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Effect of breed and sex on the body weight, slaughter traits, meat quality and meat texture parameters of rabbits

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SUMMARY

The purpose of the study was to determine the influence of breed on the growth, slaughter traits, meat quality traits and meat texture parameters of Blanc de Termonde and Flemish Giant rabbits. Young animals were weaned at 35 days of age. Their weight was recorded from birth to 84 days of age at 7-day intervals. The rabbits were slaughtered between 85 and 90 days of age. Hot carcass weight, cold carcass weight and giblets weight (liver, lungs, heart, and kidneys) were recorded. The pH and colour of the longissimus lumborum and biceps femoris muscles were measured at 45 minutes and 24 hours after slaughter. Shear force and texture parameters were measured. Flemish Giant rabbits attained a higher final body weight but a lower dressing out percentage than Blanc de Termonde rabbits. Carcasses of Blanc de Termonde rabbits had higher loin weight and fat content in the carcass. The effect of breed was found to be significant for some components of meat colour: yellowness (b*) at 45 minutes and lightness at 24 hours post mortem. The effect of sex was found to be significant for meat acidity and the b* component at 45 minutes after slaughter and for redness (a*) at 24 hours post mortem. There were statistically significant differences between Flemish Giant and Blanc de Termonde rabbits in shear force and texture profile analysis (TPA). The sex of the animals affected only the chewiness parameter in the TPA of rabbit meat. Blanc de Termonde and Flemish Giant rabbits attained a high final body weight and dressing out percentage and optimal meat quality traits, and therefore can be recommended as breeding material for the production of slaughter rabbits.

KEY WORDS: rabbit, growth, meat quality, carcass traits

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INTRODUCTION

Rabbits are animals used for many purposes. They are a source of fur, wool and above all meat of exceptional quality. Rabbit meat is distinguished by low fat content and high content of easily digestible protein, rich in essential amino acids. For this reason it is recommended as a source of protein in the diet of children, the elderly, and people with health problems such as hypertension, cardiovascular diseases, and obesity (DalleZotte and Szendro, 2011; Para et al., 2015). The European rabbit (*Oryctolagus cuniculus*) is one of the most widespread species in the world. High phenotypic diversity and breeding selection for various traits have led to the creation of many breeds and lines of this species (Fontanesi, 2021). Intensive selection of rabbits for increased growth and carcass traits have resulted in breeds and lines with a higher growth rate and high meat content in the carcass. According to Boucher et al. (2021), among large breeds of rabbits only Flemish Giants and French Lop rabbits are raised for meat purposes, while most rabbits of medium size breeds (3.5–5.5 kg live weight) can be used in meat production. These are classified as broiler breeds (Fontanesi, 2021). The most popular of these breeds are New Zealand White, Californian, Pannon White, and Blanc de Termonde (Zamaratskaia et al., 2023).

Blanc de Termonde rabbits are one of the youngest medium breeds, developed from the Flemish Giant breed. They are a common breed in Poland, used in rabbit meat production. They are distinguished by early maturation, high litter size and milk yield, and a good maternal instinct, as well as high slaughter weight of about 2600 g and very good meat quality, which are important traits in the production of rabbit meat (Kołodziejczyk et al., 2012; Pałka et al., 2017; Gugołek et al., 2019).

The Flemish Giant rabbit is one of the oldest known breeds and is considered to be the breed with the highest body weight. It matures late, after six months, with a high body weight above 7 kg, rabbits with a body weight of about 12 kg are reported as well. In optimal housing conditions, a slaughter weight of about 9–10 kg can be achieved (Frunză et al., 2023a). The slaughter weight of animals at 90–95 days of age usually ranges from 3 kg to almost 3.2 kg (Bolet, 2002; Derewicka, 2020). Seven colour variations of Flemish Giant rabbits are recognized, but the most popular is the Flemish Giant Grey rabbit. Numerous studies have confirmed that the breed of rabbit has a significant impact on the quality of the meat (Tumova et al., 2014; Kozioł et al., 2017; Pałka et. al., 2018; Siudak et al., 2023).

The present study was designed to determine the influence of breed on the body weight, slaughter traits, meat quality, and meat texture parameters of Blanc de Termonde and Flemish Giant rabbits.

