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Comparison of carcass traits and meat quality of Hyplus hybrid, purebred Pannon White rabbits and their crossbreds

Abstract

The aim of the experiment was to compare the weight gain, carcass traits and meat quality of Hyplus hybrid (HH, offspring of Hyplus PS59 bucks and Hyplus PS19 does, n = 77), purebred Pannon White rabbits (PP, offspring of Pannon White bucks and Pannon White does, n = 84) and their crossbreds (PH: offspring of Pannon White bucks and Hyplus PS19 does, n = 97; HP: offspring of Hyplus PS59 bucks and Pannon White does, n = 79). Pannon White rabbits are selected for body weight gain and for carcass traits by computerised tomography (CT), while Hyplus PS19 females and Hyplus PS59 males are selected on prolificacy and body weight gain, respectively. Rabbits of HP genotype had the highest while those of PP genotype the lowest body weight gain (38.9 and 36.6 g/day, respectively; P<0.05). Pannon White breed had an advantageous influence on dressing out percentage (PP: 58.0%; PH: 58.7%; HP: 57.7%; HH: 57.6%; P<0.001) and on the weight of the *m. Longissimus dorsi* (PP: 152 g; PH: 143 g; HP: 137 g; HH: 136 g; P<0.001). The fat content of the carcass was lower in the offspring of the Hyplus PS59 bucks (1.15, 1.16, 0.89 and 0.85% for PP, PH, HP and HH rabbits, respectively; P<0.001). Significant differences were found between the meat samples of progenies of purebred Pannon White and the hybrid terminal cross rabbits in the moisture and fat content of hindleg meat (moisture content: PP: 75.5%, HH: 76.1%, P<0.05; fat content: PP: 2.38%, HH: 1.46%; P<0.001). From the view point of dressing out percentage and the volume of the *m. Longissimus dorsi* the usage of Pannon White genotype is advantageous. Dressing out percentage of the offspring of the early-matured Hyplus PS19 does and Pannon White bucks selected with the help of computerised tomography is remarkable.

Key Words: rabbit, genotype, body weight gain, carcass traits, meat quality.

Zusammenfassung

Titel der Arbeit: Vergleich von Schlachtmerkmalen und der Fleischqualität der Kaninchenrassen Hyplus Hybrid, Ungarische Weiße und deren Kreuzungen

Ziel der Untersuchungen war der Vergleich der Wachstums-, Schlacht- und Fleischqualitätsmerkmale von Kaninchen zweier Rassen und deren reziproken Kreuzungen. Einbezogen wurden Tiere der Rassen: Hyplus Hybrid (HH, Nachkommen von Hyplus PS59 Böcken und Hyplus PS19 Häsinnen, n= 77), Reinzuchttiere Ungarischer Weißer (PP, n= 84) und deren reziproken Kreuzungen (PH, Nachkommen aus PP Böcken und PS19 Häsinnen, n= 97 sowie HP, Nachkommen aus HH Böcken PS59 und PP Häsinnen, n= 79). PP wurden selektiert nach Körpergewichtszunahme und Schlachtmerkmalen mittels Computertomographie (CT) während die HH PS19 Häsinnen und HH PS59 Böcke nach Fruchtbarkeit und Körpergewichtszunahme selektiert wurden. Die HP Genotypen zeigten das höchste während die PP Tiere das geringste Körpergewicht erreichten (38,9 bzw. 36,6 g/Tag P<0,05). Die PP Genotypen hatten einen positiven Einfluss auf die Schlachtkörperteilstücke (PP 58,0 %; PH 58,7 %; HP 57,7 %; HH 57,6 %; P<0,001) sowie das Gewicht des *m. longissimus dorsi* (PP 152 g; PH 143 g; HP 137 g; HH 136 g; P<0,001). Der Fettanteil des Schlachtkörpers war bei den Nachkommen der HH Böcke (1,15; 1,16; 0,89; bzw. 0,85 in der Folge PP, PH, HP bzw. HH) am niedrigsten (P<0,001). Signifikante Unterschiede fanden sich bei der CT Messung der Schlachtmerkmale zwischen PP und den HH Tieren im Wasser- bzw. Fettgehalt des Hinterschenkels (Wassergehalt/Fettgehalt: PP 75,5/2,38 %; HH 76,1/1,46 % (P<0,05/0,001). Hinsichtlich Zerlegeergebnis und Gewichte des *m. longissimus dorsi* waren die PP Tiere im Vorteil. Die Zerlegeergebnisse von Nachkommen der frühreifen Hyplus PS19 Häsinnen gepaart mit PP Böcken, welche mit Hilfe der CT Technik selektiert wurden, waren bemerkenswert.

