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Growth, slaughter performance and selected meat quality traits of New Zealand White and Grey Flemish Giant rabbits and their crosses

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SUMMARY

The purpose of the study was to compare the growth, slaughter performance and selected meat quality traits (meat texture and basic chemical composition) of New Zealand White (NZW) rabbits, Grey Flemish Giant (GFG) rabbits and their crossbreds. Pre-slaughter, slaughter and meat quality traits were analysed for 52 New Zealand White rabbits (26 male and 26 female), 42 Grey Flemish Giant rabbits (21 male and 21 female) and 78 crosses of these two breeds (39 male and 39 female). Two rabbits (1 male and 1 female) were selected from each litter for evaluation of slaughter performance and meat quality. At least 4 offspring from each male were selected for analysis. Each group comprised a total of 20 rabbits. After weaning at 35 days of age, the animals were fed pellets *ad libitum*. Rabbits were weighed weekly from birth to 12 weeks of age, when they were slaughtered and dissected. Body weight measurements showed that GFG rabbits had significantly higher body weights than NZW rabbits and their crossbreds up to and including week 4. After 5 and 6 weeks of rearing the differences between the kits were not significant. From 7 to 10 weeks of age, the crossbred rabbits had the highest body weight. In the last two weeks of life, the highest body weight was achieved by young rabbits of the GFG breed. Slaughter weight was significantly the highest in GFG rabbits and lowest in purebred NZW rabbits. The highest hot carcass weight and cold carcass weight were attained by animals from the crossbred group. The shear force value was identical in the NZW rabbits and the crossbred group, but lower in the GFG rabbits. Hardness and chewiness were lowest in the NZW rabbits, while springiness and cohesiveness were highest in that breed. The meat of the crossbreds had the highest protein content and the lowest fat content, as well as the highest water content, and thus statistically the lowest dry matter content.

KEY WORDS: crossbreds, rabbits, growth, slaughter traits, meat quality traits

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INTRODUCTION

The domestic rabbit (*Oryctolagus cuniculus*), due to its relative ease of adaptation to a variety of environmental conditions, high fertility and prolificacy, and ease of breeding, is kept around the world and improved to increase its productivity and the quality of its products. We can distinguish between breeds of rabbits raised for meat, fur, or wool, a growing group of animals used in laboratory research, and rabbits kept as pets (Kowalska, 2006). However, according to an overview provided by the National Animal Breeding Centre in 2021, as many as 141 of 149 herds included in performance value evaluation are herds of medium broiler breeds (3.5–5.5 kg body weight) and large breeds (over 5.5 kg body weight) for meat use (KCHZ, 2022). The growing popularity of rabbit meat is due to its health-promoting properties, which include high content of easily digestible protein rich in essential amino acids, low fat content, and relatively low cholesterol content (Para et al., 2015). In addition, rabbit meat has high content of monounsaturated and polyunsaturated fatty acids. The beneficial linoleic acid, an omega-6 fatty acid, makes up as much as 3% of all fatty acids in rabbit meat (Hernandez and Gondret, 2006). According to the National Animal Breeding Centre, the most commonly bred rabbit breeds in Poland are New Zealand White (NZW) and Grey Flemish Giant (GFG), classified as a broiler breed and a large breed, respectively. The Grey Flemish Giant is currently considered the oldest and largest breed of rabbits, reaching an average body weight of 8–10 kg, and carcasses of even 4 kg can be obtained from representatives of this breed kept in the proper environment (KCHZ, 2022). Female Grey Flemish Giants, despite the absence of fertility problems, have poor maternal instincts. Their nests are of poor quality, and they do not produce enough milk to feed an entire litter of young rabbits (Pałka et al., 2018). They rarely look into the nest, and in consequence the kits leave the nest and then die of hypothermia. Crushing of kits by their mother is also a significant problem. However, fertility can be improved by using high-quality concentrate feeds to prevent abnormalities in the development of young rabbits. Moreover, the Grey Flemish Giant is a late-maturing breed with a mild temperament, fond of human companionship, and for these reasons it is often kept on backyard farms and reared extensively (Bielański et al., 2009; Pałka et al., 2018).