MATERIALS AND METHODS

The experimental animals were housed in a heated hall equipped with a water-supply system (nipple drinkers), lighting (14L:10D), and exhaust ventilation. The data for the study consisted of results concerning the growth, carcass traits, and meat quality traits of 154 rabbits –55 Flemish Giant Grey (33 ♂ and 22♀) and 99 Blanc de Termonde (55 ♂ and 44♀).

Young rabbits were weaned at 35 days of age. They were fed *ad libitum* with pelleted feed containing 16% protein, 18.9% crude fibre and 2.1% fat, constituting 10.2 MJ metabolic energy.

The weight of the animals was recorded from birth to 84 days of age at 7-day intervals. The rabbits were slaughtered between 85 and 88 days of age, after 24 hours of fasting with access to

water. Slaughter was carried out according to methods described by Blasco and Ouhayoun (1996). The carcasses were eviscerated and cooled for 24 hours at 4ºC. Hot carcass weight, cold carcass weight and giblets weight (liver, lung, heart, and kidneys) were recorded. The chilled carcass was cut at two points: between the last thoracic and first lumbar vertebra, and between the last lumbar and first sacral vertebra. Then the weight of the fore part, loin, and hind part were recorded.

Dressing out percentages were calculated according to the following formulas:

$$\text{Hot dressing out percentage (DP1)} = \frac{\text{hot carcass weight}}{\text{slaughter weight}} \times 100$$

$$\text{Cold dressing out percentage (DP2)} = \frac{\text{cold carcass weight}}{\text{slaughter weight}} \times 100$$

$$\text{Hot dressing out percentage (DP3)} = \frac{(\text{hot carcass weight} + \text{giblets weight})}{\text{slaughter weight}} \times 100$$

The pH and the colour of the longissimus lumborum and biceps femoris muscles were measured at 45 minutes and at 24 hours after slaughter. The pH measurements were made with a Consort C561 pH meter, accurate to within 0.01. Colour parameters (L* – lightness, a* – redness, and b* – yellowness) were measured with the Minolta CR-410 colorimeter (Minolta Co. Ltd., Osaka, Japan). The final result for each parameter was the arithmetic mean of three measurements at different points over the surface of the longissimus lumborum and biceps femoris muscles.

Shear force and texture parameters were measured using the TA.XTplus Texture Analyser (Stable Micro Systems). Cylindrical samples from the longissimus lumborum muscle were cut from the right half of the loin. The samples were vacuum-packed in food wrap, frozen for 72 h at −18°C, and then thawed at room temperature and boiled in a water bath at 80°C for 40 min. Shear force [kg] was measured on cylindrical samples (15 mm diameter, 15 mm height) using a Warner–Bratzler attachment with a triangular notch in the blade. Meat samples were cut perpendicular to the muscle fibres. The blade speed was 2 mm/s. Texture (hardness, springiness, cohesiveness, and chewiness) was analysed using an attached cylinder 50 mm in diameter. The samples were subjected to a double compression test, applying a force of 10 g to 70% of their height. Cylinder speed was 5 mm/s, and the interval between compressions was 5 s.

To examine the differences between the means for groups, the general linear model (PROC GLM) procedure of SAS software with Tukey's HSD test ($p < 0.05$) was used. The linear model included the genetic group (breed) and sex as fixed effects; the interaction of fixed effects; litter size at birth as a linear covariate for growth; and slaughter weight as a linear covariate for carcass

traits. Student's t-test (PROC TTEST) was performed for the pH, colour and texture of the meat (SAS, 2014).

RESULTS AND DISCUSSION

Table 1 shows the body weight of rabbits from birth to 84 days of age. The interaction of genetic group (breed) and sex was found to be significant for body weight at 63 and 84 days of age.

Flemish Giant Rabbits had significantly higher ($p < 0.05$) birth weight than Blanc de Termonde rabbits (Table 1). There were no significant differences in body weight between breeds from 7 to 84 days of age, except for day 49, when Blanc de Termonde rabbits were significantly heavier than Flemish Giant rabbits. At 7, 21, 49, and then 70 and 77 days of age, body weights of males were significantly lower than for females. The body weights of females and males were similar in the remaining records (Table 1).