Schlüsselwörter: Kaninchen, Genotypen, Körpergewichtszunahme, Schlachtmerkmale, Fleischqualität

Introduction

The productive and carcass traits of rabbit genotypes of different growth rate and selected for different criteria have been studied by several authors (PLA et al., 1996, 1998; SZENDRŐ et al., 1996; NOFAL et al., 1997; PILES et al., 2000). In those experiments, mostly different lines (PLA et al., 1996, 1998; PILES et al., 2000) or different breeds (OZIMBA and LUKEFAHR, 1990; SZENDRŐ et al., 1996), or their crosses have been compared. In the former studies the adult weight of the compared lines, breeds or crosses differed. In our experiment, the adult weight of the Hyplus PS19 females, Hyplus PS59 males and that of Pannon White rabbits was also different. A novel feature of this study was that Pannon White rabbits have been selected with the help of X-ray computerised tomography (CT) in order to improve their carcass traits (SZENDRŐ et al., 2005).

The aim of the experiment was to compare the weight gain, carcass traits and meat quality of four different genetically originated genotypes.

Materials and Methods

Animals and rearing conditions

Two genotypes were involved into the experiment: purebred Pannon White (P) and Hyplus hybrid parent lines /PS59 bucks and PS19 does/ (H).

The Hyplus PS19 females are characterised by high prolificacy and early maturity, while the Hyplus PS59 males by high body weight gain but late maturity. The selection of Pannon White rabbits is based on the body weight gain between 6 and 10 weeks and the cross-sectional area of the *m. Longissimus dorsi* measured by CT at 10 weeks of age (SZENDRŐ et al., 2005). Otherwise, the average mature body weight of the genotypes is different (P bucks: 4.8 kg; P does: 4.4 kg; H /PS59/ bucks: 5.6 kg; H /PS19/ does: 4.1 kg).

Half of the P does were inseminated at the rabbit farm of the University of Kaposvár with semen of P bucks, while the other half with semen collected from the H bucks originating from the farm of Olivia Ltd; and vica versa, half of the H does were inseminated at the rabbit farm of the Olivia Ltd with semen of H bucks, while the other half with semen of P bucks originating from Kaposvár. The same males were used in both cases (the semen was taken on the same day and was divided into two halves).

Thus, four progeny groups were formed:

PP: progenies of Pannon White bucks (P) x Pannon White does (P), n = 84

HH: progenies of Hyplus PS59 bucks (H) x Hyplus PS19 does (H), n = 77

HP: progenies of Hyplus PS59 bucks (H) x Pannon White does (P), n = 79

PH: progenies of Pannon White bucks (P) x Hyplus PS19 does (H), n = 97

According to the facts mentioned above, PP and HP rabbits were born at the University of Kaposvár while those of genotypes HH and PH were born at the rabbit farm of Olivia Ltd., at the same time. Intra-group standardisation to 9-10 kits per litter was done on both farms. After weaning at 5 weeks of age, the rabbits born in Kaposvár were transported to the farm of Olivia Ltd.; thus, all the genotypes examined were reared in the same building and on the same diet up to 12 weeks of age, until they reached the slaughter weight. The rabbits were reared in groups (7-9 rabbits/cage, littermates together), in so-called "happy rabbit cages" corresponding to the Swiss

Animal Welfare Decree, having 0.64 m² basic area and provided with a wooden gnawing stick and a hay-pocket. Rabbits were fed *ad libitum* (DE: 11.8 MJ/kg; crude protein: 16%; crude fibre: 17%; ether extract: 3.7%), and drinking water was also available *ad libitum*.

Slaughtering and dissection procedure

Rabbits were slaughtered at 12 weeks of age – without fasting – at the slaughterhouse of Olivia Ltd. Rabbits were weighed immediately before slaughter, then killed by bleeding after electric stunning. Carcass was placed into a cooling room of 4 °C temperature and provided with circulated air for 24 hours, then the chilled carcass (together with head, heart, lungs, liver, kidneys, periscapular and perirenal fat) was weighed. Carcass dissection was performed according to the suggestion of BLASCO and OUHAYOUN (1996). First the heart, lungs, liver and kidneys, and then the periscapular and perirenal fat were removed. The head was separated from the carcass and then the carcass was cut between 7th and 8th thoracic vertebrae and between 6th and 7th lumbar vertebrae, and thus the fore, intermediate and hind parts were obtained. Subsequently the hindlegs were weighed then deboned, and the meat on the hindlegs (HL) was weighed. The *m. Longissimus dorsi* (MLD) was removed from the intermediate part.

Meat quality examinations

MLD and HL samples were taken from 15 rabbits of average body weight in each group. The pH_u was measured *in situ* in the *m. Biceps femoris* in the HL samples and in the MLD samples at the level of the 5th lumbar vertebra with INO LAB Level 3 pH meter using SenTix SP penetration probe. The colour of the MLD was measured with a MINOLTA CR-300 Chromameter on its surface also at the level of the 5th lumbar vertebra. Chemical analysis of the meat samples was performed at the Institute of Chemistry of the University. During the chemical analysis of the minced and homogenised samples, the moisture (HS ISO 1442, 2000), protein (HS ISO 937, 2002), fat (HS ISO 1443, 2002) and ash contents (HS ISO 936, 2000) were determined.