Originating in the United States and classified as a medium breed, New Zealand White rabbits were developed as a result of breeding work aimed at creating a versatile rabbit for both meat and fur production. At 90 days of age New Zealand White rabbits reach a body weight of more than 3 kg, not due to outstanding meatiness but to excessive fat in the carcass. Dissection has revealed that organ fat can account for as much as 2% to 3%. Fattening of animals at this level is not a problem if they are purely slaughter material, but if the animals are intended for further breeding, reproductive problems may result. Pseudopregnancy, reduced milk yield, and even complete loss of lactation have been observed in New Zealand White does. A significant problem in the breeding of New Zealand White rabbits is the intentional mating of animals in close consanguinity in order to maintain outstanding features in the offspring, which is associated with a decrease in the herd's production traits (Kowalska, 2011). Previous research, e.g. by Mallam et al. (2018), has shown that the genotype of rabbits significantly influences their growth, carcass characteristics, and even blood parameters. The popularity of the breeds described above in Poland, as well as the problems in the breeding of Grey Flemish Giant and New Zealand White rabbits, prompted us to study the production performance of purebred animals and their crossbreds under the conditions of a commercial production farm. Hence, the purpose of the study was to compare the growth, slaughter performance and selected meat quality traits, such as meat texture and basic chemical composition, in New Zealand White rabbits, Grey Flemish Giant rabbits and their crossbreds.

MATERIAL AND METHODS

The experiment was carried out at the experimental station of the Department of Animal Genetics, Breeding and Ethology at the University of Agriculture in Krakow. The experimental material was New Zealand White rabbits (n = 52; 26 males and 26 females), Grey Flemish Giant rabbits (n = 42; 21 males and 21 females) and their crosses (n = 78; 39 males and 39 females). Two rabbits (1 male and 1 female) were selected from each litter to evaluate slaughter performance and meat quality. At least 4 offspring from each male were selected for analysis. Each group comprised a total of 20 rabbits. The mating system was designed to avoid inbreeding. Until weaning, young rabbits were housed with their mothers in wooden cages in a hall equipped with nipple drinkers, lighting (14L:10D) and forced air ventilation. Rabbits were weaned at 35 days of age and kept in a battery system designed for commercial rabbit rearing. They were fed *ad libitum* with pelleted complete feed with 16.5% crude protein content, 14% crude fibre, and minimum metabolizable energy of 10.2 MJ, according to the feed manufacturer (de Heus, Poland).

The study included growth traits of rabbits, i.e. litter weight at birth and at 1 week [g], body weight in successive weeks of rearing (from 2 to 12 weeks) [g], and daily weight gains in each week of rearing [g].

Rabbits were slaughtered at 84 days of age, after 24-hour fasting with uninterrupted access to water. The animals were stunned, bled and skinned, after which the carcasses were eviscerated and refrigerated for 24 h at 4°C. Then the carcasses were divided into three basic cuts: the front part, the loin, and the back part, which were submitted for detailed dissection.

The following slaughter performance traits were also analysed: body weight at slaughter [g], hot and cold carcass weight without head [g], weight of the liver, lungs, heart, kidneys and head [g], weight of the front part, loin, and back part [g], weight of meat, bones and fat in individual parts of the carcass [g], proportion of the front part, loin and back part in the carcass (%), meat, bone and fat content in individual parts of the carcass (%), and meat, bone and fat content in the carcass (%). Hot (DP1) and cold (DP2) dressing out percentage was also determined according to the following formulas:

$$DP1 = \frac{\text{Carcass}}{\text{Animal's body weight before slaughter}} * 100\%$$

$$DP2 = \frac{\text{Cold carcass weight}}{\text{Animal's body weight before slaughter}} * 100\%$$

The entire slaughter and dissection process followed the methodology described by Barabasz and Bieniek (2003). The chemical composition of the meat (*m. longissimus lumborum*) was determined according to Polish Standards.

To test the shear force and determine the meat texture profile, cylindrical samples 15 mm in diameter and 15 mm high were cut from the right half-carcass (*m. longissimus lumborum*). The samples were individually packaged and stored for 72 h at −18°C. Then they were defrosted at room temperature, wrapped in aluminium foil, and roasted at 180°C until reaching an internal temperature of 78°C. The shear force was measured using a TA.XT plus texture analyser (Stable Micro Systems) equipped with a Warner-Bratzler blade with a triangular notch. The shear force value [kg/cm^2] of 10 × 10 mm samples was measured at a blade speed of 2 mm/s (average of 3 measurements), transverse to the course of the muscle fibres, until the sample was cut through. Texture profile analysis was performed using the same device with an attachment, i.e. a 50 mm diameter cylinder. The hardness [kg], springiness, cohesiveness, and chewiness [kg] of 10 mm cube-shaped samples were measured (average from 3 measurements). A double compression test was carried out at 70% of the height of the sample at a rolling speed of 5 mm/s and a 5 s interval between compressions, along the course of the muscle fibres. All meat texture parameters and shear force were calculated automatically using Exponent for Windows ver. 5.1.2.0 (Stable Micro Systems).

