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EFFECTS OF STOCKING DENSITY, CAGE AND FLOOR TYPE ON THE MEAT QUALITY OF GROWING RABBITS

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ABSTRACT

The experiment was carried out with Pannon White growing rabbits, which were divided into four experimental groups: 1. rabbits were reared in pens, on wire net floor, at 16 rabbits/m² stocking density; 2. rabbits were reared in pens, on wire net floor, at 12 rabbits/m² stocking density; 3. rabbits were reared in pens, on straw litter, at 12 rabbits/m² stocking density; 4. rabbits were reared in conventional cages (2 rabbits/cage, 16 rabbits/m²). The experiment took place between 5 and 11 weeks of age. At the end of the trial animals were slaughtered, and the following meat quality parameters were measured: pH 24 hours after slaughter in the *m. Longissimus dorsi* and in the thigh muscle, dry matter content in the *m. Longissimus dorsi* and in the thigh muscle, meat color (L, a*, b*) in the *m. Longissimus dorsi*, drip, cooking and thawing loss in the *m. Longissimus dorsi* and the shear force also in the *m. Longissimus dorsi*. The effects of cage type, floor type and stocking density on the meat quality parameters were evaluated by means of multi-factor analysis of variance. For testing the significance of differences between the meat quality of rabbits reared in pens or in conventional cages (control) the Dunnett-test was used. Based on the results it was established, that the pH was not affected by the cage type, floor type and stocking density. The dry matter content of the thigh muscle was significantly higher in the conventional cages, on the wire net floor and at 12 rabbits/m² stocking density. The drip and thawing loss of the *m. Longissimus dorsi* was the highest in rabbits reared on the straw litter floor. The cooking loss was affected significantly only by the type of cage. The shear force was significantly affected by the cage type and stocking density. Based on our results it could be concluded that compared to the conventional cages rearing rabbits in pens on wire net or straw bedded floor had no substantial effect on the rabbits' meat quality.

Key words: growing rabbits / housing / meat quality

VPLIV GOSTOTE ŽIVALI, VRSTE KLETKE IN NASTILJA NA KAKOVOST MESA RASTOČIH KUNCEV

IZVLEČEK

V poskusu so bili panonski beli rastoči kunci razdeljeni v štiri poskusne skupine, in sicer: 1. kunci v zajčnikih z žičnato mrežo, 16 kuncev/ m²; 2. kunci v zajčnikih z žičnato mrežo, 12 kuncev/ m²; 3. kunci v zajčnikih na slami, 12 kuncev/ m²; 4. kunci v običajnih kletkah (2 kunca v kletki, 16 kuncev/ m²). Živali v poskusu so bile stare od 5 do 11 tednov. Po končanem poskusu in zakolu smo izmerili sledeče lastnosti kakovosti mesa: pH vrednost 24 ur po klanju ter vsebnost suhe snovi v dolgi hrbtni mišici (*m. longissimus dorsi*) in v stegenski mišici in barvo mesa (L, a*, b* vrednosti), izgube z izcejo, kuhanjem in odtajanjem ter rezno trdota v *m. longissimus dorsi*. Vpliv vrste kletke, nastilja in števila živali v kletki na lastnosti kakovosti mesa smo ovrednotili z večfaktorsko analizo variance. Značilnosti razlik med kakovostjo mesa kuncev iz kunčnikov oziroma iz običajnih kletk (kontrolna skupina) smo preverili z Dunnettovim testom. Iz dobljenih rezultatov ugotavljamo, da na pH vrednost vrsta kunčnika, vrsta nastilja in števila živali v kunčniku ne vplivajo. Vsebnost suhe snovi v stegenski mišici je bila značilno višja pri

kuncih iz običajnih kletk z žičnato mrežo in z 12 živalmi/m². Izguba z izcejo in odtajanjem v *m. longissimus dorsi* je bila najvišja pri kuncih z nastiljem iz slame. Na izgubo pri kuhanju je najbolj vplivala vrsta kunčnika. Na rezno trdoto je značilno vplivala vrsta kunčnika in število živali/m². Na osnovi dobljenih rezultatov lahko rečemo, da reja v običajnih kletkah z žičnato mrežo ali na nastilju iz slame ne vpliva pomembno na kakovost kunčjega mesa.