Statistical analysis

Data were evaluated with SPSS 10.0 programme package (SPSS FOR WINDOWS, 1999). Productive traits (body weight, body weight gain) were analysed using one-way analysis of variance on the basis of the following model:

$$Y_{ij} = \mu + G_i + e_{ij}$$

where: μ = population mean, G_i = effect of the genotype ($i=1-4$), e_{ij} = error

Evaluating the carcass traits and the meat quality parameters, the body weight was included into the model as a covariant:

$$Y_{ijk} = \mu + G_i + b_1(x_{ij} - z) + e_{ijk}$$

where: μ = population mean, G_i = effect of genotype ($i=1-4$), b_1 = regression coefficient, x_{ij} = individual body weight, z = mean body weight of the population, e_{ijk} = error.

Data of the different experimental groups were compared with Bonferroni's test. Mortality during the rearing period was analysed by chi-squared test. The effect of gender was not taken into consideration in the statistical analysis.

Results

Growth traits

The body weight at 5 weeks of age was significantly influenced by the genotype ($P < 0.001$). At 5 weeks of age, the body weight of groups PP and HP, reared by Pannon White does in Kaposvár, was significantly higher than that of HH and PH genotypes, reared by hybrid does on the rabbit farm of Olivia Ltd. ($P < 0.05$) (Table 1).

Table 1

Growth traits of rabbits of different genotype (Wachstumsmerkmale bei unterschiedlichen Genotypen)

Traits	Genotype				P
	PP	PH	HP	HH	
	Mean \pm SE	Mean \pm SE	Mean \pm SE	Mean \pm SE	
Number of rabbits	84	97	79	77	
BW at 5 weeks of age (g)	1096 ^b \pm 9.41	1007 ^a \pm 9.21	1123 ^b \pm 9.41	1036 ^a \pm 10.28	***
Body weight gain (g/day)	36.6 ^a \pm 0.58	38.0 ^{ab} \pm 0.56	38.9 ^b \pm 0.58	38.4 ^{ab} \pm 0.63	*
BW at 10 weeks of age (g)	2304 ^a \pm 22.1	2261 ^a \pm 21.6	2408 ^b \pm 22.1	2304 ^a \pm 24.1	***
Mortality ⁺ (%)	7.0 ^a	7.9 ^a	7.0 ^a	21.3 ^b	*

*, $P \leq 0.05$; **, $P \leq 0.01$; ***, $P \leq 0.001$; a, b: different superscripts mark significant differences between groups ($P < 0.05$)

BW: Body weight; +: between 5 and 10 weeks of age

Body weight gain was also significantly influenced by the genotype ($P < 0.05$). Between 5 and 10 weeks of age, rabbits of HP genotype had the highest while rabbits of PP genotype had the lowest body weight gain ($P < 0.05$; Table 1). The body weight gain of groups HH and PH did not differ significantly from that of either of the above two groups.

At 10 weeks of age, group HP had the highest body weight, which differed significantly from that of all the other groups ($P < 0.05$) (Table 1). The body weight of the other three groups was the same.

Between 5 and 10 weeks of age, the mortality rate of HH rabbits was extremely high as compared to that of genotypes PP, HP and PH (Table 1).

Table 2

Body weight at slaughter and weight of body parts of rabbits of different genotypes (g) (Schlacht- und Teilstückgewichte bei unterschiedlichen Genotypen)

Traits	Genotype				P
	PP	PH	HP	HH	
	Mean \pm SE	Mean \pm SE	Mean SE	Mean SE	
BW at slaughter	2773 ^b \pm 28.3	2655 ^a \pm 26.4	2923 ^c \pm 29.2	2741 ^{ab} \pm 29.6	***
Chilled carcass	1607 ^{ab} \pm 5.68	1622 ^b \pm 5.43	1599 ^a \pm 6.10	1598 ^a \pm 5.94	**
Reference carcass	1346 ^{ab} \pm 5.36	1355 ^b \pm 5.12	1335 ^{ab} \pm 5.76	1326 ^a \pm 5.60	***
Fore part	393 ^a \pm 1.99	405 ^{bc} \pm 1.90	412 ^c \pm 2.14	401 ^b \pm 2.08	***
Intermediate part	392 ^b \pm 2.41	396 ^b \pm 2.31	375 ^a \pm 2.59	382 ^a \pm 2.52	***
Hind part	540 ^b \pm 2.35	535 ^{ab} \pm 2.24	532 ^{ab} \pm 2.52	529 ^a \pm 2.45	**
MLD	152 ^c \pm 1.48	143 ^b \pm 1.40	137 ^a \pm 1.58	136 ^a \pm 1.53	***
HL	358 ^b \pm 2.12	353 ^{ab} \pm 2.01	356 ^{ab} \pm 2.26	349 ^a \pm 2.20	*
Perirenal fat	15.6 ^b \pm 0.73	15.6 ^b \pm 0.70	12.4 ^a \pm 0.79	11.9 ^a \pm 0.77	***
Liver	70.3 ^a \pm 0.96	77.5 ^b \pm 0.92	73.1 ^a \pm 1.03	79.3 ^b \pm 1.00	***
Kidneys	19.6 ^{ab} \pm 0.23	20.0 ^b \pm 0.22	18.7 ^a \pm 0.25	19.3 ^{ab} \pm 0.24	**

*, $P \leq 0.05$; **, $P \leq 0.01$; ***, $P \leq 0.001$; a, b, c: different superscripts mark significant differences between groups ($P < 0.05$)

BW: Body weight; MLD: *m. Longissimus dorsi*; HL: hindleg meat

Carcass traits

Body weight at slaughter (at 12 weeks of age) was significantly ($P < 0.001$) influenced by the genotype (Table 2).

