EFFECT OF CAGE FLOOR AND STOCKING DENSITY ON GROWTH PERFORMANCE AND WELFARE OF GROUP-HOUSED RABBITS

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ABSTRACT

Two hundred forty rabbits weaned at 36 d (LW=1103±41 g) were housed in groups to evaluate the effect of stocking density and type of cage floor on behaviour, health status, growth performance, and carcass and meat quality. The rabbits were put in groups of 6 into 40 cages of two sizes (78 x 64 cm or 58 x 64 cm) corresponding to two stocking densities (D12, 12.1 rabbits/m^2 vs. D16, 16.2 rabbits/m^2). Within density, four types of floor were compared (steel slat, plastic slat, wire net and straw litter on wire net) according to a 2 x 4 factorial arrangement with five replications (cages). The rabbits were fed a unique diet (CP: 15.8%, ADF: 19.3%, DE: 9.8 MJ/kg). No antibiotic was added to feed or water. Rabbit reactivity was assessed by the tonic immobility and open-field tests at 70 and 74 d of age. Rabbits were slaughtered at 78 d to evaluate carcass and meat quality. Femur dimensions and resistance to fracture were measured. Sanitary status and growth performance were highly satisfying in all treatments: growth rate averaged 45.5 g/d and final weight 2967 g, with a feed conversion rate of 3.49. Stocking density did not affect growth performance, meat quality, nor animal reactivity. In contrast, the type of floor significantly affected growth performance: rabbits kept on straw bedded floor showed the lowest final weight (2865 g vs. 3000 g on average, P=0.03), weight gain and feed intake. Differences in carcass and meat quality mainly depended on the weight at slaughter: dressing percentage and separable fat of the carcass were lower (P<0.01) in the lightest rabbits kept on straw (58.6% and 2.3%, respectively) compared to the heavier animals of the other three experimental groups (average values 59.9% and 3.0%, respectively). The type of floor also affected animal reactivity: the number of attempts necessary to induce immobility, considered inversely correlated with fear towards humans, was lower in rabbits kept on straw; these rabbits also showed a more passive reaction during the open field test, spending less time exploring and more time in an immobile state (P<0.01) in comparison with the animals housed in the cages with plastic slat or wire net floors.

Key words: Stocking density, Cage floor, Welfare, Growth performance, Meat quality.

INTRODUCTION

The increasing attention of consumers to the welfare of intensively reared animals has recently stimulated discussion on rabbit breeding as well (Verga, 2000; Combes and Lebas, 2003; Trocino and Xiccato, 2006). Since 1996, the Standing Committee of the European Council for the protection of Animals kept for intensive purposes has been working on specific recommendations for the welfare of domestic rabbits. The European Commission asked the European Food and Safety Authority (EFSA) for its opinion on "The impact of the current housing and husbandry systems on the health and welfare of farmed domestic rabbits" (EFSA, 2005a and 2005b). Different aspects of cages or pens (dimensions, type of floor, enrichment, etc.) are considered in view of their effects on animal comfort and welfare during rearing. The proposition is to substitute the individual or bicellular cages used in some countries (e.g. Italy) for group cages or pens to permit social interaction and to increase the space available per animal, in an attempt to enable natural behaviour. Some studies showed that group housing at high stocking densities negatively affects growth performance and favours animal aggressiveness especially with increasing age (Aubret and Duperray, 1992; Bigler and Oester, 1996; Morisse and Maurice, 1997). Also, rearing on wire net floors is considered unsuitable for animal welfare, because it does not permit the expression of some behaviours shown by wild animals, like scratching or digging. The presence of straw might also represent an environmental enrichment useful to limit aggressive interactions in group-housed rabbits, even if growing rabbits usually show a preference for wire net over straw bedded floors (Morisse *et al*., 1999; Dal Bosco *et al*., 2002). The objective of our study was to evaluate the type of cage floor and the effect of stocking density on behavioural patterns and reactivity, growth performance, carcass and meat quality of group-housed rabbits.

