Research Article

Effect of Production Systems on Carcass Traits, Visceral Development and Meat Quality in Fattening Rabbits

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Abstract | Actually, some consumers have displayed a growing preference for rabbit meat sourced from alternative rearing systems as opposed to intensive cage-based systems. This trial was designed to explore the influence of production systems (cages - Cg; 13.3 rabbits/m2, closed parks - CP; 7.7 rabbits/m2, and open-air systems - Oa; 0.25 rabbits/m2) and slaughter age (70 and 84 days) on the growth, carcass traits and meat quality of growing rabbits. 120 animals were randomly allocated to three different production systems. At both slaughter ages, the *M. biceps femoris* of Oa and CP rabbits exhibited higher cooking losses (5.50 vs. 3.83%) and total pigments (0.37 vs. 0.28 mg/g) compared to Cg rabbits. The production system did not significantly impact dressing out, visceral development, Warner-Bratzler Shear Force – WBSF and meat pH. In contrast, 84-day-old rabbits reared in cages displayed reduced digestive organ development, decreased caecal acetic acid and increased butyric acid concentration, compared to their counterparts. When comparing slaughter ages, the 84-day-old rabbits exhibited higher dressing out percentages, lower relative organ weights (liver, kidney, lung and heart), decreased hind part proportions and lower cooking loss values. Furthermore, the hind legs of these rabbits had a greater proportion of muscle and less bone, along with increased luminosity and reduced redness. In conclusion, production systems exert influence on specific carcass and meat characteristics.

Keywords | Rabbit, Housing system, Slaughter-age, Carcass, Meat

Received | May 26, 2023; **Accepted** | October 27, 2023; **Published** | January 10, 2024
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Citation | Monteiro DO, Silva JA, Mourão JL, Pinheiro V (2024). Effect of production systems on carcass traits, visceral development and meat quality in fattening rabbits. Adv. Anim. Vet. Sci., 12(1):165-172.
DOI | https://dx.doi.org/10.17582/journal.aavs/2024/12.1.165.172
ISSN (Online) | 2307-8316

INTRODUCTION

Presently, consumers exhibit a clear preference for rabbit meat derived from alternative farming systems over intensive cage-based systems, with a focus on preserving environmental sustainability, animal welfare, economic viability, and food safety (Matics *et al*., 2019; Krunt *et al*., 2022). Carcass quality must meet economic objectives and saleable meat yield, while also appealing to consumer preferences. Significant alterations in carcass traits and meat quality have been observed when animals are reared in alternative systems (Dalle Zotte, 2002; Combes and Lebas, 2003). Some studies have examined alternative housing systems for growing rabbits (Orova *et al*., 2004;

Jekkel *et al*., 2010; Krunt *et al*., 2020).

Housing systems have a substantial impact on rabbit performance (Dal Bosco *et al*., 2000; Dalle Zotte *et al*., 2009) as well as carcass and meat quality (Xicatto *et al*., 2013). Factors such as stocking density, group size, and floor type have been identified as crucial (Matics *et al*., 2019). The European Food Safety Authority (EFSA) established a housing systems committee to provide recommendations, recognizing the importance of this aspect (EFSA, 2020). Confined housing systems have historically yielded optimal productive performance (Maertens and De Groote, 1984) and superior meat quality (Xiccato *et al*., 2013). Collective housing systems with environmental enrichment have gained popularity due to their welfare benefits (Buijs *et al*., 2011). However, it should be noted that larger group sizes, exceeding 10 rabbits, can lead to reduced performance and compromised carcass and meat quality (Dal Bosco *et al*., 2000; Xiccato *et al*., 2013).

In response to the End the Cage Age European Citizens' Initiative (ECI), the European Commission has outlined plans to phase out the use of cages for rabbits and other farmed animals by 2027, necessitating comprehensive research into alternative housing systems. Consequently, our study aimed to investigate the effects of different productio/housing systems (cages, closed pens, and open-air pens) on visceral development, carcass characteristics and meat traits in growing rabbits.

MATERIALS AND METHODS

Housing, animals and experimental design

The research was conducted at the Rabbit Experimental Unit within the Animal Science Department at the University of Trás-os-Montes e Alto Douro in Portugal. This experiment adhered to the guidelines set forth by Portuguese legislation governing animal welfare in scientific research, as stipulated in Government Order No. 113/2013 dated August 7th.

