

THE EFFECT OF HOUSING SYSTEM ON CARCASS TRAITS AND MEAT QUALITY OF RABBIT

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ABSTRACT: One hundred and sixty one weaned New Zealand White rabbits were housed in 0.4x0.4 m cages (3 rabbits/cage, 18.7 rabbits/m²) or in 3x3.3 m pen on deep litter (80 rabbits/pen, 8.1 rabbits/m²). At 13 weeks of age the pen-housed rabbits (n=52) had lower body weight (2318 vs 2437 g; $P<0.01$) and dressing percentage (59.8 vs 61.0 %; $P<0.01$), higher proportion of the fore part (32.3 vs 31.4 %; $P<0.01$) and hind part (40.3 vs 37.9 %; $P<0.001$), and lower proportion of the intermediate part of the carcass (27.5 vs 30.7 %; $P<0.001$) than the cage-housed rabbits (n=68). The percentage of perirenal fat was lower in the pen-housed rabbits (0.45 vs 0.83 % $P<0.001$) than in the cage-housed group. The meat on the hind legs (HL) and the *m. longissimus dorsi* (MLD) of pen-housed rabbits contained more water (HL: 75.0 vs 73.9 %; MLD: 74.6 vs 74.0 %; $P<0.001$) but less protein (HL: 21.3 vs 21.5 %; MLD: 23.6 vs 23.9 %; $P<0.05$) and fat (HL: 2.48 vs 3.36 %; MLD: 0.65 vs 0.90 %; $P<0.05$) than those kept in cages. The housing system had no effect on ash content and pH value of the meat samples.

Key Words: Housing, rabbits, carcass, meat quality.

INTRODUCTION

Scientists, decision-makers of the food industry and even consumers need information on the effect of alternative breeding systems on animal welfare as well as on meat quality and animal health. To meet the expectations of customers, several

researchers have studied the effects of alternative production methods on the performance traits of fattening rabbits. VERGA (2000) reviewed the main results of those studies. One of the most important conclusions of the studies is that breeders have to keep in mind the new trends of animal husbandry which are directed toward a better quality of the whole production process, including the improvement of the life-quality of animals. Fattening rabbits were kept under markedly different conditions: cages of different size were used with different stocking densities or group sizes. Many methods of keeping rabbits on deep litter have been examined. From these trials increasingly clear tendencies are emerging. According to MAERTENS and VAN OECKEL (2001) PODBERSCHEK *et al.* (1991); VAN DER HORST *et al.* (1999); MIRABITO *et al.* (1999); and DAL BOSCO *et al.* (2000, 2001), the housing system affects body weight, some carcass parameters and sometimes the meat quality (DAL BOSCO *et al.* (2000, 2002).

The aim of our experiment was to study the influence of housing systems (cage or pen) both on the carcass traits and meat quality.

MATERIALS AND METHODS

The trial was carried out at the rabbit farm of Lab-Nyúl Ltd. in Gödöllő. At 5 weeks of age, 161 New Zealand White rabbits were randomly assigned to groups housed in cages (0.4 x 0.4 m, 0.35 m high, 3 rabbits/cage, 18.7 rabbits/m², n=81) or in pen on deep litter (3 x 3.3 m, 80 rabbits/pen, 8.1 rabbits/m² n=80). Both groups had the same weaning weight (1.04 kg). The 0.2 m thick wheat straw litter placed on the concrete floor was refreshed with a new layer every two weeks. The temperature of the rabbitry was 18±2 °C during the trial.

The rabbits received a commercial medicated pellet (50 mg/kg tiamulin, 500 mg/kg oxytetracyclin; 1 mg/kg diclasuril) and drinking water *ad libitum*. The diet contained 16.3% crude protein; 15.2% crude fibre; and 10.6 MJ DE/kg. In the final phase of fattening (4 weeks before slaughtering) a non-medicated diet was fed.

