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Effect of genotype on physico-chemical characteristics of rabbit meat

Daniela Belichovska[1], Katerina Belichovska[2], Zlatko Pejkovski[2], Zora Uzunoska[3]

A b s t r a c t: Basic chemical composition (water, protein, fat, ash), water holding capacity and cooking loss of rabbit meat (Oryctolagus cuniculus) were investigated. The meat originated from three different genotypes (New Zealand White, Californian and crossbred animals of these two breeds). Animals up to 30 days old fed exclusively on their mother's milk and then received commercial feed ad libitum until they were 90 days old. Before slaughter, rabbits had an average live weight of 2038.17 g. Muscles from the hind legs from 21 animals (7 of each genotype) were taken for examination at 48 h post mortem. Chemical composition was determined according to standard methods. Water holding capacity was determined by the Grau-Hamm filter paper press method. Cooking losses were measured by dipping 10 g meat pieces into boiling water for 10 minutes, as well as by roasting chops in an electric oven at 180°C to an internal temperature of 78 °C. On average, rabbit meat contained 74.49% water, 21.79% protein, 2.78% fat, 1.24% ash and its energy value was 494.79 kJ 100g^{-1}. Genotype had no significant effect on chemical composition or water holding capacity of meat. The content of free water in the meat amounted, on average, to 52.28% and bound water content was 22.21%. Cooking loss was significantly (P<0.05) lower in meat from crossbreds. During boiling, the meat, on average, lost 32.73% of its weight, compared with a 38.11% loss during roasting.

***Keywords:** rabbit meat, chemical composition, water holding capacity, cooking loss.*

Introduction

Rabbit meat production is based on pure breeds (selected for meat production) and their crossbreds. New Zealand White (NZW) and Californian (CAL) are the most popular breeds in commercial production (*Ozimba and Lukefahr*, 1991; *Shemeis and Abdallah*, 1998). Rabbit meat is appreciated due to its high nutritional and dietetic properties: it is lean, contains highly unsaturated lipids (60% of total fatty acids are unsaturated), is rich in proteins (20–21%) and has amino acids of high biological value, while it is poor in cholesterol and sodium and rich in potassium, phosphorus and magnesium (*Dalle Zotte*, 2000). That is why the rabbit meat is more easily digested compared to other kinds of meat (beef, lamb or pork) and is recommended for consumption, e.g. for persons with cardiovascular illnesses (*Pogány Simonová et al.*, 2010). It is a recommended food for elderly, hypertensive or diabetic patients. The nutritive value is on a par with fish meat (*Para et al.*, 2015). Rabbit meat is one of the best white lean meats available on the market, very tender and juicy. There is no religious taboo or social stigma regarding the consumption of this meat (*Nistor et al.*, 2013).

World rabbit meat production amounted to 1.56 million tonnes in 2014. The leading world producer of rabbit meat is China with 762,627 t year^{-1}, while, in Europe, the main producer is Italy (268,980 t), followed by Spain (63,790 t), France (53,292 t), Czech Republic (38,602 t) and Germany (34,253 t year^{-1}). Unfortunately, for most Balkan countries we have not managed to find data, except for Greece (6,799 t), Bulgaria (6,629 t) and Romania (143 t year^{-1}) (FAOSTAT, 2014).

Chemical composition, water holding capacity (WHC) and cooking loss are the part of physico-chemical characteristics of meat, according to which its quality is estimated. Depending on genotype, age, sex, diet, region of the carcass, rabbit meat contains 65.93 to 77.34% water, 19.43 to

[1]*Faculty of Environmental Resources Management, MIT University, Treta Makedonska Brigada 66a, 1000 Skopje, Republic of Macedonia;*
[2]*Faculty of Agricultural Sciences and Food, Ss. Cyril and Methodius University, Aleksandar Makedonski bb, 1000 Skopje, Republic of Macedonia;*
[3]*Faculty of Technology and Technical Sciences, St. Clement of Ohrid University, Dimitar Vlahov bb, 1400 Veles, Republic of Macedonia.*