A total of 120 rabbits (New Zealand x Californian) of both genders were monitored throughout their growth period, spanning from 35 to 84 days of age. These rabbits were randomly assigned to three distinct housing groups: cages, closed pens, and open-air pens. The caged rabbits (Cg; n=40) were accommodated in 10 wire cages, each with a total area of 0.03 m2 (0.5m×0.6m; housing 4 animals per cage). Another 40 rabbits were situated in 10 pens within a closed building (CP), offering an area of 0.525 m2 per pen (1.05m×0.5m; housing 4 animals per pen), featuring a bedding of wood shavings with a depth of 10cm. All animals, whether in cages or pens, were housed within a climate-controlled facility, maintaining an air temperature ranging between 20 and 25°C, with a daily light exposure of 12 hours. The third group (Oa), consisting of 40 rabbits, was accommodated in two outdoor pens, each spanning 80 m2 (10 m×8 m), housing 20 animals per pen, and providing access to pasture.

All rabbits were provided with *ad libitum* access to a pellet diet, which consisted of 91.6% organic matter, 24.7% starch, 17.2% acid detergent fiber, 16.2% crude protein and 3.7% crude fat. Additionally, rabbits housed in the outdoor pens were afforded access to natural pasture. Importantly, all rabbits had continuous access to drinking water throughout the duration of the study.

Slaughter traits and sample collections

When the rabbits reached the ages of 70 and 84 days, 30 animals per age group (10 per treatment) were selected for slaughter to conduct carcass and meat studies. Carcass preparation and dissection followed the guidelines established by the World Rabbit Science Association (WRSA) as outlined in Blasco and Ouhayoun (1996). Following the slaughtering process, the hot carcasses, which included the head, kidneys, liver, and thoracic viscera, were weighed and then suspended in a well-ventilated area for 60 minutes. Subsequently, they were cooled in a chamber maintained at 3°C for 24 hours to obtain the weight of the chilled carcass and calculate the drip loss and dressing out percentage.

The weight of the hind part was recordedin accordance with Blasco and Ouhayoun (1996), and the right hind legs were dissected into bone and meat, with their respective weights documented. Measurements of the femur length and diameter were also taken. The weights of the head, liver, and reference carcass were expressed as a percentage of the chilled carcass weight, while the hind part weights and dissectible fat were expressed as a percentage of the reference carcass weight. The meat-to-bone ratio of the hind leg was calculated as the ratio between the dissected meat weight and bone weight.

For rabbits slaughtered at 84 days of age, additional measurements were conducted to gain further insight into digestive characteristics, organ development, and volatile fatty acid (VFA) concentrations. After slaughter, the pH levels of the cecal and stomach contents were measured, and the weights and lengths of both full and empty gastrointestinal tracts were recorded. Samples of cecal content were collected and frozen for subsequent determination of VFA concentrations. The analysis of VFA followed the procedures outlined by Costa-Silva *et al.* (2022).

Rheological and analytical measurements

Measures of color in the CIELAB color space (lightness, L*; redness, a*; yellowness, b*) were conducted following the method outlined by Ouhayoun and Dalle Zotte (1996).

These measurements were taken at 24 hours post-mortem using a Minolta CR-300 Minolta Chromameter (Osaka, Japan). The color of the carcass was assessed on the surface of the *M. biceps femoris* muscle (left), while the meat color was evaluated in the transverse section of the same muscle.

The pH of the chilled carcass at 24 hours post-mortem (pH24h) was determined using a pH glass electrode (pH 91, WTW, Weilheim, Germany), which was inserted to a depth of 5 mm into the right *M. biceps femoris* muscle.

Cooking loss (CL, %), tenderness (WBSF), and pigment concentration were assessed following the methodology described by Pinheiro *et al.* (2011).

Statistical analysis

The results obtained for visceral development, carcass traits, and meat characteristics were subjected to a two-factorial analysis, considering the housing system and age as factors, along with their interaction. In the analysis pertaining to gut development and cecal volatile fatty acids (VFA), the influence of age was not taken into consideration. All statistical analyses were conducted using JMP-SAS software (v.13; JMP-SAS Institute Inc., Cary, NC).

