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QUALITY OF CARCASSES AND MEAT FROM MALE AND FEMALE RABBITS

Sabine Sampels*, Jonna Skoglund
Swedish University of Agricultural Sciences, Uppsala, Sweden

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Abstract
Meat from rabbits offers high nutritive properties as it has high levels of essential amino acids, minerals and vitamins. Rabbit meat is also regarded lean, since it contains less fat than many other meat types. The composition of rabbit meat lipids is also favourable due to higher contents of unsaturated fatty acids compared to other types of meat. The aim of the present study was to examine and compare meat quality from male and female rabbits. A total of 24 rabbits (12 males and 12 females) were used. The rabbits were slaughtered at an age of 17–18 weeks. The following parameters were studied: slaughter traits, colour, pH, cooking loss, tenderness, total fat content and water holding capacity (WHC). Interestingly, the ultimate pH was significantly lower in male compared to female rabbits ($p = 0.008$). Moreover, cooking losses were higher in the meat from male rabbits ($p = 0.001$). No other relevant differences were found between meat from male and female rabbits suggesting that sex might be regarded as a minor factor in the production of rabbit meat at the chosen slaughter age.

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Introduction

Nowadays, interest in a healthy and sustainable lifestyle and particularly a healthy diet is constantly growing. A Healthy diet became a priority in sustainable production and consumption because of the increasing number of scientific evidences linking quality and quantity of food consumption to human health. Consumer's demands for food products with low content of saturated fat pushed industry and researchers to find alternative food sources and continue investigations on underestimated traditional food sources. Rabbit meat was repeatedly suggested as a functional food and as an attractive part of a healthy, diet, mainly due to the high nutritional value [1,2]. Indeed, rabbit meat is characterized by high contents of proteins and oleic acid, and a low-fat content [3–5]. Rabbit meat is also characterized by lower calory content (approximately 618 kJ/100 g fresh meat) compared to red meats [6]. Additionally, rabbit meat consumption might be important role in fighting food shortage in some countries. New rabbit-based products are continuously being developed to satisfy the consumer's needs and promote rabbit meat on the market [5]. Another important issue to consider is the low environmental impact from raising rabbits compared to raising of cattle and some other livestock species. Thus, it can be regarded as is a sustainable choice compared to red meat [7]. However, compared to other species, our knowledge on the effects of slaughter age and rabbit sex on productive performance, slaughter traits and carcass quality is still limited. Knowledge on the relationship between rabbit welfare and meat quality is also fragmentary. Similar to other types of meat, quality of rabbit meat is affected several factors, including age and sex of the animals, genetic propensity of the animals, rearing conditions and nutritional status [8–10]. Animal welfare and health status are also important determinants of the final meat quality [9].

The objectives of the present study were to examine and compare meat quality from male and female rabbits. The following parameters were studied: slaughter traits, colour, pH, cooking loss, tenderness, total fat content and water holding capacity (WHC).

Objects and methods

Animals raising and slaughter

An equal number of male and female rabbits of a crossbreed of Champagne d'Argent and New Zealand red ($n = 24$) were raised at a conventional farm located in Avesta Krylbo, Sweden. The animals were fed 1–1.5 dl of the commercial feed Kalvstart from Edel (Table 1) per animal and day and had free access to water and hay. The rabbits were also occasionally provided with fresh branches, grass, fruits and vegetables. The male rabbits were housed in a 10×4 m pen, while the female rabbits were kept in a 7×3 m pen.

The rabbits were slaughtered at an age of 17–18 weeks on the farm at the same day, using a captive bolt pistol for anesthetization, followed by severing of the carotid arteries and jugular vein. The body weights were recorded after

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bleeding. The carcasses were placed in a cold room and pH (pH1) was measured 1 hour after slaughter using a Knick Portamess 913 X pH (Berlin) pH-meter with a penetrating electrode. The pH-meter was adjusted to muscle temperature at each measurement. The meat was then packed into plastic bags and transported to a laboratory at Swedish University of Agricultural Sciences for further analyses. Colour and ultimate pH were investigated on fresh meat within 24 hours after slaughter, carcasses were stored at 4 °C overnight. The samples for all other analyses were stored at minus 20 °C until analyses.

Table 1. Composition of the feed Kalvstart from Edel

Item	Value	Units
Energy	13	MJ
Protein	200	g
Fat	45	g
Starch	270	g
Neutral detergent fiber	255	g
Dry matter	87	%
Calcium	11	g
Phosphorus	8	g
Magnesium	3.0	g
Vitamin A	10000	IE
Vitamin D	2800	IE
Vitamin E	60	mg
Copper	7	mg
Selenium	0.5	mg

The experiment on animals, including their housing, welfare, care and all manipulations, were run in compliance with the Council Directive 86/609/EEC of November 24, 1986 on the approximation of laws, regulations and administrative provisions of the Member States regarding the protection of animals used for experimental and other scientific purposes.