The results were analysed using the General Linear Model (GLM) procedure of SAS software with Tukey's test ($p < 0.05$) (SAS, 2014). The linear model included the genetic group and sex as fixed effects; the interaction of fixed effects; litter size at birth as a linear covariate for growth and average daily gains; and then slaughter weight as a linear covariate for carcass traits. The analysis of variance and statistical tests did not show any significant differences between male and female rabbits for any of the traits.

RESULTS AND DISCUSSION

The rabbits' body weight and daily gains are shown in Table 1. Body weight measurements showed that through day 28 Grey Flemish Giant rabbits had significantly higher ($p < 0.05$) body weight than New Zealand White rabbits and their crossbreds. At 35 and 42 days of rearing, i.e. in the weaning period, the differences between the kits were not significant. From 49 to 70 days of age, rabbits that were crosses of the two breeds had the highest body weight. In the last two weeks of life, the highest body weight was noted for young rabbits of the Grey Flemish Giant breed. At 84 days, they were on average 700 g larger than purebred New Zealand White rabbits and about 200 g larger than the crossbred rabbits. The significantly higher ($p < 0.05$) body weight of the Grey Flemish Giant rabbits is due to the fact that it is a large breed. The body weight of GFG adults averages 8–10 kg, and outstanding individuals can reach a weight of up to 20 kg (Bielański et al., 2009). Purebred New Zealand White rabbits intended for breeding evaluation must not exceed a body weight of 5.3 kg, according to the Rabbit Phenotype Evaluation Pattern developed by the National Centre for Animal Breeding. Animals of this breed will never achieve results comparable to those of purebred Flemish Giants.

Daily weight gains during the first 14 days of life were fairly even, but significantly higher ($p < 0.05$) gains were achieved by rabbits of the Grey Flemish Giant breed. This pattern changed between 14 and 21 days of life, when the GFG kits achieved the lowest gains, while for the next two weeks of rearing the New Zealand White rabbits had the best growth. Between 28 and 35 days of life, i.e. at the time of weaning, the best daily gains were obtained by crossbred rabbits. Significantly higher ($p < 0.05$) gains were observed in this group until 56 days of rearing, excluding the 6th week (between 35 and 42 days), when the values in all groups were comparable. From 56 days to the end of rearing, daily gains were highest in Grey Flemish Giant rabbits, with the highest growth observed between 70 and 77 days of rearing. As noted above, the Grey Flemish Giant is a late-maturing breed for extensive rearing, so higher daily weight gains begin to be observed later than in broiler breeds such as New Zealand White (Kozioł et al., 2017). Mating of New Zealand White and Grey Flemish Giant rabbits significantly improved the daily gains and body weights of the crossbreds in each week of rearing compared to those achieved by medium-breed rabbits. This provides a real opportunity to improve the rearing performance of purebred animals reared on commercial farms in intensive and semi-intensive systems.

Table 1

Growth traits of New Zealand White (NZW) and Grey Flemish Giant (GFG) rabbits and their crosses (NZW×GFG)