Corresponding author: Daniela Belichovska, *daniela.belichovska@gmail.com*

24.40% protein, 0.90 to 4.10% fat and 0.99 to 2.08% ash (*Panic et al*., 1986; *Mohamed*, 1989; *Metzger et al*., 2003; *Metzger et al*., 2006; *Omojola and Adesehinwa*, 2006; *Skandro et al.,* 2008; *Rafay et al*., 2008; *Baiomy and Hassanien*, 2011; *Bivolarski et al*., 2011).

Water in meat can be free, loosely bound or tightly bound. Free water is extracted from the meat by gravity, loosely bound using a force, and tightly bound by drying (*Karan-Djurdjic and Peric*, 1966). The ability of meat to retain its own water and to bind added water is one of the most important technological properties of meat. The WHC of meat includes the ability of meat to retain its own water when applying force (pressing, centrifugation, chopping or warming), as well as to bind added water. Depending on the method applied and other factors (genotype, diet, rabbit age, part of the carcass, time *post mortem* etc.), WHC varies widely from 15.42% to 57.16% (*Omojola and Adesehinwa*, 2006; *Rafay et al*., 2008; *Bivolarski et al.,* 2011; *Suradi and Yurmiaty*, 2011).

The losses during meat cooking depend on the same factors that affect WHC. Various procedures are applied to determine the cooking loss (boiling, roasting, different temperatures and duration of treatment), which varies from 30.22 to 39.15% (*Hernández et al*., 1998; *Dal Bosko et al*., 2001; *Yalçın et al.,* 2006; *Omojola*, 2007). The diversity of rabbit breeds offers the opportunity to increase the efficiency of meat production by commercial crossbreds. The aim of this research was to examine the effect of genotype on chemical composition, WHC and cooking loss of NZW and CAL rabbits and crossbreds between them.

Materials and methods

Meat from three genotypes of rabbit (*Oryctolagus cuniculus*): NZW, CAL and crossbreds between these two breeds, with an average live weight of 1794.4, 1706.2 and 2613.9 g, respectively, were examined. Young rabbits up to 30 days old fed exclusively on their mother's milk and then recieved a commercial feed *ad libitum* until they were 90 days old, when they were slaughtered. Chemical composition and WHC were determined using minced and homogenized muscles from the hind legs, 48 h *post mortem*. Seven samples from each genotype, making a total of 21 samples, were investigated.

Chemical composition and energy value

Chemical composition was determined using minced, homogenized meat according to standard methods (*AOAC, 2005*). The water content was determined by drying the meat in an oven at 105°C according to AOAC 950.46. Total proteins (Nx6.25) were determined using the Kjeldahl method according to AOAC 928.08. Crude fat content was measured according to AOAC 991.36 and ash content according to AOAC 920.153.

The energy value of the meat was calculated by multiplying the determined percentage of fat by 37.7 kJ and the percentage of proteins by 17.9 kJ. The sum of these two obtained values is reported as the energy value of the meat.

Water holding capacity (WHC)

WHC was determined by the pressing method as described by Grau and Hamm (*1953*), using a hydraulic press (Johann Stiel Maschinenbau, Germany). On a previously desiccated filter-paper (Whatman no^{o} 1), 300±3 mg of meat was weighed and pressed between two plexiglass plates and a load of 1000 kg was applied for 5 min. Mean values of two replications were used for analysis. The area of the extruded meat juice (wet area) was measured by planimeter (Reiss-precision, BR 3005, Germany) and expressed in cm^2. The content of free (or loosely bound) water, expressed in mg, was calculated as follows:

$$\text{mg } H_2O = \frac{\text{Wet area (cm}^2)}{0.0948} - 8.0 \qquad \text{(eq. 1)}$$