Table1.
Effect of breed and sex on body weight of rabbits

Day	FGG		TW		Male		Female		Inter-action
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
	Body weight [g]								
Birth weight	79.52[a]	6.40	65.96[b]	9.98	66.81	10.48	68.73	10.72	NS
7	164.49	10.46	155.71	29.83	152.89[b]	20.95	161.65[a]	35.38	NS
14	258.21	43.79	258.97	55.99	263.65	56.33	255.64	51.22	NS
21	361.79	60.21	364.61	85.89	355.55[b]	78.74	375.63[a]	87.60	NS
28	552.50	110.81	557.17	121.80	548.28	119.71	567.45	120.82	NS
35	832.86	182.46	858.99	165.56	843.20	167.26	872.14	167.19	NS
42	1149.29	285.15	1079.90	174.43	1070.55	200.32	1111.94	180.07	NS
49	1265.83[b]	242.28	1387.37[a]	229.36	1341.94[b]	225.00	1415.10[a]	238.24	NS
56	1746.79	360.60	1702.93	233.41	1677.89	249.07	1748.16	250.32	NS
63	1920.71	455.32	2014.34	238.37	1943.02	237.72	2086.88	257.02	*
70	2289.17	432.78	2270.41	249.50	2205.31[b]	266.61	2357.39[a]	258.01	NS
77	2606.92	335.64	2508.56	281.22	2445.00[b]	244.13	2622.50[a]	315.52	NS
84	2838.93	460.01	2742.63	314.02	2652.27	308.19	2888.16	322.74	*

Blanc de Termonde (TW), Flemish Giant Grey (FGG)

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

Table2.
Effect of breed and sex on slaughter traits of rabbits

Slaughter traits [g]	FGG		TW		Male		Female	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Slaughter weight	3101.20[a]	304.20	2790.05[b]	309.41	2833.28[b]	340.12	2987.65[a]	324.06
Hot carcass Weight	1457.24[a]	196.54	1482.32[b]	167.02	1434.90[b]	171.23	1524.32[a]	174.60
Cold carcass Weight	1415.02[b]	195.80	1442.61[a]	164.67	1394.09[b]	173.72	1478.85[a]	170.14
Liver	104.92[a]	25.03	75.25[b]	16.91	78.41	19.99	79.06	20.86
Lungs	23.77[a]	5.99	17.62[b]	3.23	18.62	4.17	17.96	4.08
Heart	13.85[a]	3.08	11.53[b]	2.43	11.75	2.91	11.86	2.18
Kidneys	26.77	4.88	20.33	17.63	22.41	22.03	19.37	4.30
Head	197.15[a]	30.21	140.36[b]	13.48	148.76	25.67	144.63	22.59
Front part	577.20[b]	77.68	611.29[a]	78.49	582.21[b]	76.70	618.65[a]	79.14
Loin	296.85[b]	49.98	311.55[a]	51.08	297.65[b]	51.50	316.38[a]	48.82
Back part	540.41[a]	71.09	519.34[b]	52.41	513.68[b]	61.94	543.44[a]	55.16
Fat weight	24.33[b]	6.22	61.18[a]	42.06	53.47[b]	40.04	65.73[a]	43.16
DP1[%]	46.84[b]	1.91	53.14[a]	1.78	50.79	3.68	51.10	3.33
DP2[%]	45.47[b]	2.03	51.42[a]	1.71	48.93[b]	3.58	49.57[a]	3.19
DP3[%]	48.10[b]	3.05	57.61[a]	1.91	54.21	5.37	54.30	4.85

Flemish Giant Grey (FGG), Blanc de Termonde (TW)