MATERIALS AND METHODS

Two hundred forty Grimaud rabbits of both sexes were weaned at 36 d (LW=1103±41 g) and put into 40 cages holding groups of 6 animals each. The cages were 64 cm-wide and had 120 cm-high sides made of wire net, a large wire net front door for inspection and no ceiling. The back wire net wall was movable, thus permitting to modify the cage dimensions (78 x 64 cm; 58 x 64 cm) that yielded two stocking densities (D12=12.1 rabbits/m^2, 825 cm^2/rabbit; D16=16.2 rabbits/m^2, 617 cm^2/rabbit). Within stocking density, the cages had four types of floor: steel slat (galvanized steel bars of 2.0 x 1.5 cm section and 1.5 cm span), plastic slat (plastic surface with 7.3 x 1.0 cm holes at a distance of 1.0 cm each other), wire net (galvanized wire net of 2.5 mm diameter forming grids of 7.5 x 1.5 cm) or wire net bedded with 5-cm layer of wheat straw. The experiment was designed according to a 2 x 4 factorial arrangement (2 stocking densities x 4 floor types) with 5 replicates (cages). Two nipple drinkers were placed on the back side and two 20 cm-wide manual feeders on the front side of the cage. The rabbits were fed a commercial diet for growing rabbits (CP: 15.8%, ADF: 19.3%, DE: 9.8 MJ/kg as-fed basis) during the entire experiment. No antibiotic was administered in feed or water. Individual live weight and cage feed intake were recorded three times a week. Health status was controlled daily. The tonic immobility test and the open-field test were performed at 70 and 74 d of age, respectively, on 64 rabbits (2 rabbits per 32 cages) (Ferrante *et al*., 1992). One hundred twenty rabbits (3 per 40 cages) were slaughtered at 78 days in a commercial slaughterhouse according to international scientific protocols (Blasco *et al*., 1993). After 24 h, pH and colour were assessed on the *longissimus lumborum* and *biceps femoris* muscles (Xiccato *et al*., 1994). Carcasses were dissected to separate hind leg and dissectible fat and to measure in the hind leg the meat to bone ratio. Femur dimensions and resistance to fracture were measured as described by Xiccato *et al*. (1999). Growth performance data were analysed by means of the GLM procedure of SAS (Version 9.1), considering the cage as the experimental unit and stocking density, cage floor and their interaction as the variability factors. Individual data of carcass and meat quality were analysed including in the model the effect of the cage. Behavioural and reactivity data were first submitted to the Kruskal-Wallis and Mann-Whitney tests to assess the normal distribution of data. Non-normal data were analysed by means of PROC NPAR1WAY of SAS.

RESULTS AND DISCUSSION

Rabbit growth performance from 36 to 78 d of age is reported in Table 1. Average performance showed group housing to be compatible with the full expression of growth capability of the commercial rabbit hybrid, which reached a mean live weight of 2967 g at 78 d of age. Growth performance was significantly impaired when rabbits were kept on a wire net bedded with straw: final live weight was the lowest (2865 g *vs* 3000 g on average, P=0.03); both daily weight gain and feed intake were reduced, thus not affecting feed conversion rate. In previous studies, feed intake reduction was ascribed to the ingestion of straw (Morisse *et al*., 1999; Dal Bosco *et al*., 2002). The plastic floor was apparently cleaner than the steel one. Previous studies did not show important differences in growth performance of rabbits kept on steel slat or wire net floors (Trocino *et al*., 2004 and 2006). Weight gain and feed intake were not affected by reducing the stocking density from 16 to 12 animals/m^2 as also observed by Trocino *et al*. (2004 and 2006) in trials with similar cages. Previous studies on group housing found that reducing stocking density from 20-23 to 15-16 rabbits/m^2

significantly improved growth performance (Aubret and Duperray, 1992; Morisse and Maurice, 1997). In the present experiment, maximum weight was 35 kg/m^2 in D12 and 48 kg/m^2 in D16 groups. According to EFSA (2005a), fattening rabbits in collective cages should be kept at a minimum individual surface of 625 cm^2 and maximum weight at slaughter of 40 kg/m^2.

Table 1: Growth performance from 36 to 78 d of age

	Cage floor					Stocking density			RSD[1]
	Steel slat	Plastic slat	Wire net	Straw on net	Prob.	D12	D16	Prob.	
Number of cages	10	10	10	10		20	20		
Initial live weight (g)	1106	1102	1099	1103	0.83	1105	1100	0.34	17
Final live weight (g)	2987^b	3023^b	2991^b	2865^a	0.03	2946	2987	0.29	118
Daily weight gain (g/d)	45.9^b	46.8^b	46.1^b	43.0^a	0.02	44.9	46.0	0.23	2.8
Feed intake (g/d)	163^B	162^B	161^B	148^A	<0.001	157	159	0.39	7
Feed conversion rate	3.57	3.46	3.49	3.44	0.14	3.51	3.47	0.25	0.13

A, B: P<0.01; a, b: P<0.05. [1]Residual standard deviation

During the immobility test, the number of attempts necessary to induce immobility, considered inversely related with fear towards humans (Verga, 2002), was lower in rabbits kept on a floor bedded with straw (P=0.02), while the duration of immobility was not affected (Table 2). During the open-field test, rabbits reared in cages with straw showed a more passive reaction towards the new environment, exploring less the arena and staying immobile for a longer time (P<0.01) in comparison with the animals reared in cages with plastic slat or wire net. The two behaviours may be negatively considered (Rushen, 2000) and, therefore, despite the increased animal welfare claimed, the choice of providing litter on the floor does not seem justified. Our results confirm previous findings: when rabbits reared in collective cages with wire net floor were given free access to an area bedded with straw, they preferred the floor without straw (Morisse *et al*., 1999; Orova *et al*., 2004). The animals kept in groups in pens bedded with straw dedicated more time to cleaning their dirty fur and moving around in search of a more comfortable place inside the cage, thus expressing a lower welfare condition (Dal Bosco *et al*., 2002).