Day	NZW		NZW×GFG		GFG	
	Mean	SD	Mean	SD	Mean	SD
			Body weight [g]			
Birth weight	62^{a}	13	60^{a}	9	83^{b}	2
7	127^{a}	21	123^{a}	22	164^{b}	8
14	216^{a}	44	203^{a}	39	261^{b}	28
21	304^{ab}	65	284^{a}	60	331^{b}	36
28	495^{ab}	98	461^{a}	117	513^{b}	53
35	742	146	769	158	750	87
42	951	199	993	184	986	13
49	1122^{a}	251	1285^{b}	211	1215^{ab}	286
56	1299^{a}	283	1544^{b}	241	1425^{ab}	286
63	1496^{a}	303	1794^{b}	255	1764^{b}	373
70	1677^{a}	336	2119^{b}	271	2093^{b}	390
77	1900^{a}	345	2361^{b}	298	2511^{c}	396
84	2109^{a}	356	2601^{b}	313	2821^{c}	364
			Daily gains [g/day]			
Birth-7	65^{a}	20	63^{a}	19	81^{b}	6
7-14	89^{ab}	33	80^{a}	27	97^{b}	29
14-21	87^{a}	36	81^{ab}	29	69^{b}	16
21-28	191	57	177	78	182	43
28-35	248^{a}	68	309^{b}	83	238^{a}	45
35-42	208	102	224	58	235	87
42-49	171^{a}	78	265^{b}	87	229^{b}	146
49-56	176^{a}	85	285^{b}	101	249^{b}	144
56-63	198^{a}	73	250^{b}	81	340^{c}	146
63-70	181^{a}	62	325^{b}	115	329^{b}	76
70-77	222^{a}	102	242^{a}	92	418^{b}	122
77-84	209^{a}	68	240^{a}	115	310^{b}	66

a, b, c – averages marked with different letters are significantly different ($P \leq 0.05$).

The slaughter performance traits of rabbits are shown in Table 2. Slaughter weight was highest ($p < 0.05$) in rabbits of the Grey Flemish Giant breed and lowest in New Zealand White rabbits. However, the highest hot carcass weight and cold carcass weight were obtained in the crossbred group. This was not a significant difference to the Grey Flemish Giant group, while the lowest carcass weight was obtained from New Zealand White rabbits. Significant differences ($p < 0.05$) were noted in the weight of the liver, lungs, heart and kidneys. For all of these organs, the values were highest in Grey Flemish Giants. The weights of the head and of the front and back part of the carcass were comparable for crossbreds and Grey Flemish Giants, while the weight of the loin was significantly the highest ($p < 0.05$) in the crossbred group. The present study also analysed the proportion of meat, bones and fat in individual carcass cuts. The meat weight in the front part, loin and back part was significantly the highest ($p < 0.05$) in carcasses from the two-breed crossbreed group. In contrast, the highest proportion of meat in the carcass was recorded in New Zealand White rabbits. The highest bone weight in the front part, loin and back part as well as the highest proportion of bone in the carcass were obtained for purebred Grey Flemish Giants. The weight of the fat in the front part of the carcass was highest for Grey Flemish Giants, while the amount of fat in the loin and back part was highest in the crossbreds. The carcass fat content was also highest in this group. The experiment also determined the proportion of individual carcass cuts in relation to the whole carcass. The carcasses obtained from Grey Flemish Giant rabbits had the highest proportion of front part in the carcass. The highest proportion of loin in the carcass was observed in the two-breed crosses, while the proportion of back part in the carcass was similar in the New Zealand White and Grey Flemish Giant rabbits. Analysis of hot and cold dressing out percentage showed that both parameters were highest in carcasses from crossbred rabbits and lowest in Grey Flemish Giants. The low dressing out percentage in this group is due to the fact that despite the high slaughter weight, the carcass weight was relatively low. Grey Flemish Giants had high head and giblet weights, which significantly increased ($p < 0.05$) their live weight.

Table 2

Slaughter traits of New Zealand White (NZW) and Grey Flemish Giant (GFG) rabbits and their crosses (NZW×GFG)