DP- dressing out percentage

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

According to the literature, the body weight of rabbits varies depending on housing conditions and feeding. Compared to our results, the body weight of newborn Blanc de Termonde rabbits reported by Pałka and Otwinowska-Mindur (2023) was higher – 72.28 g. Setiaji et al. (2022) observed lower birth weight of Flemish Giant rabbits (54.57 g) compared to our research. Body weight at weaning reported by Kmiecik et al. (2016) was higher than for our Blanc de Termonde rabbits – 909g at 35 and 1442g at 49 days of age. In other reports of body weight, the results were similar to those obtained in our research, except in the last two weeks; Kmiecik et al. (2016) observed lower body weight at 77 and 84 days of age compared our research – 2452g and 2707g final weight. The authors observed no effect of sex on the body weight of rabbits. Gugołek et al. (2019) reported lower weaning weight of Blanc de Termonde rabbits about 721 g as well as lower

weight at 91 days of age– 2619g – than in our study at 84 days of age. Zawiślak et al. (2015) observed no significant effect of sex on the final body weight of Blanc de Termonde rabbits, which was 2471.72 g for males and 2515 g for females. Similar results for the body weight of Flemish Giant rabbits were observed in our previous research on the effect of genotype on the growth and carcass traits of purebred and crossbred rabbits, except for final body weight at 84 days of age, which was higher than in the present study at 2957g (Derewicka et al., 2020). Pałka et al. (2023b) obtained similar body weights for Flemish Giant Rabbits from birth to 28 days of age, but a lower result was reported for body weight from weaning at 35 days of age to slaughter at 84 days, amounting to 2838g. The differences in body weight were greatest between 42 and 70 days of age, especially at 56 days, when body weight was about 322g lower than for our Flemish Giant rabbits.

Significant differences in the slaughter weight of rabbits of different breeds and sexes were observed (Table 2). The highest slaughter weight was recorded for the Flemish Giant breed, and the differences were significant. The slaughter weight and the hot and cold carcass weight were significantly higher for females. Significant differences were observed for hot and cold carcass weight between the Flemish Giant and Blanc de Termonde breeds. Higher hot carcass weight was recorded for Flemish Giant rabbits, and higher cold carcass weight for Blanc de Termonde rabbits. Breed was shown to influence giblets weight and head weight; significant differences were observed for the liver, lungs and heart weight, with higher results for Flemish Giant rabbits. Differences were also observed for the weight of the front part, loin and hind part of the carcass: the front part and loin were significantly heavier for Blanc de Termonde rabbits, while the weight of the hind part was significantly higher for the Flemish Giant group. The results for dressing percentage measured for cold and hot carcasses with or without giblets were significantly higher for Blanc de Termonde rabbits. The sex and breed significantly influenced the weight of fat removed from the carcasses (Table 2), with higher fat content noted in the carcasses of Blanc de Termonde rabbits and females. The weight of carcass parts was significantly higher for females than males. The differences between males and females were significant only for DP2 – dressing percentage calculated for chilled carcasses, with a higher result for females (Table 2). There were no significant differences between males and females for hot dressing percentage with or without giblets (Table 2).

The differences in dressing percentage, carcass weight and other carcass traits in the works of various authors are often the result of different slaughter methods and calculations; some authors include the head and giblets in the carcass weight, while others do not. Compared to our results, Bolet (2002) reported a higher hot dressing percentage, i.e. 61.2% for Flemish Giant rabbits at 80 days of age, with a higher average slaughter weight of 3126g, while Pałka et al. (2023b) reported hot and cold dressing percentages of 46.73% and 45.39%, respectively. In that study, the carcass traits reported for Flemish Giant rabbits were slaughter weight 3057g, hot carcass weight 1432g and cold carcass weight 1392g, which was similar to our findings. The weights of the front and back parts of the carcass were slightly lower, while the loin weight was similar, almost 294 g. In our previous research, the dressing percentage of Flemish Giant Rabbits ranged from 47.56% for cold carcasses to 53.96% for hot carcasses with giblets. These results were higher than in the present study, as were the slaughter body weight – 3193g – and the hot and cold carcass weight– 1566g and 1520g (Derewicka et al., 2020). Gugołek et al. (2019) noted a lower hot dressing percentage for the Blanc de Termonde breed, i.e. 47.43%, with slaughter weight of 2616g, carcass

weight 1241g, and carcass parts 480.56g, 318.02g and 442.56g. The weight of the loin was higher than in our work, while the front and back parts weighed less.