At the end of the trial (at 13 weeks of age) all the surviving rabbits (cage: n=68, pen: n=52) were transported to a slaughterhouse located at a distance of 100 km from the farm. After 24-hour fasting (including the period of transportation), the rabbits were weighed at the slaughterhouse before slaughter. After slaughter (using electrical stunning) the hot carcass was weighed (together with the head, liver and kidneys). After cooling at 3 °C for 4 h, the chilled carcass weight was measured (carcass temperature was 4.5-5 °C). During the dressing process the weights of the head, liver, kidneys and perirenal fat were determined. The chilled carcass was cut into three pieces according to BLASCO *et al.* (1993) between the 7th and the 8th thoracic vertebrae and between the 6th and 7th lumbar vertebrae. After the carcass division the hind legs were separated from the hind part.

Meat from the hind legs (HL), and *m. longissimus dorsi* (MLD) from the intermediate part were removed. The meat/bone ratio was calculated from the data of the hind legs and HL. The pH of the MLD and the *m. biceps femoris* were measured *in situ* on the chilled carcass (INO LAB Level 2 pH meter using SenTix SP penetration probe).

Meat samples were stored at -20 °C, then subjected to homogenisation and chemical analysis to determine the moisture (determination of the total dry matter content by drying with sand), crude protein (KJEL-FOSS with rapid nitrogen determination (N × 6.25)), fat (by Soxhlet extraction after hydrochloric acid digestion) and ash contents (by heating at 550 °C for 3 hours).

The experimental results of carcass traits were evaluated by one-factor analysis of variance (cage or pen) using body weight as covariate. The results of chemical analyses of meat samples were evaluated by two-factor analysis of variance (cage or pen and HL or MLD) using SPSS 10.0 for Windows.

RESULTS AND DISCUSSION

The mean and standard deviations of the measured and calculated carcass traits are shown in Table 1.

Body weight

The slaughter weight of rabbits housed in pens was 4.9% lower ($P<0.01$) than cage-housed rabbits. MAERTENS and VAN HERCK (2000), and MAERTENS and VAN OECKEL (2001) observed similar body weight differences between rabbits raised in cages and those housed in pens having floor netting. VAN DER HORST *et al.* (1999), DAL BOSCO *et al.* (2000) and CANQUIL *et al.* (2001) reported more than 10% lower body weights for pen-housed rabbits when compared to caged ones. According to MAERTENS and VAN HERCK (2000), increased locomotor activity played a role in the lower body weight gain. According to DAL BOSCO *et al.* (2000) and MORISSE *et al.* (1999) the consumption of litter material is also responsible for the poorer body weight gain. The small difference between the body weights of the two groups in the present study may partly be caused by the differences in mortality (cage: 16 %, pen: 35 %). The mortality of rabbits with poor growth and lower body weight was probably higher in the pen-housed group.

Carcass traits

The dressing percentage of rabbits raised in pens (calculated on the basis of hot and chilled carcass) was 1.1 and 1.2%, respectively, ($P<0.01$) lower than that of the cage-housed rabbits (Table 1). VAN DER HORST *et al.* (1999) and DAL BOSCO *et al.* (2000, 2002) also obtained a lower dressing percentage for pen-housed rabbits. At the same time, MAERTENS and VAN OECKEL (2001) did not find significant differences between the groups for this parameter.

The dressing percentage is influenced by the stocking density (the higher stocking density and the smaller living place are disadvantageous) (FERRANTE *et al.*, 1997; XICCATO *et al.*, 1999). The stocking density of the groups was different in our experiment (18.7 vs. 8.1 rabbits/m²). However, the poorer dressing percentage of pen-housed rabbits is not related to the stocking density because in this study the pen-housed rabbits had

Table 1: Live weight and carcass traits of rabbits housed in cages or in pens slaughtered at 13 weeks of age.