Group HP had the highest while group PH the lowest slaughter weight. This trait of PP and HH rabbits was similar.

The weight of different body parts and organs of rabbits of different genotypes followed the same order as their body weight. The body weight masked the effect of the genotype; therefore, the evaluation was performed after adjustment for identical body weight. After taking into account the body weight as covariant, the weights of the different body parts and organs were as shown in Table 2.

The weight of the chilled and the reference carcasses was the highest in rabbits of genotype PH and the lowest in rabbits of genotypes HP and HH ($P < 0.01$ and 0.001 , respectively).

The fore part of the carcass was significantly ($P < 0.05$) heavier in rabbits of genotype HP than in rabbits of genotype PP. At the same time, the intermediate and the hind parts of the carcass had the highest weight in rabbits of group PP ($P < 0.05$) and the lowest weight in rabbits of groups HP and HH.

The MLD weight of PP rabbits significantly ($P < 0.05$) exceeded that of all other groups, while the MLD had the lowest weight in HP and HH rabbits. The weight of the HL was also the highest in PP genotype, but the difference was significant only as compared to group HH ($P < 0.05$).

The weight of the perirenal fat of genotypes derived from the Pannon White males (genotypes PP and PH) was significantly ($P < 0.001$) higher than that of rabbits derived from Hyplus PS59 males (HP and HH).

The liver of rabbits originating from Hyplus PS19 females (PH and HH) weighed significantly ($P < 0.001$) more than that of rabbits PP and HP. The weight of the kidneys was the highest in rabbits of PH genotype and the lowest in HP rabbits ($P < 0.01$), while the values of kidney weight were the same in groups PP and HH.

The genotype was found to exert a significant effect on the dressing out percentage (the ratio of chilled carcass weight to pre-slaughter liveweight; $P < 0.001$; Table 3). The dressing out percentage was 1% higher in rabbits of PH genotype than in HH and HP rabbits ($P < 0.05$). The dressing out percentage of PP genotype did not differ significantly from that of the other groups.

The genotype significantly influenced the relative proportion of carcass parts as compared to the reference carcass (Table 3). The fore part to reference carcass ratio was the highest in group HP and the lowest in group PP; the 1.6% difference obtained between these groups was significant ($P < 0.05$). The intermediate part to reference carcass ratio was the highest in rabbits of PH genotype and the lowest in group HP; the 1.1% difference was significant ($P < 0.05$). The hind part to reference carcass ratio was significantly ($P < 0.05$) lower in PH rabbits than in the other three genotypes.

The genotype significantly influenced the ratio of MLD and HL to the reference carcass (Table 3). The MLD to reference carcass ratio was 1% ($P < 0.05$) higher in group PP than in HH rabbits. The results of HP genotype were the same as those of group HH, while the value obtained for rabbits PH was 0.4% ($P < 0.05$) higher. The HL to reference carcass ratio was the highest in PP and HP rabbits and the lowest in group PH ($P < 0.05$).

The perirenal fat to reference carcass ratio was significantly influenced by the genotype (Table 3).

Table 3

Dressing out percentage and the ratio of different body parts of rabbits of different genotypes (%) (Zerlegeergebnis und Verhältnis von Teilstücken zu Schlachtdaten in % bei unterschiedlichen Genotypen)

Traits	Genotype				P
	PP Mean \pm SE	PH Mean \pm SE	HP Mean \pm SE	HH Mean \pm SE	
Dressing out percentage	58.0 ^{ab} \pm 0.22	58.7 ^b \pm 0.21	57.7 ^a \pm 0.24	57.6 ^a \pm 0.23	***
Fore part ¹	29.2 ^a \pm 0.11	29.9 ^b \pm 0.11	30.8 ^c \pm 0.12	30.3 ^b \pm 0.12	***
Intermediate part ¹	29.1 ^{bc} \pm 0.12	29.2 ^c \pm 0.11	28.1 ^a \pm 0.13	28.7 ^b \pm 0.12	***
Hind part ¹	40.2 ^b \pm 0.11	39.5 ^a \pm 0.10	40.0 ^b \pm 0.12	39.9 ^b \pm 0.11	***
MLD ¹	11.2 ^c \pm 0.09	10.6 ^b \pm 0.09	10.3 ^{ab} \pm 0.10	10.2 ^a \pm 0.10	***
HL ¹	26.6 ^b \pm 0.11	26.1 ^a \pm 0.10	26.6 ^b \pm 0.12	26.3 ^{ab} \pm 0.11	**
Perirenal fat ¹	1.15 ^b \pm 0.05	1.16 ^b \pm 0.05	0.89 ^a \pm 0.06	0.85 ^a \pm 0.06	***
Liver ²	2.55 ^a \pm 0.03	2.80 ^b \pm 0.03	2.64 ^a \pm 0.04	2.85 ^b \pm 0.04	***
Kidneys ²	0.71 ^{ab} \pm 0.01	0.73 ^b \pm 0.01	0.68 ^a \pm 0.01	0.70 ^{ab} \pm 0.01	**