Measurements of meat colour and pH

The colour was measured in three sites on the surface of the inside of the loin using Chroma Meter CR-300 Minolta 1991 (Singapore). To evaluate the colour, we used L*a*b* system, where the L* value designates lightness, while a* and b* are colour coordinates (+a* = redness, minus a* = green, +b* = yellow, minus b* = blue). Ultimate pH was determined 24 hours post mortem using a Knick Portamess 913 X pH (Berlin) pH-meter with a penetrating electrode. The pH-meter was adjusted to muscle temperature.

Fat content of meat

For determination of fat content, the fat was extracted as previous described [11] with slight modifications. Briefly, approximately 2 g of rabbit meat was chopped and homogenized with 15 ml 3:2 (v/v) hexane: isopropanol, (HIP) using Ultra-turrax (T25 basic, IKA-Werke, Germany). The samples were transferred to a Teflon tube, and 12 ml of Na_2SO_4 were added, the tubes were well shaken and subsequently centrifuged at 1079 g for 5 minutes using a Sorvall Super T21 (SL-50T rotor, Newtown, Connecticut, USA.). Fat content was determined gravimetrically from the separated upper phase after evaporation of the Hexan.

Water holding capacity (WHC)

WHC was analysed by putting the samples between two filter papers (Munktell 00A 125mm Ø) under a weight of 2000 g for 10 min. Final weight of the sample was recorded as compared to initial weigh before the press was applied. WHC was calculated as following:

$$WHC = \frac{(\text{Initial weight} - \text{Final weight})}{\text{Initial weight}} \quad (1)$$

Cooking loss and tenderness

To evaluate the cooking loss, the loin samples were thawed in 4 °C overnight, kept in room temperature for 3 hours and weighted prior to cooking in a water bath (Tectron-Bio 100, Barcelona) in vacuum bags, at 70 °C for 120 min with constant circulation. Then, the samples were cooled under running water for 30 min. The samples were removed from the vacuum bags, dried with paper and weighted. Cooking loss was calculated as following:

$$\text{Cooking loss (\%)} = \frac{(\text{Weight prior to cooking} - \text{Weight post cooking})}{\text{Weight prior to cooking}} \quad (2)$$

The tenderness was evaluated using the Warner-Bratzler shear test. Right and left longissimus dorsi muscles were dissected and three pieces from each muscle were cut along the fibre direction in 10 x 10mm. The shear force was measured using TA.HDi Texture analyser (Hamilton, MA) with a shear blade. The load cell was 50 kg and the speed 50–100 mm/min. Both maximum and total forces were recorded.

Statistical analyses

Statistical analysis was performed with the Statistical Analysis System, version 9.4 (SAS Institute, Cary, NC, USA). The Shapiro–Wilk and Kolmogorov–Smirnov tests as well as visual evaluation of the data were used to investigate normality of data distribution. Eventual sex-related difference in measured parameters were estimated using the general linear model (GLM). The relationships between measured parameters were estimated using Pearson's correlation coefficients. The level of statistical significance was set at $p<0.05$.

Results and discussion

The major characteristics of meat from male and female rabbits are presented in Table 2. The relationships between the measured traits are presented in Table 3. Majority of characteristics were similar in male and female rabbits ($p>0.05$; Table 2).

The rabbits in the present study were slaughtered at an age of 17–18 weeks. One of the limitations of the study is that maturity stage was not evaluated. Since rabbits of both

sexes often are slaughtered at the same age, male and female rabbits might be at different maturity stages, which might result in difference carcass weight and other related characteristics. In many species, males have a higher growth potential compared to females. However, weights of male and female rabbits (at least prior to adult weight) are usually similar. This was also demonstrated in several previous studies on rabbits [10,12]. The slaughter weights in the present study did not differ between male and female rabbits. Slaughter weight at 17–18 weeks (119–126 days) was higher than found by Viliene et al [13] in Californinan rabbits raised up to 112 days, which might be due to difference in breed but also due to a longer rearing period. Carcass yield was higher in the study by Viliene, which however might be affected by different cutting methods, as traditions might be different in different countries.