The percentage of free (or loosely bound) water in the meat and in the total water was calculated as follows:

$$\text{Free water (\%) in meat} = \frac{\text{mg free water}}{300 \text{ mg}} \times 100 \qquad \text{(eq. 2)}$$

$$\text{Free water (\%) in total water} = \frac{\text{mg free water}}{\text{total water (mg)}} \times 100 \qquad \text{(eq. 3)}$$

$$\text{Total water (mg) in 300 mg meat} = \frac{\text{\% water} \times 300}{100} \qquad \text{(eq. 4)}$$

The percentage of bound water in meat = % of total water minus % of free water in meat. The percentage of bound water in total water = 100 minus % of free water in total water.

Cooking losses

Cooking loss during boiling meat was determined by dipping cubic pieces of thigh muscle, weighing 10 g, into boiling water for 10 minutes. The boiling weight loss was calculated by the difference in weight of a meat cube before and after boiling, expressed as a percentage of its initial weight.

Cooking loss during roasting meat was determined using samples of chops, weighing about 30 g, placed into an open porcelain dish and roasted in an electric oven at 180±3°C, until the core temperature was 78°C. The chops were cooled to room temperature and weighed again. The roasting weight loss was calculated by the difference in weight of a chop before and after roasting, expressed as a percentage of its initial weight.

Statistical analysis

Statistical evaluation of the results was performed by analysis of variance (ANOVA). The differences between the mean values of the groups were tested using Tukey's test. The results are given as means±standard deviation.

Results and discussion

The chemical composition of hind legs muscles was not significantly different (P>0.05) between genotypes (Table 1). No significant differences between the chemical composition of meat of NZW and CAL rabbits were found in another study (*Baiomy and Hassanien*, 2011). The established water content in our NZW rabbit meat

Table 1. Chemical composition and energy value of rabbit meat (mean±standard deviation), n=7

Traits	NZW	CAL	NZW x CAL
Water, %	74.60±4.61	74.85±3.71	74.02±1.69
Proteins, %	21.76±1.23	21.59±1.31	22.01±1.27
Fats, %	2.88±0.29	2.62±0.42	2.84±0.15
Ash, %	1.23±0.09	1.37±0.06	1.12±0.03
Energy value, kJ $100g^{-1}$	498.08±27.32	485.23±34.15	501.05±31.75

Legend: NZW – New Zealand White rabbit; CAL – Californian rabbit; NZW × CAL – crossbred New Zealand White × Californian rabbit

Table 2. Water holding capacity of rabbit meat (mean±standard deviation), n=7

Traits	NZW	CAL	NZW x CAL
Total water in meat (%)	74.60±4.61	74.85±3.71	74.02±1.69
Total water in 300 mg meat (mg)	223.80±24.15	224.55±25.16	222.06±24.82
Free or loosely bound water:			
cm^2	15.71±2.87	15.31±2.48	15.86±1.89
mg	157.72±21.15	153.50±21.25	159.30±19.78
Free or loosely bound water (%) in:			
meat	52.57±5.43	51.17±5.22	53.10±4.85
total water	70.47±7.72	68.36±7.69	71.73±6.67
Bound water (%) in:			
meat	22.03±2.34	23.68±2.79	20.92±2.12
total water	29.53±3.25	31.64±3.37	28.27±2.96

Legend: NZW – New Zealand White rabbit; CAL – Californian rabbit; NZW × CAL – crossbred New Zealand White × Californian rabbit

Table 3. Cooking loss (%) of rabbit meat (mean±standard deviation), n=7

	NZW	CAL	NZW x CAL
Boiled meat	35.48±1.85[a]	33.46±1.39[a]	29.25±3.25[b]
Roasted meat	39.80±1.34[a]	39.51±1.31[a]	35.02±3.05[b]

Legend: NZW – New Zealand White rabbit; CAL – Californian rabbit; NZW × CAL – crossbred New Zealand White × Californian rabbit; [a, b] – Values with different letters within a row are significantly different (P<0.05)