Weight	NZW		NZW×GFG		GFG	
	Mean	SD	Mean	SD	Mean	SD
Slaughter weight [g]	2511[a]	116	2896[b]	361	3057 [c]	228
Hot carcass[g]	1205[a]	84	1496[b]	218	1432[b]	156
Cold carcass [g]	1170[a]	83	1433[b]	200	1392[b]	159
Liver [g]	83.76[a]	10.72	74.55[b]	13.90	93.54[c]	3.36
Lungs [g]	20.14[a]	4.00	25.36[b]	5.66	28.93[c]	3.12
Heart [g]	8.46[a]	1.80	10.86[a]	2.16	15.49[b]	1.80
Kidneys [g]	17.76[a]	2.15	20.31[a]	3.59	27.10[b]	5.56
Head [g]	168.04[a]	11.68	179.11[b]	21.75	180.17[b]	5.93
Front part [g]	460.44[a]	40.12	565.34[b]	81.08	565.87[b]	62.13
Loin [g]	263.88[a]	20.36	337.67[b]	61.99	293.66[c]	42.72
Back part [g]	444.74[a]	31.40	528.75[b]	70.35	531.6[b]	56.40
Meat of the front part [g]	356.00[a]	36.87	435.30[b]	69.00	404.32[c]	56.27
Bones of the front part [g]	99.86[a]	8.58	119.02[b]	13.26	148.63[c]	23.73
Fat of the front part [g]	3.78[a]	6.71	11.03[b]	8.26	12.93[b]	6.63
Meat of the loin [g]	224.14[a]	17.31	271.27[b]	47.59	239.73[a]	45.19
Bones of the loin [g]	29.34[a]	4.39	37.39[b]	7.78	41.20[c]	5.13
Fat of the loin [g]	9.80[a]	9.26	29.02[b]	13.49	12.24[a]	2.86
Meat of the back part [g]	360.58[a]	27.42	427.16[b]	60.56	416.07[b]	43.99
Bones of the back part [g]	83.86[a]	9.12	98.81[b]	12.86	115.15[c]	15.87
Fat of the back part [g]	0.54[a]	2.40	2.78[b]	4.57	0.00[a]	0.00
Proportion of front part in the carcass [%]	39.31[a]	1.22	39.52[a]	2.17	40.71[b]	1.87
Proportion of loin in the carcass [%]	22.57[a]	1.17	23.44[b]	1.66	21.04[c]	1.01
Proportion of back part in the carcass [%]	38.01[a]	0.85	36.98[b]	1.52	38.22[a]	0.46
Proportion of meat in the carcass [%]	80.37[a]	1.85	79.06[b]	1.76	76.07[c]	2.25
Proportion of bones in the carcass [%]	18.24[a]	1.42	17.97[a]	1.90	22.04[b]	2.53
Proportion of fat in the carcass [%]	1.17[a]	1.20	2.91[b]	1.21	1.80[c]	0.42
Hot dressing out percentage [%]	47.93[a]	1.89	51.59[b]	3.44	46.73[a]	1.60
Cold dressing out percentage [%]	46.57[a]	1.91	49.45[b]	3.25	45.39[a]	1.79

a, b, c – averages marked with different letters are significantly different ($P \leq 0.05$).

Table 3 shows the quality traits of rabbit meat. Analysis of meat texture showed statistically significant differences ($p < 0.05$) between groups. The shear force value was identical in the New Zealand White rabbit and the crossbred group, while it was statistically lower in the Grey Flemish Giant rabbits. Meat hardness and chewiness were statistically the lowest in the New Zealand White rabbit. The highest values for these parameters were recorded for meat from crossbreds, while the value for chewiness was statistically significantly the highest. Meat springiness and cohesiveness were highest in New Zealand White rabbits and the lowest in Grey Flemish Giants. Analysis of meat quality also included the chemical composition of meat obtained during dissection in all three experimental groups. The meat of the crossbreds had the highest protein content and the lowest fat content. The lowest protein content and at the same time the highest fat content were noted in the meat of New Zealand White rabbits. The crossbreds had the highest water content in their meat, and consequently statistically the lowest dry matter content.

Table 3

Selected meat quality traits of New Zealand White (NZW) and Grey Flemish Giant (GFG) rabbits and their crosses (NZW×GFG)

Trait	NZW		NZW×GFG		GFG	
	Mean	SD	Mean	SD	Mean	SD
Shear force [kg/cm^2]	3.00^a	0.84	3.00^a	0.93	2.48^b	0.77
Hardness [kg]	21.85^a	8.08	57.60^b	18.79	54.83^b	13.69
Springiness	0.74^a	0.12	0.52^b	0.07	0.50^b	0.07
Cohesiveness	0.49^a	0.05	0.46^a	0.07	0.41^b	0.04
Chewiness [kg]	7.96^a	4.24	13.47^b	4.15	11.45^c	3.63
Dry matter [%]	27.43^a	1.20	25.74^b	0.43	26.96^a	1.25
Crude ash [%]	1.23	0.05	1.24	0.05	1.24	0.05
Water [%]	72.57^a	1.20	74.26^b	0.43	73.04^a	1.25
Total protein [%]	22.97^a	0.66	23.21^b	0.37	23.01^{ab}	0.59
Total fat [%]	2.81^a	0.90	0.83^b	0.35	2.22^c	1.16

a, b, c – averages marked with different letters are significantly different ($P \leq 0.05$).