¹ Ratio compared to reference carcass, ² Ratio compared to the slaughter weight; *: P \leq 0.05; **: P \leq 0.01; ***: P \leq 0.001

a, b, c: different superscripts mark significant differences between groups (P < 0.05); MLD: *m. Longissimus dorsi*; HL: hindleg meat

Rabbits of genotypes originating from Pannon White males (PP and PH) had the highest while those derived from Hyplus PS59 males (HH and HP) had the lowest relative amount of fat (P < 0.001).

The ratio of liver and kidney weight to the carcass weight was significantly influenced by the genotype (Table 3). The ratio of liver weight to carcass weight was in average 0.33% higher in rabbits of HH and PH genotypes than in groups PP and HP (P < 0.001). The ratio of kidney weight to carcass weight was the highest in group PH and the lowest in group HP. The 0.05% difference between the groups was statistically significant (P < 0.05).

Table 4

Some meat quality parameters of rabbits of different genotypes (Einige Fleischqualitätsmerkmale bei unterschiedlichen Genotypen)

Parameters	Genotype				P
	PP Mean \pm SE	PH Mean \pm SE	HP Mean \pm SE	HH Mean \pm SE	
Number of samples	15	15	15	15	-
<i>m. Longissimus dorsi</i> (MLD)					
Chemical composition (%)					
Moisture	75.0 \pm 0.12	75.2 \pm 0.22	74.8 \pm 0.26	75.2 \pm 0.13	NS
Crude protein	23.0 \pm 0.11	22.7 \pm 0.20	23.3 \pm 0.23	22.8 \pm 0.12	NS
Crude fat	0.48 \pm 0.04	0.44 \pm 0.07	0.49 \pm 0.08	0.49 \pm 0.04	NS
Crude ash	1.32 ^b \pm 0.02	1.24 ^{ab} \pm 0.04	1.24 ^{ab} \pm 0.04	1.23 ^a \pm 0.03	*
Meat colour:					
L*	57.5 \pm 0.67	57.7 \pm 1.20	57.7 \pm 1.41	56.5 \pm 0.72	NS
a*	4.15 \pm 0.33	3.78 \pm 0.59	4.00 \pm 0.69	3.86 \pm 0.35	NS
b*	3.00 \pm 0.21	3.74 \pm 0.38	2.76 \pm 0.45	3.51 \pm 0.23	NS
pH _u	5.65 \pm 0.02	5.66 \pm 0.04	5.60 \pm 0.04	5.70 \pm 0.02	NS
Hindleg meat (HL)					
Chemical composition (%):					
Moisture	75.5 ^a \pm 0.15	76.0 ^{ab} \pm 0.26	76.0 ^{ab} \pm 0.31	76.1 ^b \pm 0.16	**
Crude protein	20.9 \pm 0.10	21.1 \pm 0.17	20.7 \pm 0.21	21.1 \pm 0.11	NS
Crude fat	2.38 ^b \pm 0.15	1.56 ^{ab} \pm 0.28	1.96 ^{ab} \pm 0.33	1.46 ^a \pm 0.17	***
Crude ash	1.17 \pm 0.02	1.23 \pm 0.04	1.16 \pm 0.05	1.19 \pm 0.03	NS
pH _u (<i>m. Biceps femoris</i>)	5.89 \pm 0.03	5.89 \pm 0.05	5.71 \pm 0.06	5.89 \pm 0.03	NS

*, P \leq 0.05; **, P \leq 0.01; ***, P \leq 0.001; NS: not significant;

a, b: different superscripts mark significant differences between groups (P < 0.05)

Meat quality parameters

Of the meat quality parameters studied, only the moisture and crude fat content of the HL and the crude ash content of the MLD was found to be influenced by the genotype (Table 4).

The moisture content of the HL was 0.6% higher in group HH than in PP rabbits ($P < 0.05$). The values measured in the crossbred genotypes were the same. The fat content of the HL was the highest in PP genotype and the lowest in meat samples of HH rabbits. The 0.92% difference between the groups was significant ($P < 0.05$). The crude ash content of the MLD was the highest in PP rabbits and the lowest in HH genotype ($P < 0.05$).

Discussion

At 5 weeks of age, the body weight of PP and HP rabbits born at the University of Kaposvár was significantly higher than that of HH and PH rabbits born on the rabbit farm of Olivia Ltd. This difference could theoretically be due to the differences in management and feeding; however, there were no such differences in the conditions which could explain the body weight disparities found. It is more likely that the disparities in body weight at weaning were due to the different performance of Pannon White and Hyplus PS19 females. Although the milk production of the two genotypes has not been compared yet, the general correlation, that does of larger body size produce more milk, could be true also in this case (LUKEFAHR et al., 1990). An effect of the males is unlikely, as the males did not influence the weaning weight in the experiment of DALLE ZOTTE and OUHAYOUN (1998) either, when the INRA female line was mated to a male line of large body size.