(74.60%) was close to the results of other studies on the same breed: *Skandro et al.* (2008) (74.39 to 74.93%), *Rafay et al*. (2008) (74.84%), *Metzger et al.* (2003) (73.9 to 75.0%). However, lower water content (65.93 to 71.42%, 70.2%, 71.5%, respectively) (*Omojola and Adesehinwa*, 2006; *Baiomy and Hassanien*, 2011; *Chrenek et al.,* 2012) as well as higher ones (77.34%) (*Mohamed*, 1989) have also been reported. The mean protein level we determined in NZW rabbit muscle (21.76%) was similar to the findings of *Mohamed* (1989) (21.55%), *Metzger et al.* (2003) (21.3 to 21.5%), *Skandro et al.* (2008) (21.79 to 22.02%) and *Chrenek et al.* (2012) (21.12%). *Omojola and Adesehinwa* (2006), *Baiomy and Hassanien* (2011) found lower protein (19.43 to 21.05% and 20.3%, respectively), while *Rafay et al.* (2008) found a higher protein level (22.12%). The fat content determined in NZW rabbit muscle (2.88%) is in agreement one previous result (2.32%; *Rafay et al.,* 2008), and lower than the 3.35% elsewhere reported (*Chrenek et al.,* 2012). Depending on the dressing methods, fat content was 1.49 to 3.58% (g 100g^{-1}) (*Omojola and Adesehinwa*, 2006), and depending on the age of weaning and muscle type, it was 2.20 to 3.61% (*Bivolarski et al*., 2011). Depending on housing for the rabbits, the amount of fats in the hind legs ranged from 2.48 to 3.36% (*Metzger et al.,* 2003). It seems that there are large variations in fat content. The ash content we determined (in NZW; 1.23%) was close to the published results of *Metzger et al.* (2003) (1.29 to 1.31%), *Skandro et al.* (2008) (1.17 to 1.26%), *Bivolarski et al*. (2011) (1.08 to 1.26%), and lower than that reported by *Mohamed* (1989) (1.63%). The water content (74.85%) in the hind leg muscles of CAL was close to the result published for CAL (73.80%; *Panic et al.,* 1986), and higher than the 69.6% reported elsewhere (*Baiomy and Hassanien*, 2011). The percentage of proteins we determined in CAL rabbit muscle (21.59%) agrees with the published value of 21.87% (*Panic et al.,* 1986), but is higher than 20.4% (*Baiomy and Hassanien*, 2011). The fat content of our CAL rabbit muscle (2.62%) was lower than 3.21% (*Panić et al.,* 1986) and particularly lower than 8.11% (*Baiomy and Hassanien*, 2011). The percentage of ash (1.37%) was higher than 1.07% (*Baiomy and Hassanien*, 2011). Regarding the chemical composition of meat from crossbred (NZW x CAL) rabbits, the water content (74.02%) was higher, and of percentage of proteins (22.01%) lower than the values (71.79 to 72.32% and 23.22 to 24.11%, respectively) obtained previously for the same crossbreds (*Marongiu et al.,* 2008). In Hyla hybrid and other hybrid rabbits, water content was from 73.2% to 74.12%, proteins from 22.2 to 22.7%, fats 1.85 to 3.4% and ash 1.06 to 1.3% (*Nizza and Moniello*, 2000; *Dal Bosco et al*., 2001).

Calculated energy values for the three genotypes (485.23 to 501.05 kJ 100g^{-1}) were higher than those reported in the literature (415 to 458 kJ 100g^{-1}) (*Rafay et al.,* 2008; *Pogány Simonová et al*., 2010; *Chrenek et al.,* 2012).