Khalil and Afifi (2000) set out to study the heterosis manifested in the offspring from the crossing of New Zealand White rabbits and Gabali rabbits. The researchers focused on trying to classify the breeds into paternal or maternal breed groups. They also presented data on the growth of the animals in each week of rearing from weaning. They showed no significant differences in body weight at 4, 6, 8, 10 and 12 weeks of rearing between groups of purebred animals and their crosses. The final body weight of the animals was also low (on average from 1711 to 1726 g) compared to the values obtained in our experiment.

North et al. (2018) studied the growth, slaughter performance and meat quality of New Zealand White rabbits in two feeding groups. Animals that received commercial complete feed achieved a slaughter weight of 3200 g, which is more than 500 g higher than that obtained in our experiment. The cold carcass weight presented by North et al. (2018) was 1862 g, which was also significantly higher than that obtained in our experiment. The weights of the liver, kidney and heart with lungs were 112 g, 22.4 g and 25.6 g, respectively. The liver and kidney weights were higher than in our study, but the total heart + lung weight was lower. The head weight of the animals was 112 g, while in our experiment it averaged 168 g. The dressing out percentage of the slaughtered animals was also examined, and at 57.9% it was 10% higher than that obtained in our experiment. However, the reason for the difference is unknown, as the paper did not provide the formula by which the dressing out percentage was calculated.

Omar et al. (2020) focused on the effect of nutritional supplementation on the slaughter performance traits of New Zealand White rabbits. In the group with no nutritional supplement, the slaughter weight of rabbits was 2085 g, and the chilled carcass weight was 1202 g. The slaughter weight value was lower than that recorded in our study, while the cold carcass weight was similar in both experiments. The slaughter yield, calculated as the ratio of chilled carcass to slaughter weight, was 57.67%. This value was much lower in the present study, due to the animals' higher body weight before slaughter. The authors of the paper cited examined the proportion of the front part, the loin, and the hind part in the rabbit carcass and obtained values of 38.23%, 20.87%, and 39.29%, respectively. In our experiment, the proportion of each carcass cut in relation to the whole carcass was similar to the cited results. Individual values may differ by about 2%.

Bieniek et al. (2012) studied the body weight of New Zealand White rabbits, Burgundy rabbits, and their crossbreds in individual weeks of rearing and showed that for the first two weeks of life body weight was highest in young New Zealand White rabbits, while from the 3rd week of rearing until slaughter, the highest body weight was obtained by the crossbreds. The slaughter weight of crossbreds was on average about 200 g higher than that of purebred animals, as in the present study, despite the use of a different breed component. The results presented by the authors of the 2012 paper also show that the carcasses obtained from crossbreds were about 100–150 g heavier than the carcasses from purebred animals. In the present study, the disparity between New Zealand White rabbits and their crossbreds was even greater, averaging 290.36 g for warm carcasses and 262.13 g for cold carcasses. The calculated hot and cold dressing percentages were not significantly different in the group of New Zealand White rabbits and their crossbreds. The proportion of meat in the front part of the carcass and the loin was significantly the highest in New Zealand White rabbits, as in our study. The carcasses obtained from these animals also had the lowest proportion of fat.

Medellin and Lukefahr (2001) studied the body weight by week of rearing and daily weight gains of New Zealand White rabbits and their crossbreds. They showed that daily weight gains during the rearing period from weaning to day 70 were higher in the crossbred group than in New Zealand White rabbits. The body weight of animals at 70 days of rearing was on average 218 and 130 g higher in the crossbred groups, depending on whether the maternal component was New Zealand White rabbit or Altex rabbit, also used in the experiment. The final body weight of the animals ranged from 1833 to 2051 g; this is lower than in our experiment, but it should be borne in mind that in the 2001 study the animals were kept only until day 70, while in our experiment they were kept until day 84.

Chwastowska-Siwiecka et al. (2011) attempted to determine the dressing percentage of New Zealand White rabbits and California rabbits. Body weight before slaughter, hot and cold carcass weights, and head and giblet weights were determined in the experiment. The authors then calculated the hot and cold dressing percentage according to four formulas, two of which were also used in the present study. The hot and cold dressing percentages of New Zealand White rabbits were 46.17% and 46.10%, respectively. The value of cold dressing percentage was similar to that obtained in our experiment, while hot dressing percentage was higher, at 47.93%. Kowalska and Piechocka (2014) also studied the dressing percentage of New Zealand White rabbits divided into three groups according to growth rate. Depending on the group, the dressing percentages were 58.20%, 60.30% and 60.60%. These values are much higher than those obtained in our study, but the differences are due to the use of a formula that takes into account the carcass weight with giblets.