As all rabbits were reared in the same rabbit house after weaning, the inter-group differences in body weight gain and body weight were due to disparities in the growth rate of the individual genotypes. Does inseminated with semen from Hyplus PS59 males achieved significantly higher body weight gain than those inseminated with the semen of Pannon White males (37.8 vs. 37.3 g/day). When mating hybrid females with Flemish Giant or INRA 9077 males, DAVID et al. (1990) also demonstrated the superiority of the male line of large body size. At 10 weeks of age, the body weight of growing PH rabbits exceeded that of all the other three genotypes, since they combined the higher milk production potential of their does with the faster growth rate of the hybrid terminal sire.

We could not explain the difference found in the mortality rate, as HH and PH rabbits had originated from the same hybrid females and were born and reared in the same building.

The carcass characteristics are basically determined by the adult body weight of different breeds and their maturity at slaughter. The individual organs and tissues have different growth rates (DELTORO and LÓPEZ, 1985). The skeleton and the digestive system mature earlier, while the intensive growth of muscle is completed later and the increase of fat tissue starts the latest of all. This is why breeds of smaller body size mature earlier, while breeds of larger body size mature later. In our experiment rabbits were slaughtered at the same age. It was clearly demonstrable that rabbits originating from Hyplus PS59 males had poorer dressing out percentage than those derived from the Pannon White males (57.6 vs. 58.3%, respectively). This could be explained by the

difference in the adult body weight of the two male lines (Hyplus PS59: 5.6 kg, Pannon White: 4.8 kg). The results of numerous experiments (PLA et al., 1996; GÓMEZ et al., 1998; DALLE ZOTTE and OUHAYOUN, 1998) prove that later matured breeds and lines of large body size have poorer dressing out percentage than those of smaller body size. Heavier and faster growing rabbits eat more (LOBERA et al., 2000) and thus their digestive system become proportionally higher, which also reduce the dressing out percentage.

The weight and relative ratios of carcass parts are also influenced by the genotype. According to several authors (PLA et al., 1996; GÓMEZ et al., 1998), at the same body weight the larger sized breeds have a higher ratio of the fore part, similar ratio of the intermediate part and lower ratio of the hind part than in breeds of medium body size and selected for litter size. In lines selected for body weight gain over several generations no significant change was demonstrated in the relative ratio of the different carcass parts (PILES et al., 2000). In our experiment, in agreement with the data reported in the literature, the weight and ratio of the fore part were higher in rabbits originating from Hyplus PS59 males. This could be explained by the fact that this is the boniest part of the carcass and the bone belongs to the early matured tissues (DELTORO and LÓPEZ, 1985). The weight and ratio of the intermediate part were the highest in rabbits derived from Pannon White males, and in the PP genotype the MLD had an outstandingly high ratio. These results can be explained by selection done with the help of CT. Pannon White rabbits included into the experiment has been selected on the basis of the cross-sectional area of the MLD for three years (SZENDRŐ et al., 2005). The cross sectional area of the MLD, determined *in vivo* by CT between the 2nd and 3rd and between the 4th and 5th lumbar vertebrae, is positively correlated to the most important carcass traits (SZENDRŐ et al., 1992). Results of a divergent selection demonstrated that the cross sectional area of the MLD, the ratio of the intermediate part and the dressing out percentage increased as a result of the CT selection, while the weight of the skin and the digestive tract decreased (SZENDRŐ et al., 2005).

Group PH had the highest dressing out percentage. This is primarily due to the fact that the Hyplus PS19 females have a high dressing out percentage for itself, as demonstrated by the results of several studies (PLA et al., 1996). Another important factor was that the hybrid females were inseminated with semen from Pannon White males efficiently selected by CT. Thus, the PH rabbits inherited above-average carcass traits from both the female and the male parents.

Similarly as for the HL, in the weight of the hind part of carcass and its relative ratio to carcass weight inter-group differences were obtained in a few cases only.

On the basis of the perirenal fat, two groups can be distinguished sharply: the amount of perirenal fat is significantly higher in rabbits originating from Pannon White males (PP and PH) than in rabbits originating from the Hyplus PS59 males of large body size (HH and HP). The maternal parent line seems to play a negligible role in this regard. The results of experiments have clearly demonstrated that rabbit breeds and lines of larger body size (PLA et al., 1996; DALLE ZOTTE and OUHAYOUN, 1998), as well as rabbits crossbred with breeds of larger body size have less fat depots (LUKEFAHR et al., 1983; OZIMBA and LUKEFAHR, 1990), and that the amount of perirenal fat decreases as a result of selection for body weight gain or body weight (PILES et al., 2000; GONDRET et al., 2002). All these are due to the late development of fat tissue

(DELTORO and LÓPEZ, 1985), however it is possible to select rabbits for body fat content (LÉVAI and MILISITS, 2002) or develop the body fat partition with selection (SHEMEIS and ABDALLAH, 2000). According to our results, the maternal genotype does not have such a substantial effect, as the difference between Pannon White and Hyplus does in adult body weight (4.4 vs. 4.1 kg) was found to be negligible.