Ključne besede: kunci / pitanci / vhlevitev / meso / kakovost

INTRODUCTION

The requirement of efficient and safe production taking animal welfare and environmental viewpoints into account is gaining importance world-wide. During the last years the consumers' demands also changed substantially and the meat originated from animals kept in (semi)natural conditions is favoured.

According to the animal welfare aspects in rabbit breeding keeping the animals in larger groups on deep litter is recommended. The effects of alternative systems on the rabbits' performance using different cage size and stocking density were analyzed by several authors (Aubret and Duperray, 1992; Rommers and Meijerhof, 1998; Matics *et al.*, 2002). Several forms of rabbit keeping on deep litter was tested and compared with rearing using different floor types (Dal Bosco *et al.*, 2002; Metzger *et al.*, 2003; Kustos *et al.*, 2003). These trials however, mainly focused on the growth or slaughter performance and the meat quality was analyzed only by a few number of studies (Dal Bosco *et al.*, 2002; Trocino *et al.*, 2004; Princz *et al.*, 2006).

In the present study the meat quality of rabbits kept in pens using different stocking densities was compared to that of rabbits reared in conventional cages.

MATERIALS AND METHODS

Trial animals, keeping conditions

The trial was conducted at the Faculty of Animal Science of the Kaposvár University using Pannon White growing rabbits. The rabbits were placed to a closed rabbitry between the ages of 5 and 11 weeks. The room temperature and the lighting schedule was 16–17 °C and 16 L, respectively. To analyze the effects of cage type, floor type and stocking density on the meat quality various trial groups were formed (Table 1).

Table 1. Experimental groups

Group	Emplacement	Size of floor	Stocking density (rabbits/m²)	Floor
1. (n = 52)	Pen	100x170 cm	16 (26 rabbits/pen)	Wire net
2. (n = 40)	Pen	100x170 cm	12 (20 rabbits/pen)	Wire net
3. (n = 40)	Pen	100x170 cm	12 (20 rabbits/pen)	Straw litter
4. (n = 72)	Cage	30x33 cm	16 (2 rabbits/cage)	Wire net

Each pen and cage was equipped with a 40 cm long feeder and two nipple drinkers and with a 30 cm long feeder and a nipple drinker, respectively. The rabbits were fed with medicated pellet

until the age of 9 weeks (10.3 MJ/kg DE, 14.5% crude protein, 2% ether extract, 17.5% crude fibre, 50 g/kg Tilmikozin, 0.025% Pulmotil 200), subsequently they received normal pellet (10.6 MJ/kg DE, 16% crude protein, 3% ether extract, 16% crude fibre) *ad libitum* till the termination of the experiment. Water was also available *ad libitum* from nipple drinkers.

Slaughter, dissection

After the end of the trial – at the age of 11 weeks – 25 rabbits were slaughtered from each group. No fasting was applied prior to slaughter. Liveweight of the rabbits was measured directly at slaughter, then after applying electric stunning the rabbits were slaughtered. After slaughter the warm carcasses were kept at the refrigerator for 24 hours at a temperature of 4 °C. The following day the chilled carcasses were dissected following the recommendation of Blasco *et al.* (1993), the mLD and the thigh muscle were separated from the middle part of the carcass and from the left hind leg, respectively.

