

Meat quality of Czech White Rabbits in relation to housing

Zdeněk Volek¹, Eva Tůmová², Darina Chodová², Lenka Volková¹, Elena Kudrnová¹

¹Institute of Animal Science

²Czech University of Life Sciences in Prague
Faculty of Agrobiological, Food and Natural Resources
Prague, Czech Republic

Abstract

The aim of the experiment was to determine the influence of stocking densities on the quality of meat of the Czech White Rabbit breed. In the first group, rabbits were kept in pairs in cages measuring 40 x 50 x 43 cm, which constituted a concentration of 10 rabbits per m². In the second group, rabbits were also kept in pairs, this time in cages measuring 60 x 80 x 43 cm (4 rabbits per m²). Rabbits were fed *ad libitum* from the time of weaning until the end of the fattening period (89th day of age) with a diet of a complete pelleted feed. From the results obtained it is evident that neither the final live weight of the rabbits nor the feed conversion over the whole research period were influenced by the number of animals per m². Rabbits kept in cages with the lower stocking density had a significantly lower content of separable fat ($P = 0.016$). The thigh meat of this group of rabbits also displayed significantly lower contents of lauric acid ($P = 0.008$) and myristic acid ($P = 0.033$). Furthermore, this group of rabbits displayed a significantly higher number of muscle fibres ($P = 0.002$), their significantly smaller area ($P = 0.015$) and diameter ($P = 0.006$), compared with rabbits kept in cages with a higher stocking density.

Rabbit, housing conditions, growth, carcass quality, meat quality

Introduction

Rabbit meat is highly valued for its nutritional and dietetic properties (e.g. Hernández 2008). It can be characterized as a lean meat with a high content of crude protein and essential amino acids of high biological value and it does not contain uric acid or purine compounds. The fat content is low, therefore the energy value of the meat is also low. Rabbit meat contains a high level of polyunsaturated fatty acids while also containing low cholesterol levels. As far as mineral substances are concerned, rabbit meat is low in sodium, zinc and iron and high in phosphorus. The concentrations of copper in rabbit meat do not differ from the meat of other livestock. Rabbit meat is a rich source of vitamin B. The consumption of 100 g of rabbit meat will ensure 8% of the daily requirements of vitamin B₂, 12% of vitamin B₅, 21% of vitamin B₆, 77% of vitamin B₃, and will fully cover the daily requirement of vitamin B₁₂ (Combes 2004).

In addition to having its own high nutritional value, the meat can be further enriched through the use of rabbit feed mixtures by various bioactive compounds that are beneficial to human health. Such enriched rabbit meat can thus be considered as the so-called „functional food“ (Dalle Zotte and Szendrő 2011). This includes, for example, increasing the rabbit meat's content of polyunsaturated fatty acids (n-3 PUFA) by enriching the feed with various sources of these acids (e.g. flax seed, fish oil, white lupin). In order to improve the oxidative stability of the meat, it is possible to add various antioxidants to the feed, such as vitamin E. The consumption of meat that contains a higher content of the conjugate linoleic acid (CLA), whose increase in the meat can be also adjusted through the rabbit's diet, has been shown to be beneficial to human health. Similarly, the same method can be used to increase the content of selenium in the meat (Dalle Zotte and Szendrő 2011).

Compared with the effects of diet on meat quality, very little information exists in available literature regarding the influence that housing has on the quality of the carcass

Address for correspondence:

Ing. Zdeněk Volek, Ph.D.
Institute of Animal Science
Přátelství 815, 104 00 Praha 10
Uhřetěves, Czech Republic

Phone: +420 267 009 614
Fax: +420 267 710 779
E-mail: volek.zdenek@vuzv.cz
www.maso-international.cz

and meat of rabbits, in particular with respect to stocking density, referred to as the number of animals per m² within a cage (Szendrő and Dalle Zotte 2011).

The subject matter of this paper is therefore the results of an experiment which monitored the impact of stocking density on the meat quality of the Czech White Rabbit. The Czech White Rabbit is one of seven rabbit breeds included in the National Programme of Genetic Resources Conservation (Tůmová et al. 2011).