The weight of the liver and its ratio to body weight were higher in rabbits of genotypes PH and HH than in the other two groups. PLA et al. (1996) and GÓMEZ et al. (1998) found that rabbits of larger body size had a larger liver. Consistently with the generally held view, GÓMEZ et al. (1998) attribute this to the fact that in the breeds of large body size the liver, as an early-maturing organ, is larger at the usual slaughtering age and weight. From our results it appears that the effect of body weight does not exert itself so clearly in the case of crossbred rabbits, since rabbits of the PH genotype were found to be the smallest and PH rabbits the largest. Comparing New Zealand White rabbits with Grimaud hybrid rabbits included also in the present experiments, CHIERICATO et al. (1996) found a somewhat larger liver in the latter. This is consistent with our own findings.

In the weight of the kidneys and their ratio to the carcass weight, a significant difference was obtained only between HP and PH rabbits, in favour of the latter. As the biggest body weight difference was also found between these two groups, this case reflected the general tendency that the kidney, which is an organ characterised by relatively early growth, is more developed in rabbits of larger body size (DELTORO and LÓPEZ, 1985).

When comparing meat samples for chemical composition, significant difference in fat content between Group PP and Group HH was obtained only for HL, which is characterised by higher fat content. According to most data of the literature, meat samples from later maturing rabbits of larger body size tend to contain less fat (PLA et al., 1996). Occasionally the fat content of HL was reported to decrease also as a result of selection for body weight (PILES et al., 2000). On the basis of our results it appears that the male line of large body size is suitable for reducing the fat content of meat in rabbits crossed with it. This effect cannot be demonstrated in the MLD, a muscle of lower fat content.

According to data of the literature, the genotype and selection for body weight gain have no influence on the protein content of meat (PILES et al., 2000). This is consistent with the results obtained in our experiment.

In conformity with our results, most studies have found that neither the genotype nor selection for body weight gain or body weight influence the pH of rabbit meat (DAVID et al., 1990; CHIERICATO et al., 1996; PLA et al., 1996; DALLE ZOTTE and OUHAYOUN, 1998; PILES et al., 2000; GONDRET et al., 2004).

The L* (lightness), a* (redness) and b* (yellowness) values of the MLD were the same in all four genotypes studied. In this respect, PLA et al. (1996) comparing lines selected for litter size and body weight gain and GONDRET et al. (2004) studying the results of divergent selection for body weight could not demonstrate differences either. In contrast, CHIERICATO et al. (1996) found a difference between the New Zealand White and the Grimaud hybrid in the values of a*. Studying the *m. Biceps femoris*, PLA et al. (1996), CHIERICATO et al. (1996) and DALLE ZOTTE and OUHAYOUN (1998) obtained a more diverse finding. In two cases lower values of L* were measured in rabbits of large body size, in one case the value of a* was higher in

the line of large body size, while in two cases the value of b^* was higher in the line of smaller body size, selected for litter size. On the basis of these results, no definite correlations can be established between the genotype and the colour of meat.

According to the results of this experiment large body sized males are suitable for increasing the body weight gain. However, as at the slaughterhouses rabbits are slaughtered at a similar body weight, rabbits for slaughter are ever younger and less mature at the time of slaughter, and therefore their dressing out percentage decreases. Selection by CT on the basis of the cross sectional area of the *m. Longissimus dorsi* (MLD) can markedly increase the weight of the MLD, the ratio of the intermediate part to carcass weight and the dressing out percentage alike. From the point of view of the dressing out percentage, crossing of the Hyplus PS19 does with the CT-selected Pannon White males is advantageous. Males of large body size are suitable for reducing the weight of the fat depots and the fat content of the meat. The latter does not have great practical importance, as rabbit meat has inherently low fat content and thus, it belongs to the healthiest types of meat. Based upon the results of this experiment and data of the literature it appears that the genotype (i.e. mature body weight or selection by CT) does not have a pronounced effect on the most of the meat quality traits, i.e. on the protein content, pH or colour of the meat.