Meat quality analysis

Meat quality was assessed on the whole mLD and left thigh muscle. Using both samples pH value and dry matter content were measured. For mLD meat colour, drip loss, cooking loss, thawing loss and shear force was also determined. The pH values were measured with Testo 205 pH tester. In order to obtain dry matter contents the meat samples were dried at a temperature of 103 ± 2 °C until the weight was stable (minimum 5 hours). The colour of the *m. Longissimus dorsi* was determined by a Minolta Chromameter CR-300. The light source was placed to the fresh cut planes of the meat samples parallel with the muscle fibres. To measure drip loss the samples were hermetically closed in plastic bags and were hanged in a refrigerator for 24 hours and kept at a temperature of 3 °C. Drip loss was determined as the weight difference between the samples prior and subsequent to storage. The drip loss was given as a percentage of the sample weight prior to storage. To determine cooking loss the samples were also hermetically closed in plastic bags then they were cooked at core temperature (75 °C) water at least for 2 hours. Thawing loss was determined after the samples were frozen at a temperature of –18 °C for 3 days, then placing to refrigerator for 24 hours and kept at a temperature of 3 °C. Cooking loss and thawing loss was calculated similarly as described for drip loss. The tenderness of the meat samples were evaluated with Zwick/Roell Z005. The samples were cooked in hermetically closed plastic bags then at core temperature (75 °C) water for 2 hours then they cooled in cold water to a temperature of 18–20 °C. Removing the samples from the plastic bags they were cooled to 4 °C then after a 12 hour long resting period samples were manipulated using gimlet with a diameter of 11 mm. Shear force was given in N/mm.

Statistical analysis

The effects of cage type, floor type and stocking density on the meat quality parameters were evaluated by means of multi-factor analysis of variance using the following model:

$$y_{ijkl} = \mu + K_i + P_j + T_k + e_{ijkl}$$

where μ = grand mean, K_i = effect of cage size (i = 1–2), P_j = effect of floor type (j = 1–2), T_k = effect of stocking density (k = 1–2), e_{ijkl} = residual.

For testing the significance of differences between the meat quality of rabbits reared in pens or in conventional cages (control) the Dunnett-test was used. Statistical evaluations were made using the SAS software package (SAS for Windows, 2003).

RESULTS AND DISCUSSION

Examining pH values it could be concluded that it was not affected significantly by cage type, floor type and stocking density neither in mLD nor in thigh muscle (Table 2.). The measured values were in the acceptable range (5.2–7.2) for both muscle types but higher values (by 0.2) were found for thigh muscle. Dry matter content of the thigh muscle exceeded that of the mLD. For thigh muscle 27.2–28.1% dry matter content was observed while it was 25.9–26.6% for mLD. Significantly higher dry matter content of the thigh muscle was observed in the conventional cages, on the wire net floor and at lower stocking density (12 rabbits/m²) considering the effects of cage type, floor type and stocking density, respectively. Similar tendencies were observed – except for the effect of cage type – for mLD but only the effects of floor type were significant. Among the meat colour parameters (brightness, redness, yellowness) brightness was affected by stocking density, redness was affected by cage type and stocking density. Yellowness was not affected significantly by either factor. The most unfavourable drip loss values were found for rabbits kept in deep litter, but the substantial difference compared to rabbits kept in wire net was not significant ($P > 0.05$). Cooking loss was only affected significantly by the cage type. Thawing loss – similarly to drip loss – was the highest for rabbits reared in deep litter. Nevertheless, the differences (compared to that of rabbits reared in wire net floor) were not significant ($P > 0.05$).

Table 2. Effect of cage type, type of floor and stocking density on the meat quality of Pannon White growing rabbits

Trait	Cage type		Floor type		Stocking density (rabbits/m²)		Level of significance		
	Cage	Pen	Wire net	Straw	12	16	Cage type	Floor type	Stocking density
mLD pH	5.53	5.54	5.55	5.52	5.54	5.53	0.829	0.633	0.843
Thigh muscle pH	5.73	5.74	5.76	5.72	5.70	5.77	0.828	0.478	0.148
mLD Dry matter content, %	26.1	26.4	26.6	25.9	26.4	26.1	0.169	**<0.001**	0.143
Thigh muscle Dry matter content, %	28.0	27.3	28.1	27.2	28.1	27.2	**0.011**	**0.007**	**0.003**
mLD brightness	59.6	59.0	59.7	58.9	60.0	58.5	0.299	0.201	**0.017**
mLD redness	2.75	3.36	2.84	3.27	2.71	3.40	**0.035**	0.155	**0.017**
mLD yellowness	2.38	2.78	2.64	2.53	2.68	2.48	0.125	0.692	0.434
mLD Drip loss, %	2.89	2.78	2.60	3.08	2.73	2.95	0.710	0.130	0.457
mLD Cooking loss, %	26.1	27.2	26.8	26.5	26.3	27.1	**0.039**	0.571	0.119
mLD Thawing loss, %	7.00	7.22	6.78	7.43	7.13	7.09	0.761	0.403	0.954
mLD Shear force, N/mm²	0.13	0.17	0.16	0.15	0.12	0.18	**0.025**	0.683	**0.001**