Materials and Methods

Twenty Czech White rabbits were used for this experiment. After weaning (day 42 of age), the rabbits were divided into two groups (n = 10). The first group of rabbits was kept in pairs in cages measuring 0.40 x 0.50 x 0.43 m, which constituted a concentration of 10 rabbits per m². The second group of rabbits was also kept in pairs in cages 0.60 x 0.80 x 0.43 m in size, which constituted a concentration of 4 rabbits per m². The research was carried out at the experimental broiler rabbit housing of the Institute of Animal Science at Prague-Uhřetěves, accredited according to European standards. Ambient temperatures ranged between 18 and 20 °C, the relative humidity of the air was 60 ± 5%, and the length of the light period was 12 hours.

Table 1. Recipe and chemical composition (g.kg⁻¹ of the original mass) of the feed mix

Components	
Lucerne granules	300
Extracted sunflower meal (NL, 280 g.kg ⁻¹)	170
Wheat bran	230
Sugar beet pulp	40
Oats	130
Barley	80
Rapeseed oil	20
Aminovitan	10
DKP	5
Limestone	10
Salt	5
Chemical composition	
Dry matter	885
Crude protein	169
Fat	34
Ash	76
Lignin	70
NDF	328
ADF	183
Hemicellulose (NDF-ADF)	145
Cellulose (ADF-ADL)	113
Starch	134

The rabbits were fed *ad libitum* from the time they were weaned until the end of the fattening period (89 days of age). They were fed a complete granular feed mixture whose composition met the stringent nutritional demands of fattened broiler rabbits (Table 1).

During the course of the experiment, feed consumption and morbidity were monitored on a daily basis while live weight was monitored on a weekly basis. At the end of the experiment carcass analysis was carried out based on internationally accepted methods (Blasco and Ouhayoun 1996) and muscle samples were taken (the meat of both thighs, *Biceps femoris* muscle) for necessary analyses: dry matter (105 °C), free fat (ISO 1444, 1997), protein (Kjeltec Auto 1030 Analyser, FOSS Tecator AB, Höganäs, Sweden), hydroxyproline (Diemair 1963), fatty acids (HP 6890 gas chromatograph, Agilent Technologies, Inc.), pHu (24 hrs after slaughter, JENWAY 3510 pH meter), cooking loss (80 °C, 1 hr), meat colour (Minolta SpectraMagic™ NX), muscle fibres (NIS Elements AR 3.1.).

Table 2. Growth performance of the Czech White Rabbit in relation to stocking density

	Czech White Rabbit		RMSE	P
	10 rabbits/m ²	4 rabbits/m ²		
Live weight (g)				
day 42 of age	846	809	84	0.549
day 70 of age	1852	1994	179	0.306
day 89 of age	2702	2652	216	0.758
Live weight (kg)/m ²				
day 70 of age	18.5	8.3	-	-
day 89 of age	27.0	11.1	-	-
Feed consumption (g/d)				
age 42 - 70 days	84.2 ^a	102.9 ^b	6.3	0.001
age 70 - 89 days	163.8	161.8	13.0	0.837
age 42 - 89 days	114.9	126.7	7.5	0.066
Live weight gain (g/d)				
age 42 - 70 days	35.9	42.5	8.5	0.098
age 70 - 89 days	44.7	40.0	5.5	0.266
age 42 - 89 days	39.5	39.9	4.9	0.907
Feed conversion				
age 42 - 70 days	2.56	2.42	0.36	0.234
age 70 - 89 days	3.70	4.12	0.28	0.007
age 42 - 89 days	3.08	3.19	0.26	0.582

^{a,b} the different letter indices show statistically significant differences at a level of $P < 0.05$

Table 3. Carcass quality of the Czech White rabbits in relation to stocking density

	Czech White Rabbit		RMSE	P
	10 rabbits/m ²	4 rabbits/m ²		
Slaughter weight (SLW; g)	2702	2652	216	0.758
Skin weight (g.kg ⁻¹ SLW)	157	158	9	0.815
Digestive tract (g.kg ⁻¹ SLW)	171	161	18	0.277
Hot carcass weight (g)	1568	1608	181	0.652
Cold carcass weight (g)	1509	1542	173	0.611
Drip loss (%)	4.33	4.01	0.75	0.491
Reference carcass weight ¹ (RCW; g)	1236	1285	146	0.488
Perirenal fat weight (g.kg ⁻¹ RCW)	17.7 ^a	12.0 ^b	5.1	0.030
Total separable fat (g.kg ⁻¹ RCW)	27.0 ^a	18.8 ^b	6.5	0.016
Conformation (meat-to-bone ratio)	4.38	4.71	0.42	0.131
Carcass yield (%)	56.9	58.1	1.79	0.147