Trait studied	Cage housing		Pen housing		P-value
	Mean	SD	Mean	SD	
Number of rabbits	68		52		
Pre-slaughter weight (g)	2437	258	2318	202	<0.01
Ratio of carcass parts to pre-slaughter weight (%)					
Dressing out percentage (hot) ¹	62.7	2.20	61.6	2.24	<0.01
Dressing out percentage (chilled) ²	61.0	2.32	59.8	2.15	<0.01
Head	6.04	0.41	5.99	0.44	<0.05
Liver	2.30	0.25	2.42	0.28	<0.05
Kidney	0.79	0.11	0.77	0.12	NS
Perirenal fat	0.83	0.43	0.45	0.32	<0.001
Fore part	16.1	1.09	16.3	1.43	NS
Intermediate part	15.7	0.94	13.8	0.93	<0.001
Hind part	19.4	0.97	20.3	0.89	<0.001
Hind legs	18.5	1.29	18.9	1.13	NS
<i>M. longissimus dorsi</i> (MLD)	5.46	0.73	4.90	0.54	<0.001
Meat on the hind legs (HL)	13.9	0.99	13.6	0.92	NS
Percentage of carcass parts in the carcass (carcass=fore+intermediate+hind part) (%)					
Fore part	31.4	1.66	32.3	2.11	<0.01
Intermediate part	30.7	1.37	27.5	1.61	<0.001
Hind part	37.9	1.35	40.3	1.44	<.001
Meat/bone ratio (hind legs)	3.21	1.01	2.80	1.27	NS
MLD/intermediate part (%)	34.8	5.81	35.4	2.43	NS

¹Ratio of the hot carcass to pre-slaughter weight.

²: Ratio of the chilled carcass to pre-slaughter weight.

NS: Non significant. $P < 0.05$

lower stocking density, consequently larger living space.

The body weight may have played a role in the poorer dressing percentage, as heavier rabbits have a higher dressing percentage (MILISITS *et al.*, 2000; SZENDRŐ, 1989; ROIRON *et al.*, 1992). Furthermore, it is known that a lower growth rate affects the development of specific tissues (PRUD'HON *et al.*, 1970; OUHAYOUN, 1998). These results refer to rabbits reared under identical conditions and the development of tissues and therefore depends on the weight gain. In our experiment the difference between the body weight of the two groups could mainly be caused by the different locomotor activities. This is shown by the statistical analysis because when body weight was used as a covariate, the difference between the groups remained significant.

No significant difference was found in the ratio of head and kidney weight to live weight between the groups (Table 1). The ratio of the liver significantly increased (2.30 and 2.42%, respectively) in the pen-raised group. Liver coccidiosis was the main reason for the mortality of pen-housed rabbits. This was caused by coccidia taken up with the consumption of litter. The larger livers in clinically healthy rabbits may also have been caused by this fact.

The ratio of perirenal fat to live weight in the pen-housed rabbits was only half of that found in the cage-raised groups. Similarly, large differences were reported by VAN DER HORST *et al.* (1999) (on the average: cage: 2.8 %, pen: 1.8 %) and DAL BOSCO *et al.* (2000, 2002) (cage: 2.43 %, pen: 0.84 % and cage: 2.68 %, pen: 1.06 %). The building of fat depots may be closely correlated with the locomotor activity of the animals. According to the findings of PODBERSCHEK *et al.* (1991) and MIRABITO *et al.* (1999), all the active behaviours were higher among rabbits kept in pens. Naturally, lower feed (MAERTENS and VAN HERCK, 2000; MAERTENS and VAN OECKEL, 2001) and energy intake due to the consumption of litter material (straw) (MORISSE *et al.*, 1999; DAL BOSCO *et al.*, 2000) play a significant role.

Compared to the carcass weight, the percentages of the fore and hind parts of pen-housed rabbits were higher ($P < 0.05$ and $P < 0.001$, respectively), while the ratio of the

Table 2: Effect of housing method (cage or pen) and muscle type on the chemical composition and pH of meat.

Traits	Hind legs						<i>m. longissimus dorsi</i>						Significance					
	Cage			Pen			Cage			Pen				Housing system	Muscle type			
	Mean	SD		Mean	SD		Mean	SD		Mean	SD							
Number of samples	10		10	10		10	10		10		10	20		20		20		
Moisture (%)	73.9	0.7		75.0	1.1		74.0	0.4		74.6	0.6					<0.001	NS	
Crude protein (%)	21.5	0.3		21.3	0.4		23.9	0.3		23.6	0.4					<0.05	<0.001	
Crude fat (%)	3.36	0.1		2.48	1.1		0.90	0.4		0.65	0.4					<0.05	<0.001	
Crude ash (%)	1.31	0.06		1.29	0.07		1.29	0.09		1.30	0.04					NS	NS	
							<i>m. biceps femoris</i>						<i>m. longissimus dorsi</i>					
pH	6.30	0.13		6.27	0.12		6.41	0.16		6.45	0.19					NS	<0.01	

There were no significant muscle x housing interactions for the chemical composition and pH of muscles.