Interestingly, the pH 24 hours post slaughter (ultimate pH) was significantly lower in male compared to female rabbits ($p = 0.008$). In contrast, no significant differences between male and female rabbits were observed in other studies [14,15]. The ultimate pH in the present study ranged from 5.6 and 6.2. It was previously suggested that this pH might indicate that rabbit meat has a poorer shelf life than meat of other types [16]. Generally, the ultimate pH is affected by various factors, including pre- and post-slaughter conditions, type of muscle and individual animal characteristics. A low ultimate pH leads decreased WHC, increased drip losses and greater cooking losses. Indeed, in the present study, cooking losses were higher in the meat from male rabbits ($p = 0.001$) and the ultimate pH was negatively correlated with cooking losses ($p = 0.007$). However, no sex-related differences in WHC were observed ($p = 0.252$). The same is true for tenderness ($p = 0.262$) and fat content ($p = 0.849$). Similar results were found previously by Daszkiewicz [17], were WHC differed between breed but not due to sex.

The colour of meat is related to pH. In the present study, the ultimate pH was negatively correlated to b* values (yellowness) ($p = 0.002$). The same results were previously observed on broiler breasts [18].

Table 2. Meat characteristics from male and female rabbits

Parameters	Male rabbits, n = 12	Female rabbits, n = 12	p-value
Carcass weight (kg)	1.7 ± 0.07	1.7 ± 0.07	0.972
Slaughter ratio (%)	52.5 ± 0.83	53.1 ± 0.68	0.586
pH 1 h post mortem	6.5 ± 0.07	6.5 ± 0.07	0.582
Ultimate pH	5.8 ± 0.05	6.0 ± 0.05	0.008
L*	44.8 ± 0.54	45.2 ± 0.54	0.615
a*	minus 0.6 ± 0.44	minus 1.7 ± 0.44	0.087
b*	18.6 ± 0.26	17.9 ± 0.26	0.289
Water-holding capacity (%)	16.2 ± 1.01	14.5 ± 1.01	0.252
Cooking loss (%)	14.6 ± 0.47	10.1 ± 0.45	0.001
Tenderness (force, N)	10.4 ± 0.76	11.6 ± 0.76	0.262
Fat%	1.1 ± 0.05	1.1 ± 0.06	0.849

Data are presented as least square mean and standard error, obtained from the GLM model with the fixed effect of sex.

The relationships between WHC and intramuscular fat have been extensively studied. Many studies have indicated a relationship between intramuscular fat content and the sensory traits such as "tenderness" and "juiciness" in meat of different types [19,20]. In the present study, fat contents were similar in meat from male and female rabbits and were not related to any of other parameters (data not shown). However, some other studies observed that the total amount of adipose tissue in females tended to be higher compared to males [21,22]. A discrepancy between the results from different study might be due to the different meat types and analytical methods.

Table 3. Pearson correlation coefficients between the ultimate pH, colour characteristics, water-holding capacity, cooking loss and tenderness of rabbit meat

	L*	a*	b*	Water-holding capacity	Cooking loss	Tenderness
Ultimate pH	minus 0.28	minus 0.38	minus 0.59**	minus 0.26	minus 0.55**	minus 0.01
L*		minus 0.47*	0.78***	0.43*	0.15	0.23
a*			-0.09	0.04	0.32	minus 0.16
b*				0.31	0.38	0.21
Water-holding capacity					0.45*	minus 0.07
Cooking loss						minus 0.14

*** $p < 0.001$, ** $p < 0.01$, * $p < 0.05$.

The comparison of our results with other studies shows that significant difference might be found in different breeds but not sex [17].

Practically, our results imply that rabbits of both sexes can be used for meat production without any relevant effects on carcass characteristics and meat quality. However, more research should be focused on the effects of other parameters of rabbit quality such as diet and stress-related factors, including raising conditions and transport.

Conclusion

Generally, our study showed no or irrelevant differences in meat from male compared to female rabbits, in contrast to other type of meat, such as beef or pork, where the sex-related difference are more notable. Thus, sex might be regarded as a minor factor which affect production of rabbit meat from with crossbreed Champagne d'Argent and New Zealand red slaughtered at 17–18 weeks. Additionally, small and no differences in majority of slaughter traits and meat quality parameters suggest that it is not necessary to raise male and female rabbits to a separate age. Other factors such as breed, age/slaughter weight, transport to slaughter and feeding regime should be further studied.

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AUTHOR INFORMATION

Sabine Sampels — PhD, Associate professor, lecturer, Department of Molecular Sciences, Swedish University of Agricultural Sciences, Box 7015, 750 07 Uppsala, Sweden. Tel.: +46-(0)18–67–20–05, E-mail: sabine.sampels@slu.se
ORCID: https://orcid.org/0000–0003–1695–5939
* corresponding author

Jonna Skoglund — MSc, student, Department of Molecular Sciences, Swedish University of Agricultural Sciences, Box 7015, 750 07 Uppsala, Sweden. E-mail: jonna_0623@hotmail.com

All authors bear responsibility for the work and presented data.

All authors made an equal contribution to the work.

The authors were equally involved in writing the manuscript and bear the equal responsibility for plagiarism.

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