¹chilled carcass weight (24 hrs) minus head, organs of the chest, liver, kidneys

^{a,b}these letter indices show statistically significant differences at a level of $P < 0.05$

Results and Discussion

The growth performance of rabbits in relation to stocking density is shown in Table 2. The table shows significantly higher feed consumption between days 42 and 70 of age, as well as throughout the whole fattening period ($P = 0.066$) with regards to rabbits fattened

in cages with a lower stocking density. The higher feed consumption was probably caused by energy needs for growth as well as for higher physical activity in contrast with rabbits kept in cages with a higher stocking density. The final live weight of rabbits ($P = 0.758$) and feed conversion ($P = 0.582$) for the entire reference period were not affected by the amount of animals per m^2 . These findings are in agreement with other authors (e.g. Szendrő et al. 2009).

Most carcass parameters were not affected by stocking density (Table 3). Rabbits kept in cages with the lower stocking density had a significantly lower content of separable fat ($P = 0.016$). A similar result was also published by Lazzaroni et al. 2009.

Table 4. Basic composition of thigh meat of the Czech White rabbits in relation to stocking density

	Czech White Rabbit		RMSE	P
	10 rabbits/ m^2	4 rabbits/ m^2		
Dry matter (g.kg ⁻¹)	255	257	8	0.636
Protein (g.kg ⁻¹)	214	212	5	0.265
Free fat (g.kg ⁻¹)	25.9	26.1	4.8	0.401
Ash (g.kg ⁻¹)	11.8	11.6	0.5	0.451
Hydroxyproline (g.kg ⁻¹)	1.3	1.4	0.1	0.431

Table 4 shows the basic composition of rabbit thigh meat. It is evident that the number of animals per unit of area has no significant influence on the content of dry matter, protein, fat, ash and hydroxyproline.

The profile and composition of fatty acids in the thigh meat of rabbits kept in cages of various stocking density is shown in Table 5. Rabbits kept in cages with the lower stocking density had a significantly lower content of lauric acid (C 12:0) and myristic acid (C 14:0), which is important

Table 5. The profile and composition of fatty acids in the thigh meat (mg.100g⁻¹) of the Czech White rabbits in relation to stocking density

	Czech White Rabbit		RMSE	P
	10 rabbits/ m^2	4 rabbits/ m^2		
lauric acid (C 12:0)	6.7 ^a	4.6 ^b	1.3	0.008
myristic acid (C 14:0)	64.4 ^a	52.2 ^b	10.3	0.033
palmitic acid (C 16:0)	679.6	620.3	83.3	0.179
stearic acid (C 18:0)	242.4	220.6	37.5	0.264
SFA ¹	1019.1	952.9	121.3	0.157
oleic acid (C 18:1 n-9)	953.1	849.8	97.8	0.053
MUFA ²	1077.3	975.7	128.7	0.137
linoleic acid (C 18:2 n-6)	706.6	660.3	75.3	0.141
α -linolenic acid (C 18:3 n-3)	121.7	117.3	15.7	0.583
eicosapentaenoic acid (C 20:5 n-3, EPA)	1.5	1.5	0.3	0.763
docosahexaenoic acid (C 22:6 n-3, DHA)	0.5 ^a	0.3 ^b	0.1	0.024
PUFA ³	926.8	877.9	77.5	0.228
n-6/n-3 PUFA ratio	5.75	5.94	0.52	0.467

¹SFA = total saturated fatty acids; ²MUFA = total monounsaturated fatty acids; ³PUFA = total polyunsaturated fatty acids

^{a,b} these letter indices show statistically significant differences at a level of $P < 0.05$

Table 6. pHu, texture, cooking loss and meat colour of thigh meat of the Czech White Rabbit in relation to stocking density

	Czech White Rabbit		RMSE	P
	10 rabbits/m ²	4 rabbits/m ²		
pHu (24 hrs after slaughter)	5.61	5.58	0.04	0.179
Force per CSA (kg/cm ²)	3.89	3.73	0.62	0.605
Cooking loss of meat (%)	27.1	27.6	2.4	0.682
Meat colour				
L*	63.40	59.71	4.18	0.088
a*	-2.19	-2.11	0.79	0.823
b*	10.47	10.86	1.02	0.444

from the point of view of human nutrition, because both myristic and lauric acids, together with palmitic acid, are responsible for an increase of the total and LDL cholesterol (Ulbricht and Southgate 1991). This group of rabbits also had a lower content ($P = 0.053$) of oleic acid (C18:1 n-9). The content of polyunsaturated fatty acids (PUFA), such as linoleic acid (C 18:2 n-6), α -linolenic acid (C 18:3 n-3), eicosapentaenoic acid (C 20:5 n-3, EPA) and the n-6/n-3 PUFA ratio were not significantly affected by stocking density. The only significantly lower content ($P = 0.024$) in the meat of rabbits in cages with a lower stocking density was the content of docosahexaenoic acid (22:6 n-3; DHA)