There were no significant differences in the acidity of meat obtained from Flemish Giant and Blanc de Termonde rabbits (Table 3). The pH of the biceps femoris was similar at 45 minutes, while for the remaining measurements, at 45 minutes post mortem and 24 hours of cooling, the differences were small and non-significant. However, sex was shown to affect the acidity of the meat, and the differences were found to be significant (Table 3). The pH value measured 45 minutes after slaughter in the biceps femoris and longissimus lumborum muscles was higher for females – 6.74 and 6.79 – than for males – 6.49 and 6.41; these differences were significant. After 24 hours of cooling, the acidity of the meat was stabilized at the same level for male and female carcasses.

Table 3.
Effect of breed and sex on pH, lightness (L∗), redness (a∗) and yellowness (b∗) of rabbit meat

Trait	FGG		TW		Male		Female	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
pH45H	6.63	0.65	6.60	0.34	6.49[b]	0.29	6.74[a]	0.38
pH24H	5.80	0.22	5.93	0.28	5.91	0.25	5.93	0.32
pH45L	6.41	0.30	6.59	0.74	6.41[b]	0.90	6.79[a]	0.29
pH24L	5.64	0.13	5.80	0.22	5.78	0.20	5.80	0.24
L45H	50.41	2.14	52.33	5.43	52.83	2.64	51.50	7.29
a45H	3.08	0.75	3.28	1.25	3.39	1.40	3.11	0.96
b45H	2.05	0.68	0.87	1.68	0.56[b]	1.68	1.39[a]	1.54
L45L	59.41	1.03	59.38	3.33	59.34	3.23	59.45	3.28
a45L	0.91	1.63	0.96	2.36	1.32	2.38	0.53	2.20
b45L	-4.97[b]	2.39	-2.15[a]	3.17	-2.01	3.40	-2.67	2.92
L24H	57.91[a]	1.27	55.04[b]	2.17	54.97	2.37	55.48	2.02
a24H	4.62	1.41	4.43	1.52	4.76[a]	1.69	4.07[b]	1.19
b24H	5.50	1.41	4.20	1.57	4.17	1.64	4.39	1.53
L24L	59.55[a]	0.94	55.09[b]	5.64	55.36	2.62	55.32	7.79
a24L	5.03	1.25	5.76	2.20	6.00	2.48	5.38	1.65
b24L	3.43	1.69	4.13	1.86	3.99	1.94	4.20	1.76

Flemish Giant Grey (FGG), Blanc de Termonde (TW)

L – *m. longissimus lumborum*, H – *m. biceps femoris*

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

The colour of meat can be characterized using three main parameters: L*– lightness, a* – redness, and b* – yellowness. Genotype and sex were shown to affect some parameters of meat colour (Table 3). The genotype affected the yellow component of meat colour measured at 45 minutes post mortem on the surface of the longissimus lumborum muscle and the lightness component measured at 24 hours post mortem on the surface of the biceps femoris and longissimus

lumborum; the differences were found to be significant. A significant effect of sex was shown for yellowness at 45 minutes after slaughter and for redness at 24 hours post mortem measured on the surface of the biceps femoris. For both muscles, minor differences in meat colour parameters between rabbit breeds and sexes were observed, but there were no significant differences between the groups.