The shear force – describing tenderness of mLD – was affected significantly by cage type and stocking density. The tenderness of mLD was better in conventional cages using a lower (12 rabbit/m²) stocking density. The tenderness of mLD of rabbits reared on deep litter was not significantly different from that of rabbits kept on wire net floor. Comparing meat quality parameters of rabbits kept in pens – using different floor type and stocking density – with that of rabbits reared in conventional fattening cages (as a control group) no significant differences were observed for pH of mLD and thigh muscle (Table 3.).

Table 3. Meat quality of growing rabbits reared in different conditions

Trait	Pen Wire net 16 rabbits/m²	Pen Wire net 12 rabbits/m²	Pen Straw 12 rabbits/m²	Control	S. E.
mLD pH	5.55	5.57	5.53	5.54	0.022
Thigh muscle pH	5.80	5.73	5.69	5.79	0.018
mLD, Dry matter content, %	26.5	26.9*	26.2	26.3	0.072
Thigh muscle, Dry matter content, %	27.2*	28.1	27.3*	28.0	0.109
mLD brightness	58.6	60.2	59.3	59.3	0.227
mLD redness	3.56*	2.74	3.19	2.85	0.108
mLD yellowness	2.70	3.01*	2.80	2.35	0.096
mLD Drip loss, %	2.63	2.49	2.87	2.76	0.108
mLD Cooking loss, %	27.8	26.9	26.7	26.6	0.193
mLD Thawing loss, %	6.89	6.90	7.53	6.65	0.267
mLD Shear force, N/mm²	0.21*	0.15	0.14	0.16	0.007

* The difference from the control group is significant at $P < 0.05$ level

The dry matter content of the mLD was found mainly higher, while that of the thigh muscle mainly lower in rabbits kept in cages compared to rabbits kept in pens. Meat colour of mLD was only occasionally different for rabbits kept either in cages or pens, on the contrary continually higher yellowness was detected for rabbits kept in pens. No significant differences were detected for drip loss, cooking loss and thawing loss between the rabbit groups reared in cages or pens although continually higher values were found for the rabbits kept in pens. Shear force was only significantly different when the rabbits were kept in wire net floor pens using 16 rabbits/ m² stocking density (compared to the control group), in the other two pens similar values were found as in the control group. The differences found between mLD and thigh muscle was in accordance with the findings of Metzger *et al.* (2004) who reported similar pH differences between mLD and m. Biceps femoris using several genotypes. Dry matter content of thigh muscle was higher in rabbits reared in conventional fattening cages also according to Princz *et al.* (2006) although the differences were not significant. Contrary to our results Princz *et al.* (2006) found that group size and stocking density had no effect on meat colour although in their study not the mLD but the thigh muscle was examined. Examining the *m. Longissimus lumborum* Dal Bosco *et al.* (2002) found significant differences between the meat colour of rabbits reared on cages or pens. However in the study of Dal Bosco *et al.* (2002) different stocking density was applied in pens (10 rabbits/m²) and in cages (16 rabbits/m²) that makes the interpretation of their results difficult. Using the same stocking densities Maertens and van Oeckel (2001) found brighter meat colour when the rabbits were reared in cages justifying our results. Examining the effects of stocking density on shear force Trocino *et al.* (2004) also found higher values by a stocking density of 16 rabbits/m²-es but contrary to our results they found no significant effects.

CONCLUSIONS

Based on the results it could be concluded that compared to the conventional cages rearing rabbits in pens on wire net or straw bedded floor had no substantial effect on the rabbits' meat quality.

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