No significant differences (P>0.05) were found between WHC of the three genotypes (Table 2). In the literature, WHC varies. The reasons for this include numerous methodology differences, different calculation of survey data, the great heterogeneity in the terminology and expression of results, and the use of different pressures when using the method of Grau and Hamm (*1953*). At different pressure, different amounts of water are extruded from meat. Using a pressure of 1 kg, 2.25 kg and free mechanical force, 22.67%, 26.83% and 42.73% free water were obtained, respectively (*Pla and Apolinar*, 2000). Therefore, *Hofmann* (1971; 1977) points out that extruded water is a function of pressure. Over the years, a wide range of conditions have been reported for meat sample evaluation. They range from forces of 0.01 to 44 kN, sample sizes of 0.3 to 1.5 g, temperatures of 4 to 23 °C and compression times from 1 to 20 minutes. In addition, different filter papers have been used. As a consequence, it is difficult to propose a standard procedure for measuring WHC by the press method because too many variations are present in published studies, so results between studies are not comparable (*Petracci and Baéza*, 2007).

Losses during boiling and roasting the meat were lower (P<0.05) in the crossbreds than in pure breeds (Table 3). The differences may be due to the different rabbit weights at slaughter. *Pla et al*. (1998) found that cooking losses were higher in lighter rabbits. Similar losses to those we measured were established by other authors (*Hernández et al.,* 1998; *Pla et al*., 1998; *Yalçin et al*., 2006). Lower cooking losses were obtained in hybrid rabbits (31.5% by boiling, 30.22% by roasting) (*Dal Bosko et al.,* 2001), probably due to the thermal treatment used. Our boiling weight losses of meat corresponded to data obtained by other researchers (*Omojola and Adesehinwa*, 2006; *Omojola*, 2007; *Yurmiati et al.,* 2010). However, it is worth noting that rabbit meat is, generally, not eaten boiled (*Dal Bosko et al.,* 2001).

Conclusion

Rabbit genotype showed no significant effect on basic chemical composition or WHC of rabbit hind leg muscles. Meat from crossbred rabbits underwent significantly (P<0.05) lower cooking loss, compared to the pure breeds. Cooking losses were higher during roasting than during boiling meat. Rabbit meat contained a high percentage of proteins and low amounts of fat, so it can be considered as a dietary product or healthful food.

Conflict of Interest. The authors declare that they have no conflicts of interest.

References

AOAC, 2005. Official methods of analysis, 18th Ed. Gaithersburk, MD, USA.

Baiomy A. A. & Hassanien H. H. M. 2011. Effect of breed and sex on carcass characteristics and meat chemical composition of New Zeland white and Californian rabbits under upper Egyptian environment. *Egypt Poultry Science, 31*, 275–284.

Bivolarski B. L., Vachkova E. G. & Ribarski S. S. 2011. Effect of weaning age upon the slaughter and physicochemical traits of rabbit meat. *Veterinarski Arhiv, 81*, 499–511.

Chrenek P., Makarevich A., Kozelová D. & Rafay J. 2012. Meat quality of transgenic rabbit. *Slovak Journal of Animal Science, 45,* 60–62.

Dal Bosko A., Castellini C. & Bernardini M. 2001. Nutritional quality of rabbit meat as affected by cooking procedure and dietary vitamin E. *Journal of Food Science, 66*, 1047–1051.

Dalle Zotte A. 2000. Main factors influencing the rabbit carcass and meat quality. Proceedings of the 7th World Rabbit Congress, 4–7 July, Valencia, Spain, A: 507–537.

FAOSTAT 2014. Food and Agriculture Organization statistical database. Available at: http://www.fao.org/faostat/en/#data/QL. Access: Production / Livestock Primary, 2014.

Grau R. & Hamm G. 1953. Eine Einfache Methode zur Bestimmung der Wasserbindung in Muskel. *Die Naturwissenschaften, 40,* 259–277.

Hernández P., Pla M. & Blasco A. 1998. Carcass characteristics and meat quality of rabbit lines selected for different objectives: II. Relationships between meat characteristics. *Livestock Production Science, 54*, 125–131.

Hofmann K. 1971. Zur definition der wasserbindung des fleisches. *Fleischwirtschaft*, 51, 806–807.