RESULTS AND DISCUSSION

Carcass characteristics

The housing system exhibited a significant effect ($P < 0.05$) on carcass, chilled carcass, and reference carcass weights, as well as the percentage of lean meat (Table 1). The rabbits housed in cages or closed pens displayed higher average slaughter and chilled carcass weights, approximately 12.5% and 12.8% greater, respectively, compared to rabbits housed in open-air systems. Caged rabbits also showed a higher percentage of excreta ($P < 0.05$) than those in closed pens and open-air systems (60.1 vs. 58.4 and 58.9%, respectively). Reference carcass weight, expressed both in grams and as a percentage of chilled carcass weight, was significantly greater ($P < 0.05$) for Cg and CP in comparison to Oa. No differences were observed in the relative weights of the liver, kidneys, heart, and lungs concerning the chilled carcass among the various housing systems (Table 1). However, the head weight of rabbits kept outdoors was 8.9% higher ($P < 0.05$) than that of rabbits in other housing groups (Table 1). Viscera weight, which includes the liver, kidneys, heart, and lungs, remained similar to values previously reported by Pinheiro *et al.* (2011) and was not influenced by the housing system.

Hind leg weight also exhibited differences ($P < 0.001$) among the three housing systems, with open-air rabbits having the highest weight, closed-park rabbits intermediate, and caged rabbits the lowest. In relation to the reference carcass weight, the proportion of the hind part in open-air housed rabbits was 11.7% and 6.5% higher compared to caged or closed-park rabbits, respectively (Table 1).

Table 1: Carcass characteristics of rabbits housed in cages, closed pens or in open air systems at 70 or 84 days of age.

	Housing System (HS)			Slaughter Age (SA)		SEM[1]	P value		
	Cages	Closed Pen	Open air	70d	84d		HS	SA	HSxSA
No. of rabbits	20	20	20	30	30				
Slaughter weight (g)	2645 a	2635 a	2309 b	2161	2899	56.9	<0.001	<0.001	0.226
Chilled carcass weight (g)	1594 a	1542 a	1368 b	1251	1750	38.1	<0.001	<0.001	0.375
Dressing Out Percentage (DP)	60.1 a	58.4 b	58.9 b	57.8	60.4	0.333	0.044	<0.001	0.821
Drip Loss Percentage (DLP)	1.53	2.63	1.59	1.81	2.02	0.250	0.124	0.670	0.147
Reference carcass									
Weight (g)	1321 a	1271 a	1112 b	1011	1458	34.3	<0.001	<0.001	0.457
Percentage of chilled carcass	82.6 a	82.3 a	81.1 b	80.6	83.3	0.28	0.010	<0.001	0.470
Head (% chilled carcass)	8.14 b	8.18 b	8.96 a	9.04	7.80	0.147	0.012	<0.001	0.267
Liver (% chilled carcass)	6.08	6.52	6.68	6.87	5.98	0.154	0.224	0.003	0.767
Kidneys (% chilled carcass)	1.06	1.05	1.14	1.18	0.98	0.022	0.087	<0.001	0.585
Heart and Lungs (% chilled carcass)	2.07	2.10	2.19	2.30	1.94	0.051	0.540	<0.001	0.316
Dissectible fat (% reference carcass)	3.74	2.75	1.90	2.32	3.27	0.183	<0.001	<0.001	0.002 [2]
Hind part (% reference carcass)	32.5 c	34.4 b	36.8 a	35.3	33.8	0.39	<0.0001	0.016	0.06

[1]SEM: Stand error of mean. [2]At 70 days of age, differences are observed between the values of cages and pens. At 84 days the values of closed pens do not differ from cages and open pens. a, b, c: Means having a common letter did not differ significantly at level *P*>0.05. No. of rabbits were 10 per treatment.

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Table 2: Hind leg characteristics of rabbits housed in cages, closed pens or in open air systems at 70 or 84 days of age.

	Housing system (HS)			Slaughter age (SA)		SEM[1]	P value		
	Cages	Closed pen	Open air	70d	84d		HS	SA	HSxSA
No. of rabbits	20	20	20	30	30				
Hind leg									
Weight (g)	189 a	189 a	174 b	161	207	3.80	0.007	<0.001	0.174
Meat (% hind leg)	80.6 a	80.6 a	78.8 b	78.6	81.4	0.35	0.023	<0.001	0.115
Bone (% hind leg)	19.4 b	19.4 b	21.2 a	21.3	18.6	0.34	0.023	<0.001	0.115
Meat/bone	4.22 a	4.20 a	3.81 b	3.76	4.41	0.081	0.033	<0.001	0.131
Femur									
Weight (g)	15.3	15.0	14.6	14.8	15.2	0.22	0.341	0.372	0.007
Length (mm)	84.7 a	84.3ab	82.7 b	80.6	87.2	0.53	0.019	<0.001	0.352
Diameter (mm)	9.11	9.34	8.95	8.71	9.60	0.095	0.062	<0.001	0.073

[1]SEM: Stand error of mean. a, b: Means having a common letter did not differ significantly at level *P*>0.05. No. of rabbits were 10 per treatment.