Maj et al. (2008) examined the meat quality of New Zealand White rabbits and their two-breed crosses with California rabbits. Purebred rabbits had a lower protein and fat content than crossbreds, which is only partially in line with the results of the present study. In the study cited, the proportion of protein was significantly increased in the crossbred group, while the fat content of meat was reduced. The meat quality of New Zealand White rabbits and their crossbreds was also the subject of an experiment conducted by Łapa et al. (2008). Meat texture analysis was performed, including the shear force, hardness, springiness, cohesiveness and chewiness of meat. Significant differences were found for hardness, chewiness and shear force between New Zealand White rabbits and their crossbreds, with higher values obtained for the meat of purebred animals. In our experiment, the meat of New Zealand White rabbits had the lowest hardness and chewiness values compared to the other two groups. The differences between the results of the experiments may be explained by the fact that in the 2008 experiment, meat texture analysis was performed on raw meat, while in our experiment it was performed on roasted meat. Kozioł et al. (2017) performed rabbit meat texture analysis for five rabbit breeds, including New Zealand White and Grey Flemish Giant. The experiment revealed statistically significant differences only for hardness, which was statistically the lowest (8.87 kg) in the Grey Flemish Giant meat. The values of all parameters were much lower than those obtained in the present study due to the use of boiled meat in the analysis performed by Kozioł et al. (2017).

Daszkiewicz and Gugołek (2020) examined the quality of meat obtained from Grey Flemish Giant rabbits. The researchers determined the chemical composition of the meat and showed average values of 23.81% dry matter, 21.96% protein and 0.66% fat. In our experiment, Grey Flemish Giant meat had higher content of dry matter, protein and fat. In the case of the last parameter, the value was much higher, amounting to 2.22%.

New Zealand White rabbits, Grey Flemish Giants and their crossbreds were the subject of a study conducted by Lukefahr et al. (1982). The experiment showed that the Grey Flemish Giants had the highest slaughter weight, as in the present study. The inclusion of the Grey Flemish Giant was not shown to improve the slaughter weight of the two-breed crosses. On the other hand, the hot carcass weight in the crossbreds was higher than in purebred New Zealand White rabbits. In our experiment, this value was highest in the crossbreds among all three groups studied. In the study cited, the carcasses obtained from the crossbreds also had the best slaughter yield (52.6%), as well as the best meat yield (70.60%). In our experiment, an analysis of the Warner-Bratzler blade shear force was performed, and the highest value was obtained for the meat of the crossbreds. Significantly the highest protein content was recorded in meat obtained from Grey Flemish Giants, while the fat content was highest in the meat from New Zealand White rabbits. The values for the meat of crossbreds were intermediate between those obtained for the other two groups.

Derewicka et al. (2021) studied growth and slaughter performance traits in New Zealand White rabbits, Grey Flemish Giants, and their crosses. Up to 21 days of age, the highest body weight among these groups was obtained for the purebred Grey Flemish Giant rabbits and the lowest values for the crossbreds. A similar relationship was noted in our experiment. In the study cited, the body weight of animals on the day of slaughter was highest in representatives of the large breed, at 3193 g, and lowest in New Zealand White rabbits (2520 g). Hot and cold carcass weight was highest in Flemish

Giant rabbits. The weights of the front part and back part of the carcass were also highest in Grey Flemish Giant rabbits, while loin weight was highest in the crossbred group. The highest weight of the head and internal organs was noted in the group of Grey Flemish Giants. The results reported in the paper were similar to those obtained in our experiment. Hot and cold dressing out percentages were calculated according to 6 formulas, two of which were also used in the present study. Hot and cold dressing out percentages were highest in the crosses, at 51.42%, and 49.31%, similar to those obtained in our experiment. The dressing out percentage recorded for purebred rabbits was higher in the cited work.

CONCLUSION

The results of the study show pronounced differences in fattening and slaughter performance traits and in meat quality between rabbits belonging to large breeds and broiler breeds. Crossbreeding of medium breeds with large breeds may be a solution worth considering in commercial rabbit breeding, as it can positively affect both the quantity and quality of the product.

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