Pałka et al. (2023a) reported similar acidity for both muscles in Blanc de Termonde rabbits: from 6.21 and 6.24 (for the longissimus lumborum and biceps femoris, respectively) to 5.70 and 5.76, depending on the measurement time. The authors reported a lower result for lightness and a higher result for yellowness in the biceps femoris at 45 minutes and a higher result for redness at 24 hours post mortem. The values for the a* and b* component in our work were lower for the loin at 45 minutes post mortem than the values reported by Pałka at al. (2023a) – a* 5.07 and b* 3.54.The authors also reported a high redness value (11.11) in the longissimus lumborum muscle, which was higher than in our study. According to Kozioł et al. (2015), the pH values of aged rabbit meat should range between 5.4 and 5.8, while our results were higher, ranging from 5.64 to 5.93 after ageing. Frunză et al. (2023b) also recorded pH values higher than the range given by Kozioł et al. (2015), above 6.0 for the semimembranosus and triceps brachii muscles, which they linked to differences in metabolism in different muscles. Higher pH of rabbit meat has been reported for New Zealand White and California crossbreds by Secci et al. (2019, 2020) and for some rabbit lines (Wang et al., 2016). In a study by Sternstein et al. (2015), the acidity of the leg meat in carcasses of Flemish Giant rabbits was 6.99 measured at 45 minutes after slaughter and 5.79 at 24 hours post mortem. In that study, the meat colour parameters for the leg of Flemish Giant rabbits were 51.01 for lightness, 2.91 for redness and 1.82 for yellowness at 45 minutes post mortem and 58.46, 4.11, and 4.78, respectively, at 24 hours; these results were similar to our findings. Frunză et al. (2023a) found that the lightness of Flemish Giant rabbit meat ranged between 58.32 and 59.12. The authors also reported significant differences in the redness and yellowness of the meat colour between females and males, but it should be noted that their experiment was conducted using older animals – 10 months old and with slaughter weight of almost 9.5kg.

Significant differences were observed for the shear force of rabbit meat between Flemish Giant and Blanc de Termonde rabbits, while no differences were shown between males and females (Table 4). For nearly all texture profile analysis (TPA) parameters, statistically significant differences were noted between breeds. The interaction of genetic group and sex was found to be significant for hardness of rabbit meat. The meat of Blanc de Termonde rabbits had a higher cohesiveness value, but lower values for springiness and chewiness than the meat of Flemish Giant rabbits; these differences were significant. The sex of animals affected only the chewiness parameter in the TPA of rabbit meat; the differences were significant. No differences were observed between sex groups for shear force, springiness or cohesiveness (Table 4).

Table 4.
Effect of breed and sex on shear force and texture profile analysis of rabbit meat

Trait	FGG		TW		Male		Female		Interaction
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Shear force [kg]	2.56[a]	0.79	1.97[b]	0.64	2.16	0.73	2.17	0.77	NS
Hardness [kg]	53.53	13.77	13.42	3.44	28.62	22.19	24.64	18.85	*
Springiness	0.50[a]	0.07	0.46[b]	0.05	0.47	0.06	0.47	0.06	NS
Cohesiveness	0.41[b]	0.04	0.43[a]	0.03	0.42	0.04	0.42	0.04	NS
Chewiness [kg]	11.05[a]	3.70	2.72[b]	1.01	5.88[a]	4.85	5.06[b]	4.16	NS

Flemish Giant Grey (FGG), Blanc de Termonde (TW)

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

In contrast to our results, Kozioł et al. (2017) found no differences in TPA parameters between breeds and sexes, except for hardness, with significant differences shown both between breeds and sexes. The results obtained by Kozioł et al. (2017) for shear force and chewiness for samples from the Flemish Giant breed were lower than our results and those obtained by Pałka et al. (2023a) for samples from Blanc de Termonde rabbits; in the latter study, the differences in the results for chewiness and hardness were especially pronounced. Pałka et al. (2023b) reported similar results to our findings for the Flemish Giant breed. Frunză et al. (2023a) found that shear force ranged from 5.14 for males to 5.62 for females, with no significant differences, but as noted above, the experimental animals were much older than in our study.

CONCLUSIONS

In summary, Flemish Giant rabbits attain a higher final body weight but a lower dressing out percentage than Blanc de Termonde rabbits. Carcasses of Blanc de Termonde had higher loin weight and fat content in the carcass. The effect of breed was found to be significant for some components of meat colour, i.e. yellowness (b*) at 45 minutes and lightness at 24 hours post mortem. The effect of sex was found to be significant for the acidity of meat and the b* component at 45 minutes after slaughter and for redness (a*) at 24 hours post mortem. Statistically significant differences were found between Flemish Giant and Blanc de Termonde rabbits for shear force and texture profile analysis (TPA). The sex of animals influenced only the chewiness parameter in the TPA of rabbit meat.

Blanc de Termonde and Flemish Giant rabbits were shown to be able to attain a high final body weight and dressing out percentage and optimal meat quality parameters, and therefore can be recommended as breeding material for the production of slaughter rabbits.

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