The proportion of the hind part was influenced by the housing system, consistent with observations made by Matics *et al.* (2019) and Pinheiro *et al.* (2011). Available space significantly influences animal movement and hind leg development, as previously noted (Combes *et al.*, 2003).

An interaction effect (HSxSA) was observed between the housing system and slaughter age for dissectible fat content (Table 1). At 70 days of age, rabbits in closed-park or open-air systems had dissectible fat content approximately one-third (35%) that of cage-housed animals. At 84 days, rabbits reared in open-air systems displayed dissectible fat content 62% lower (P<0.01) than rabbits reared in cages (1.7 vs. 4.5%). Closed-park rabbits had intermediate values (3.7%) and did not differ significantly from the other treatments.

Generally, slaughter age had a significant impact (P<0.05) on all carcass traits (Table 1), except for drip loss percentage. Slaughter weight, dressing out percentage, chilled carcass weight and reference carcass weight of rabbits increased significantly with age, reflecting greater overall development. The reference carcass weight and carcass yield also increased due to earlier viscera development, a phenomenon noted by others (Ouhayoun, 1998; Dalle Zotte, 2002). The percentage of the hind part and dissected fat also increased with age, indicating differential tissue development, consistent with findings by other authors (Dalle Zotte, 2002; Metzger *et al.*, 2011).

Hind leg characteristics in relation to housing system and slaughter age are presented in Table 2. Caged and closed-park housed rabbits had heavier hind legs and higher meat content (80.6 vs. 78.8%) compared to open-air housed rabbits. However, open-air housed rabbits displayed a higher bone content (% hind leg). The meat-to-bone ratio of the hind leg in open-air housed rabbits was 37.4% lower (P<0.05) than that of cage-housed rabbits and 35.2% lower than that of closed-park rabbits (Table 2). These effects are attributed to the increased exercise afforded to rabbits in the larger available space of the open-air system. The results of this study are consistent with those of Dal Bosco *et al.* (2000) and Chodová *et al.* (2014), although Loponte *et al.* (2018) did not observe differences in rabbits housed in pens or cages.

Femur weight was not influenced by housing system or slaughter age. However, femur length was longer in caged rabbits and shorter in open-air animals, while femur diameter remained unaffected by the housing system. Outdoor rabbits experienced less growth and, consequently, had shorter femur lengths.

Drip loss was not affected by slaughter age (P>0.05). The relative weights of the head, liver, kidneys, and heart/lungs concerning the chilled carcass decreased with age. The hind part content also decreased (P<0.05) with slaughter age and was 4.2% lower at 84 days (Table 2).

Slaughter age influenced the hind leg characteristics of rabbits (Table 2). Rabbits slaughtered at 84 days had heavier hind legs (207 vs. 161g), higher meat content (81.4 vs. 78.6%), a higher meat-to-bone ratio (4.41 vs. 3.76), and lower bone content (18.6 vs. 21.3%). Furthermore, at 84 days, rabbits had longer femurs (87.2 vs. 80.6 mm) and larger femur diameters (9.6 vs. 8.71 mm) (Table 2).

The dissectible fat content of caged rabbits at 84 days of age was higher than that observed in open-air housed rabbits. This effect can be attributed to the lower energy available for growth and fat deposition (Dal Bosco *et al.*, 2000).

Cooking loss was lower at 84 days, likely due to the higher maturity of the animals, which alters the meat composition and decreases water content (Dal Bosco *et al.*, 2001; Dalle Zotte, 2002).

Table 3: Meat quality of carcass (*M. biceps femoris*) of rabbits housed in cages, closed pens or in open air systems at 70 or 84 days of age.