Table 2: Reactivity tests

	Cage floor					Stocking density			RSD
	Steel slat	Plastic slat	Wire net	Straw on net	Prob.	D12	D16	Prob.	
Number of rabbits	16	16	16	16		32	32		
Tonic immobility test:									
Attempts (n)	2.39^b	2.25^b	1.99^{ab}	1.53^a	0.02	1.89	2.19	0.16	0.68
Duration (sec)	30	31	35	34	0.81	30	35	0.28	15
Open-field test:									
Latency[1] (sec)	51	44	48	54	0.33	52	46	0.16	-
Movements (sec)	55	59	62	42	0.34	51	58	0.42	34
Exploration (sec)	341^{ab}	372^b	372^b	326^a	0.02	347	359	0.30	47
Grooming[1] (sec)	0.38	0.81	1.63	1.87	0.38	7.0	0.8	0.76	-
Immobility (sec)	71^{AB}	36^A	34^A	108^B	<0.01	74	50	0.16	65

A, B: P<0.01; a, b: P<0.05. [1]Non parametric analysis of variance

The stocking density did not affect reactivity in either the tonic immobility or the open field tests. In contrast, Ferrante *et al*. (1997) observed a reduction of movements in rabbits reared in pens on the field at a high density (17 *vs* 12 animals/m^2) and associated this result with the more stressful conditions that reduced animal interactions with the environment. Significant differences among treatments in carcass and meat quality (Table 3) mainly depended on differences in live and slaughter weight among animals: dressing percentage and separable fat of the carcass were lower (P<0.01) in the lightest rabbits reared on straw (58.6% and 2.3%, respectively) compared with the heavier animals of the other three experimental groups (average values 59.9% and 3.0%, respectively). Meat quality (pH and colour of *longissimus lumborum*) was fairly affected by floor type, and the rabbits kept on straw showed the red index (a*) significantly lower than the other animals. Stocking density did not modify carcass traits or the pH and colour of rabbit muscles. Previous studies reported better carcass and meat quality of rabbits reared in individual or bicellular cages than of group-housed rabbits, while few differences were reported among group-reared rabbits housed in different conditions (Maertens and Van Oeckl, 2001; Dal Bosco *et al*., 2002; Trocino *et al*., 2004 and 2006).

Table 3: Carcass and meat quality

	Cage floor					Stocking density			RSD
	Steel slat	Plastic slat	Wire net	Straw on net	Prob.	D12	D16	Prob.	
Number of rabbits	30	30	30	30		60	60		
Cold dressing percentage (%)	59.3^{AB}	60.1^{B}	60.2^{B}	58.6^{A}	<0.001	59.4	59.7	0.17	1.7
Separable fat (% carcass)	3.0^{B}	2.8^{AB}	3.1^{B}	2.3^{A}	<0.01	2.7	2.9	0.18	0.9
Hind leg muscle to bone ratio	5.88	5.68	5.64	5.53	0.27	5.69	5.67	0.94	0.49
L. lumborum traits:									
pH	5.76	5.79	5.79	5.79	0.37	5.79	5.78	0.53	0.10
Lightness index, L*	49.60	50.48	49.99	49.90	0.70	50.38	49.61	0.14	2.70
Red index, a*	-1.92^{ab}	-1.62^{a}	-1.86^{ab}	-2.03^{b}	0.04	-1.96	-1.75	0.07	0.61
Yellow index, b*	2.46	2.05	2.42	1.20	0.25	1.82	2.25	0.28	2.28

A, B: P<0.01; a, b: P<0.05

Bone traits may be used to detect abnormal skeletal development in animals kept under unsuitable housing systems (Dresher, 1996). In our study, femur dimensions and resistance to fracture were unaffected by floor type or stocking density (table 4), while in a previous study tibia diameter increased when stocking density decreased (Xiccato *et al*., 1999).

Table 4: Femur characteristics

	Cage floor					Stocking density			RSD
	Steel slat	Plastic slat	Wire net	Straw on net	Prob.	D12	D16	Prob.	
Number of rabbits	30	30	30	30		60	60		
Weight (g)	12.2	12.7	12.5	12.1	0.23	12.4	12.4	0.98	0.86
Maximum length (mm)	9.25	9.27	9.29	9.20	0.58	9.22	9.29	0.18	0.20
Maximum diameter (mm)	0.89	0.92	0.90	0.90	0.64	0.90	0.91	0.38	0.05
Minimum diameter (mm)	0.67	0.68	0.68	0.68	0.70	0.67	0.68	0.67	0.03
Resistance to fracture (kg)	38.6	37.7	38.3	37.2	0.88	38.0	37.9	0.91	5.5

CONCLUSIONS

Group housing of rabbits allowed optimum sanitary status and growth results regardless of the type of floor and stocking density. Rearing rabbits in group on alternative floors, different from the classical wire net (like steel or plastic slat) was successful considering both animal performance and reactivity, management and technical aspects, and hygienic situation of the system. On the contrary, bedding the cage floor with straw litter clearly impaired performance, slaughter results and comfort of rabbits. The reduction of stocking density from the value of 16 animals/m^2, proposed by EFSA, to 12 animals/m^2 did not produce any appreciable modification of rabbit performance and welfare.

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