Table 7. Basic characteristics of the muscle fibres of the thigh meat of the Czech White Rabbit in relation to stocking density

	Czech White Rabbit		RMSE	P
	10 rabbits/m ²	4 rabbits/m ²		
Number of fibres/mm ²	277 ^a	360 ^b	47	0.002
Muscle fibre area (μm^2)	2472 ^a	2024 ^b	347	0.015
Diameter (μm)	54.5 ^a	48.8 ^b	3.8	0.006

^{a,b} the different letter indices show statistically significant differences at a level of $P < 0.05$

Rabbits fattened in cages with a lower stocking density had a lower value of L* ($P = 0.088$), which shows the lightness of the meat. Such findings are in agreement with other authors (Preziuso et al. 2009) and can probably be explained by the increased physical activity of the rabbits, which increases the oxidative energy metabolism of the muscle (Gondret et al. 2009). The pH value, texture and cooking loss of the meat were not significantly affected by the number of animals per unit of surface area.

A lower stocking density had a positive impact on the main properties of the muscle fibres (Table 7). A significantly higher number of muscle fibres was also recorded for this group of rabbits, as well as a significantly smaller area and diameter.

Conclusions

The results of the experiment have shown that the way that rabbits are housed affects the meat quality. From the perspective of the consumer, a lower stocking density reduces the content of saturated fatty acids in the thigh meat of rabbits and favourably affects the characteristics of the muscle fibres.

Acknowledgement

This work was supported by the Ministry of Agriculture of the Czech Republic (Project NAZV QI101A164).

References

- Blasco A, Ouhayoun J 1996: Harmonization of criteria and terminology in rabbit meat research. Revised proposal. *World Rabbit Sci* **4**: 93-99
- Combes S 2004 : Valeur nutritionnelle de la viande de lapin. *INRA Productions Animales* **17**: 373-383
- Dalle Zotte A, Szendrő ZS 2011: The role of rabbit meat as functional food. *Meat Sci* **88**: 319-331
- Diemair W 1963. *Laboratoriumsbuch für den Lebensmittelchemiker*. Dresden und Leipzig: Theodor Steinkopff Verlag
- Gondret F, Hernández P, Remignon H, Combes S 2009: Skeletal muscle adaptations and biomechanical properties of tendons in response to jump exercise in rabbits. *J Anim Sci* **87**: 544-553
- ISO 1444 1997: Meat and meat products. Determination of free fat content. Czech Standards Institute, Prague: International Organization for Standardization
- Hernández P 2008: Enhancement of nutritional quality and safety in rabbit meat. In: 9th World Rabbit Congress, 10-13 June, Verona, Italy: pp. 367-383
- Lazzaroni C, Biagini D, Lussiana C 2009: Different rearing system for fattening rabbits: performance and carcass characteristics. *Meat Sci* **82**: 200-204
- Preziuso Z, Dalle Zotte A, Paci G 2009: Meat traits of rabbits housed outdoors: effect of stocking density. *Ital J Anim Sci* **8**: 279-281
- Szendrő Zs, Princz Z, Romvári R, Locsmándi L, Szabó A, Bázár Gy, Radnai I, Biró-Németh E, Matics Zs, Nagy I 2009: Effect of group size and stocking density on productive, carcass, meat quality and aggression traits of growing rabbits. *World Rabbit Sci* **17**:153-162
- Szendrő Zs, Dalle Zotte A 2011: Effect of housing conditions on production and behaviour of growing meat rabbits: A review. *Livestock Sci* **137**: 296-303
- Tůmová E, Martinec M, Chodová D 2011: Analysis of Czech rabbit genetic resources. *Sci Agric Bohem* **42**: 113-118
- Ulbricht TLV, Southgate DAT 1991: Coronary heart disease: seven dietary factors. *The Lancet* **338**: 985-992