	6.70	6.67	6.68	6.69	6.69	0.01
pH LD 24 h	5.59	5.90	5.58	5.69	5.89	0.10
pH BF 24 h	5.82	5.95	5.94	5.80	6.00	0.05

C = Cage+concentrate group; GF = Cage+grass and faba group; P = Pit group; A,B = $p<0.01$; NS = Not significant; MSE = Mean square error; A, B = $p<0.01$; a, b = $p<0.05$. LW = Live weight; GI = Gastrointestinal tract; HDO = Hot dressing out; ChC = Chilled carcass; TTOLH = Tymus, trachea, oesophagus, lung and hearth; Ref. carcass = Reference carcass; PF = Perirenal fat; CL = Carcass length; CC = Carcass circumference; M/B = Meat to bone ratio; LD = Longissimus dorsi muscle; BF = Biceps femoris muscle.

Table 5. Meat traits

n	C 10	GF 10	P 10	♂ 15	♀ 15	MSE
Moisture (%)	73.7^{B}	76.4^{A}	76.3^{A}	75.4	75.5	0.51
Ash (%)	1.49^{A}	1.26^{B}	1.27^{B}	1.32	1.36	0.01
Protein (%)	20.7	20.6	20.6	20.9	20.3	0.90
Lipid (%)	4.13^{A}	1.84^{B}	1.93^{B}	2.40	2.87	0.32
	---------- Water holding capacity ----------					
CHL (%)	13.4	14.35	14.30	13.81	14.22	1.77
BMC (%)	31.5	34.1	34.2	34.9^{A}	31.5^{B}	8.71
HPC (%)	34.7	34.6	34.6	35.3	34.1	8.39
Pressure (%)	15.0	16.4	16.3	15.6	16.2	3.83

CHL = Chill losses; BMC = Bain-marie cooking; HPC = Hot plate cooking.

traits of rabbits by raising technique and sex. The interaction between the effects resulted not significant for all the parameters and was not reported in the table. As expected, group C showed significantly ($p<0.01$) higher values for the weights of hot, chilled and reference carcasses, as well as for the percentages of skin. Groups GF and P showed a higher incidence of the full (15.5 vs. 20.9 and 20.8% LW, $p<0.01$, respectively for groups C, GF and P) and, empty gastrointestinal tract (7.58 vs. 9.35 and 9.31% LW, $p<0.01$, respectively for groups C, GF and P) and head (8.64 vs. 11.61 and 11.63% PV, $p<0.01$, respectively for groups C, GF and P). As a consequence, significant differences were found for net hot dressing out, higher for the group C, probably due to the lower incidence of empty gastro-intestinal tract. The dressing out values (on average 67.4%) were in agreement with the findings of other authors on commercial hybrids selected for meat production (Parigi-Bini et al., 1992). As expected, group C shoved significantly ($p<0.01$) higher values for the percentage of perirenal fat (1.67 vs. 0.23 and 0.21% respectively for groups C, GF and P).

Regarding carcass measurements, the main differences were in carcass circumference, indicating a poor development of muscular mass in groups GF and P. The meat to bone ratio, albeit not statistically different between the groups, was higher in the group C. However, the

reduced muscular mass was accompanied by a lower bone weight in the animals of groups GF and P. Finally, as regards meat physical and chemical characteristics, group C showed higher percentages of fat (4.13 vs. 1.84 and 1.93%, respectively for groups C and GF, $p<0.01$) and lower moisture contents (73.7 vs. 76.4 and 76.3%, respectively for groups C and GF, $p<0.01$).

In our trial, raising technique determined great modification in carcass and meat traits of Ischia grey rabbit. In particular, the differences were found among the raising in cage, feeding a commercial concentrate and the other two techniques (in cage feeding grass and crushed faba beans or in pits feeding grass and crushed faba bean). This seems indicate, firstly, that, Ischia rabbit, feeding an adequate diet in terms of energy supplies, can reach very interesting weight at slaughter. With this raising technique, Ischia rabbits reach a great development of muscular mass but, the higher energy content of the diet induce, in this low-growth genetic type, a significantly higher accumulation of adipose tissue (dissectible and intramuscular) than the other two raising technique that can probably affect the flavour of the meat. Very interesting to note, the raising technique in pit with traditional island feeding do not induce differences in terms of carcass and meat traits in respect of the raising technique in cage but with the traditional island feeding. It can mean that rabbits in pits, once the tunnels were dug, spent most of hits time to rest and that, the distance between the tunnels where animals stay and the feeding area in pits are not so long to justify a higher quote of energy spent for movements. This also considering that no statistical differences in feed intake of both grass and faba were found between the groups GF and P.

No significant differences emerged between the sexes, except between the percentage incidences of the full gastrointestinal tract, carcass length, meat to bone ratio and bain-marie cooking losses.

CONCLUSIONS

Our results allow us to formulate some preliminary conclusions. First, the Ischia grey rabbit is confirmed as a slow-growing genetic type, with a lower daily weight gain than those of commercial hybrids commonly used for meat production, even when it raised according to the intensive system (in cage with commercial concentrates as feed). Hence it reaches its slaughter weight at a high age.

The raising technique significantly affects carcass and meat characteristics of Ischia grey rabbits. The technique in cage, with a commercial concentrate as feed produces animals with higher live weight but also with an higher content of fat, intramuscular and of deposition. However, no differences were found in terms of dressing out percentage or other carcass and meat traits in respect of the other two raising techniques.

The results suggest the chance to obtain heavier animals raised in the pits if their diets were integrated with commercial feed. Further studies are in progress in order to verify, in rabbits raised in pits, the effect of the diet (grasses or commercial concentrates) on *in vivo* performance, carcass traits as well as on some nutritional characteristics of rabbit meat such as fatty acid composition, the macro and micro mineral contents, the colour and tenderness of the meat.

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