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References

- BLASCO, A.; OUHAYOUN, J.:
Harmonization of criteria and terminology in rabbit meat research. Revised proposal. *World Rabbit Sci.*, **4** (1996) 2, 93-99
- CHIERICATO, G.M.; RIZZI, C.; ROSTELLATO, V.:
Meat quality of rabbits of different genotypes reared in different environmental conditions. 6th World Rabbit Congress, Toulouse, (1996), 147-151
- DALLE ZOTTE, A.; OUHAYOUN, J.:
Effect of genetic origin, diet and weaning weight on carcass composition, muscle physicochemical and histochemical traits in the rabbit. *Meat Sci.*, **50** (1998) 4, 471-478
- DAVID, J.J.; OUHAYOUN, J.; DELMAS, D.:
Alourdissement des carcasses par croisement. Croissance et qualites boucheres de lapins issus du croisement de males Geants des Flandres et de femelles hybrides. *Cuniculture*, **91** (1990), 27-30
- DELTORO, J.; LÓPEZ, A.M.:
Allometric changes during growth in rabbits. *J. Agric. Sci., Camb.*, **105** (1985), 339-346
- GONDRET, F.; COMBES, S.; LARZUL, C.; ROCHAMBEAU, D.H.:
The influence of divergent selection for body weight at 63 days of age in rabbits on muscle characteristics at the same age or at similar weight. *Arch. Tierz., Dummerstorf* **48** (2004) Special Issue, 98-104
- GÓMEZ, E.A.; BASELGA, M.; RAFEL, O.; RAMON, J.:
Comparison of characteristics in five strains of meat rabbit selected on different traits. *Livest. Prod. Sci.*, **55** (1998), 53-64
- HS ISO 936:2000:
Meat and meat products. Determination of total ash. Hungarian Standards Institution. (2000) (in Hung.)
- HS ISO 1442:2000:
Meat and meat products. Determination of moisture content (Reference method). Hungarian Standards Institution. (2000) (in Hung.)
- HS ISO 937:2002:
Meat and meat products. Determination of nitrogen content (reference method). Hungarian Standards Institution. (2002) (in Hung.)
- HS ISO 1443:2002:

- Meat and meat products. Determination of total fat content. Hungarian Standards Institution. (2002) (in Hung.)
- LEVAL, A.; MILISITS, G.:
Einfluss des nach der TOBEC-Methode bestimmten Fettgehaltes bei Kaninchen auf die Wurfleistungen und die Körperzusammensetzung der Nachkommen. Arch. Tierz., Dummerstorf **45** (2002) 4, 403-411
- LOBERA, J.; RUIZ, F.; FERNÁNDEZ, F.; BASELGA, M.; TORRES, C.:
Terminal Sire and production of meat quality. 7th World Rabbit Congress, Valencia, (2000), 449-455
- LUKEFAHR, S.D.; HOHENBOKEN, W.D.; CHEEKE, P.R.; PATTON, N.M.:
Appraisal of nine genetic groups of rabbits for carcass and lean yield traits. J. Anim. Sci., **57** (1983) 4, 899-907
- LUKEFAHR, S.D.; CHEEKE, P.R.; PATTON, N.M.:
Prediction and causation of litter market traits from preweaning and weaning characteristics in commercial meat rabbits. J. Anim. Sci., **68** (1990), 2222-2234
- NOFAL, R.Y.; TÓTH, S.; VIRÁG GY.:
Evaluation of seven genetic groups of rabbits for carcass traits. Arch. Tierz., Dummerstorf **40** (1997) 1, 61-67
- OZIMBA, C.E.; LUKEFAHR, S.D.:
Evaluation of purebred and crossbred rabbits for carcass merit. J. Appl. Rabbit Res., **13** (1990), 193-198
- PILES, M.; BLASCO, A.; PLA, M.:
The effect of selection for growth rate on carcass composition and meat characteristic of rabbits. Meat Sci., **54** (2000), 347-355
- PLA, M.; HERNÁNDEZ, P.; BLASCO, A.:
Carcass composition and meat characteristics of two rabbit breeds of different degrees of maturity. Meat Sci., **44** (1996) 1-2, 85-92
- PLA, M.; GUERRERO, L.; GUARDIA, D.; OLIVER, M.A.; BLASCO, A.:
Carcass characteristics and meat quality of rabbit lines selected for different objectives: I. Between lines comparison. Livest. Prod. Sci., **54** (1998) 2, 115-123
- ROMVÁRI, R.; MILISITS, G.; SZENDRŐ, ZS.; SORESENSEN, P.:
Non invasive method to study the body composition of rabbits by X-ray computerised tomography. World Rabbit Sci., **4** (1996) 4, 219-224
- SHEMEIS, A.R.; ABDALLAH, O.Y.:
Possibilities of developing favourable body fat partition via selection indexes – Application on rabbits. Arch. Tierz., Dummerstorf **43** (2000) 2, 193-201
- SPSS FOR WINDOWS 1999.
VERSION 10.0, COPYRIGHT SPSS INC.
- SZENDRŐ, ZS.; HORN, P.; KÖVÉR, GY.; BERÉNYI, E.; RADNAI, I.; BIRÓ-NÉMETH, E.:
In vivo measurement of the carcass traits of meat type rabbits by X-ray computerised tomography. J. Appl. Rabbit Res., **15** (1992), 799-809
- SZENDRŐ, ZS.; BIRÓ-NÉMETH, E.; RADNAI, I.; JENSEN, N.E.; KENESSEY, Á.:
Comparison of the production of Danish White and Pannon White purebred and crossbred rabbits. Arch. Tierz., Dummerstorf **39** (1996) 3, 309-320
- SZENDRŐ, ZS.; ROMVÁRI, R.; MILISITS, G.; METZGER, SZ.; NAGY, I.; RADNAI, I.; BIRÓ-NÉMETH, E.; SZABÓ, A.; PETRÁSI, ZS.; REPA, I.; HORN, P.:
Computerised tomography in rabbit breeding. Hungarian Journal of Animal Production, **5** (2005), 416-426 (in Hung.)

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