	Housing system (HS)			Slaughter age (SA)		SEM[1]	P value		
	Cages	Closed pen	Open air	70d	84d		HS	SA	HSxSA
No. of rabbits	20	20	20	30	30				
pH									
Slaughter	6.62	6.59	6.60	6.56	6.63	0.023	0.863	0.139	0.167
24 h post mortem	6.03	5.93	5.97	6.01	5.95	0.022	0.188	0.191	0.07
Carcass color *of biceps femoris*									
L*	53.5	52.6	52.9	50.4	55.6	0.58	0.753	<0.001	0.523
a*	4.24	5.83	4.57	6.57	3.19	0.505	0.320	0.005	0.221
b*	5.96	6.42	5.80	6.07	6.05	0.299	0.698	0.962	0.518
Meat color of *M.biceps femoris*									
L*	59.7	59.1	58.8	59.0	59.4	0.38	0.617	0.615	0.412
a*	-1.24	-0.92	-1.21	-1.38	-0.87	0.109	0.386	0.018	0.142
b*	3.82	4.55	4.57	5.56	4.06	0.199	0.189	0.192	0.070
Cooking loss (%)	3.83 b	5.46a	5.55a	6.28	3.61	0.304	0.005	<0.001	0.217
WBSF (N)	50.90	54.92	54.03	50.80	55.70	1.569	0.527	0.118	0.304
Total pigments (mg/g)	0.28 b	0.38a	0.36a	0.33	0.35	0.014	0.002	0.250	0.432

[1]SEM: Stand error of mean. a, b: Means having a common letter did not differ significantly at level $P>0.05$. L*, lightness; a*, redness; b*, yellowness; WBSF: Warner-Bratzler Shear Force. No. of rabbits were 10 per treatment.

Meat physical characteristics

The effects of housing system and age on meat quality are presented in Table 3. Color characteristics, pH values, and tenderness were not influenced by the housing system. However, cooking loss and the total pigment content of the *M. biceps femoris* (BF) muscle were affected (P<0.01). Cooking loss and total pigment content in the BF muscle of cage-housed rabbits were 30.5% and 24.3% lower, respectively, than those of the BF muscle in rabbits housed in closed pens or open-air systems.

The pH of the meat at slaughter and the pH at 24 hours post-mortem were not influenced by the housing system, which aligns with observations made by other authors (Pla *et al*., 1996; Pascual and Pla, 2007; Dalle Zotte *et al*., 2009). The housing system did not impact the color of the carcass and meat. These results were unexpected, given that the meat of open-air (Oa) rabbits had a higher pigment content, which could confer a reddish color. Therefore, a positive correlation between the two factors, as observed by Pinheiro *et al*. (2011), could have been anticipated. In similar studies, some authors reported an effect of rabbit housing on color (Pla, 2008; DalleZotte *et al*., 2009), while others, like us, did not observe housing system effects on color (Dal Bosco *et al*., 2001; Metzger *et al*., 2003).

Cooking loss was lower in cage (Cg) rabbits compared to other systems. This result could possibly be explained by differences in maturity, growth rate, and higher fat content (Lukefahr *et al*., 1983) among the treatments. The treatments did not affect the Warner-Bratzler Shear Force (WBSF) of the meat, which is in line with findings from other studies (Combes and Lebas, 2003; Metzger *et al*., 2003).

The increase in total pigments in the meat of Oa rabbits can be attributed to the fact that exercise enhances the oxidative capacity of muscle, resulting in a higher proportion of oxidative myofibers and the transition from type IIB to type IA fibers (Monin and Ouali, 1991; Volek *et al*., 2012), along with increased metabolism (Krunt *et al*., 2020).

The development of bone occurs earlier than that of muscular tissue (Picard *et al*., 2002), which may explain the higher proportion of muscle mass, lower bone mass, and a higher meat-to-bone ratio in older rabbits. In this study, slaughter age had a significant effect on carcass color defined by the L* and a* indices. L* increased with age, whereas a* decreased, but the a* color increased with age. Changes in carcass and meat color are not universally consistent, and results in the literature differ, as noted by Dalle Zotte (2002). These color changes may be associated with alterations in the predominant fiber types and modifications in oxidative muscular metabolism (Hernández *et al*., 2004), although in our study, pigment concentrations did not differ with age.

The reduction in pHu (ultimate pH) in the meat of older animals, observed in some studies, may correspond to a

Table 4: Gut characteristics of rabbits housed in cages, closed pens or in open air systems at 84 days of age.