SD: Standard deviation.

NS: Not significant. $P < 0.05$.

intermediate part was lower ($P<0.001$) than for the cage-housed group. Our results prove that in pen-housed rabbits the fore and the hind part of the carcass – closely related to locomotor activity – increased intensively, at the expense of the intermediate part. XICCATO *et al.* (1999) found a larger tibia diameter in groups of rabbits kept in larger cages. DAL BOSCO *et al.* (2000, 2002) showed that pen-housed animals were superior only in regard of the proportion of the hind part.

There was no difference between the two groups in the proportion of hind leg muscles (HL), but the proportion of the *m. longissimus dorsi* (MLD) was significantly higher in the cage-housed rabbits.

No differences were found between cage-housed rabbits and pen-housed rabbits in meat/bone ratio and percentage of MLD in the intermediate part. However, DAL BOSCO *et al.* (2000, 2002) found higher meat/bone ratios in cage-housed rabbits.

Meat quality

Quality traits of the HL and MLD of rabbits kept in cages and in pens on deep litter are shown in Table 2.

The housing system significantly ($P<0.001$) affected the moisture content of meat samples. In the cage-housed rabbits, the meat from the HL and MLD had 1.1% and 0.6% lower moisture content respectively than in the pen-housed group. DAL BOSCO *et al.* (2000, 2002) found 1.1 and 0.82 % difference, respectively, in the moisture content of the MLD, while FINZI and MARGARIT (1999) measured a 1.6% difference in that of the *m. biceps femoris* between cage- and pen-housed rabbits.

As expected, opposite results were found for the fat content. In both meat samples the fat content was lower ($P<0.05$) in the pen-housed rabbits. It is generally known that fat replaces water when it is incorporated into cells. According to the results obtained, the higher level of locomotor activity, the lower feed consumption and the lower energy intake were reflected not only in the size of the fat depots but also in the fat content of meat.

The housing system also had an effect on the protein content of meat samples ($P<0.05$), showing somewhat higher values in the cage-housed group.

The pH was not affected by the housing system. In agreement with the results of this study, DAL BOSCO *et al.* (2001) could not detect significant differences in the pH value of the MLD as a function of the housing system. In another studies, DAL BOSCO *et al.* (2000, 2002) found significantly lower pH in the MLD of pen-housed rabbits.

CONCLUSIONS

Compared to the cage-housed group, the pen-raised rabbits achieve the same body weight a few days later. Therefore they need a longer rearing period to achieve the same body weight. For this reason the rearing costs increase, although these increased costs could be compensated partly or totally by the lower investment costs. According to our experimental data, the weight of the chilled carcass is 100 g less in the case of fattening to the same age.

It might be possible that as a consequence of an increased locomotor activity, the ratio of the hind part increased in the carcass, while there was no difference between the weight of the hind part (473 g and 470 g in cage and pen respectively) in the two groups. This condition is advantageous because in the pen-housing system there is no alteration in the weight of one of the most valuable products. On the other hand, the decreasing weight and ratio of the intermediate part is definitely disadvantageous.

The decrease of the perirenal fat of the pen housed rabbits to about half the amount of the caged ones can be advantageous. Therefore, less of the feed eaten is used for this fat deposit and, during slaughtering, the elimination of this small amount of fat is not necessary.

The fat content of the meat samples of pen-housed rabbits decreased, which is not advantageous from the viewpoint of the consumers (flavour, juiciness, tenderness).

The higher moisture content may be disadvantageous by influencing the cooking loss. Therefore, in future studies investigation of these factors is important.

The decrease of the protein content of the meat samples of pen-housed rabbits did not reach a level that could significantly decrease the advantageous characteristics of rabbit meat. However, it would be useful to take this condition into account in feed formulation.

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