	Housing system			SEM[1]	P level
	Cages	Closed pen	Open air		
No. of rabbits	10	10	10		
Live weight (LW)	3036 a	3068 a	2619 b	61.0	<0.001
Stomach pH	1.60 b	2.20 a	1.95 a	0.163	0.047
Caecal pH	5.51	5.62	5.63	0.054	0.143
Organ weight g by g of LW					
Full stomach	29.8 b	42.8 a	44.6 a	2.326	<0.001
Empty stomach	7.71 b	9.04 a	10.09 a	0.364	<0.001
Stomach content	22. 0 b	33.7 a	34.5 a	2.12	<0.001
Full small intestine	35.3 b	42.6 a	39.3 a	1.28	0.002
Full caeco	44.1 b	52.6 a	49.5 a	2.23	0.045
Empty caeco	13.72	14.13	12.25	0.557	0.062
Caecal content	30.4 b	38.4 a	36.3 a	2.03	0.020
Full colon	21.8	24.2	25.4	1.39	0.184
Total digestive tract	129.6 b	154.9 a	156.9 a	3.74	0.001
Organ length cm by LW					
Small intestine	1.14 b	1.16 a	1.36 a	0.035	<0.001
Caeco	16.6 b	17.2 ab	18.5 a	0.49	0.030
Colon	46.8 b	45.0 b	54.2 a	1.82	0.004

[1]SEM: Stand error of mean; a, b, c: Means having a common letter did not differ significantly at level P>0.05.

decrease in water holding capacity in meat. However, this alteration was not observed in other studies (Dalle Zotte, 2002). Contradictory results may arise from differences in breeding conditions and breeds used by different authors, which may overlap with age.

Gut characteristics

The effects of the production system on gut traits at 84 days of age are summarized in Table 4. Rabbits housed in cages exhibited less development in various organs of the digestive tract compared to other housing conditions ($P < 0.05$), relative to their live weight. These findings align with results reported by other authors (Lambertini *et al*., 2001; Loponte *et al*., 2018). It is likely that animals with access to pasture or straw have higher fiber intake, leading to increased gut development. Additionally, the earlier development of digestive organs (as indicated by an allometry coefficient greater than 1) results in their relative proportion being smaller in animals of the same age but heavier. However, some other studies did not observe such differences (Maertens and van Oeckel, 2001; Dalle Zotte *et al*., 2009; Roy *et al*., 2017; Matics *et al*., 2019), possibly due to variations in genotypes, feed composition, or stocking density.

Housing conditions also had a significant effect ($P < 0.05$) on the proportion of volatile fatty acids (VFAs) in the cecum (Table 5), even though the total concentration and dry matter content were not different. In rabbits housed in cages, the concentration of acetic acid decreased while that of butyric acid increased. Rabbits housed in pens or outdoor systems have access to bedding or forage, which alters the composition of their diet, making it more fibrous. The fiber content of the diet impacts the VFA profile, leading to an increase in the proportion of acetic acid and a decrease in butyric and propionic acid levels (Gidenne *et al*., 2000).

Table 5: Caecal VFA concentration of rabbits housed in cages, closed pens or in open air systems at 84 days of age.

	Housing system			SEM[1]	P level
	Cages	Closed pen	Open air		
No. of rabbits	10	10	10		
Total (mmol/100ml)	9.89	9.73	10.38	0.686	0.789
Acetic (%)	69.1 b	73.2 a	74.4a	0.86	<0.001
Propionic (%)	5.59 a	5.13 ab	4.44b	0.304	0.040
Butyric (%)	25.3 a	21.7 b	21.1b	0.84	0.003
Propionic/Butyric	0.22	0.24	0.21	0.016	0.617
Caecal VFA pool(mmol)	6.98	8.05	7.90	0.312	0.305
Caecal dry mater (%)	23.3	22.2	22.0	0.39	0.332

[1]SEM: Stand error of mean. a, b, c -Means having a common letter did not differ significantly at level P>0.05.

CONCLUSIONS AND RECOMMENDATIONS

The carcasses of rabbits housed in cages displayed a higher fat content, whereas the hind legs exhibited a higher proportion of muscle and lower cooking loss. Furthermore, in older rabbits (84 days of age compared to 70 days), the hind legs contained more meat with reduced cooking loss, while maintaining similar Warner-Bratzler Shear Force (WBSF) and total pigment content. In future research, it will be valuable to work with a larger sample size to gain a more comprehensive understanding of the impact of the housing system on growth, carcass characteristics, and meat quality.

ACKNOWLEDGMENTS

The authors integrated in the CECAV, recognize the support of the Foundation for Science and Technology (FCT) of Portugal, project number UIDB/CVT/00772/2020 and LA/P/0059/2020.

NOVELTY STATEMENT

Provide information on the influence of the production system on meat quality.

AUTHOR'S CONTRIBUTION

All authors contributed equally.

Conflict of interest

The authors have decalred no conflict of interest.

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