Hofmann K. 1977. Die wasserbindung des fleisches und ihre messing. *Fleischwirtschaft, 57*, 727–731.

Karan-Djurdjic S. & Peric V., 1966. Hidracija mesa. *Hrana i Ishrana, 7*, 562.

Marongiu M. L., Pinna W., Floris B. & Nizza A. 2008. Rabbit meat production as affected by a delayed-weaning technique. In: Olaizola A., Boutonnet J.P., Bernués A. (ed). Mediterranean livestock production: uncertainties and opportunities. Zaragoza: *CIHEAM/CITA/CITA,* 279–285.

Metzger Sz., Kustos K., Szendro Zs., Szabo A., Eiben Cs. & Nagy I. 2003. The effect of housing system on carcass traits and meat quality of rabbit. *World Rabbit Science, 11*, 1–11.

Metzger Sz., Odermatt M., Szendro Zs., Mohaupt M., Romvari R., Makai A., Biró-Németh E., Radnai I. & Sipos L. 2006. Comparison of carcass traits and meat quality of Hyplus hybrid, purebred Pannon White rabbits and their crossbreds. *Archiv Tierzucht, 49*, 389–399.

Mohamed K. I., 1989. Studies on some productive traits in rabbits under the environmental conditions of El-Minia Governorate (MSc Thesis). El-Minia, Egypt, El-Minia University.

Nistor E., Bampidis V.A., Păcală N., Pentea M., Tozer J. & Prundeanu H. 2013. Nutrient content of rabbit meat as compared to chicken, beef and pork meat*. Journal of Animal Production Advances, 3*, 172–176.

Nizza A. & Moniello G. 2000. Meat quality and caecal content characteristics of rabbit according to dietary content and botanical origin of starch. *World Rabbit Science*, *8*, 3–9.

Omojola A. B., 2007. Effect of delayed bleeding on carcass and eating qualities of rabbit meat. Pakistan *Journal of Nutrition*, *6*, 438–442.

Omojola A. B., Adesehinwa A. O. K. 2006. Meat characteristics of scalded, singed and conventionally dressed rabbit carcasses. *World Journal of Zoology, 1*, 24–29.

Ozimba C. E., Lukefahr S. D. 1991. Comparison of rabbit breed types for postweaning litter growth, feed efficiency, and survival performance traits. *Journal of Animal Science*, 69, 3494–3500.

Panic M., Peric V., Urosevic M. 1986. Neka kvalitativna i kvantitativna svojstva mesa kunića. *Tehnologija Mesa, 27*, 209–212.

Para A. P., Ganguly S., Wakchaure R., Sharma R., Mahajan T. & Praveen K. P. 2015. Rabbit meat has the potential of being a possible alternative to other meats as a protein source: A Brief Review. *International Journal of Pharmacy & Biomedical Research*, 2, 17–19.

Petracci M. & Baéza E. 2007. Harmonization of metodology of assessment of meat quality features. Proceedings of the 18th European Symposium on the Quality of Poultry Meat and 12th European Symposium on the Quality of Eggs and Eggs Products, 2–5 September, Prague, Czech Republic, 175–180.

Pla M. & Apolinar R. 2000. The filter-paper press as method for measuring water holding capacity of rabbit meat. Proceedings of the 7th World Rabbit Congress, 4–7 July, Valencia, Spain, A: 659–662.

Pla M., Guerrero L., Guardia D., Oliver M.A. & Blasco A. 1998. Carcass characteristics and meat quality of rabbit lines selected for different objectives: I. Between lines comparison. *Livestock Production Science*, *54*, 115–123.

Pogány Simonová M., Chrastinová L., Mojto J., Lauková A., Szabóová R., Rafay J. 2010. Quality of rabbit meat and phyto-additives. *Czech Journal of Food Sciences, 28*, 161–167.

Rafay J., Novotna K., Mojto J., Bozic A. & Chrenek P. 2008. Some meat utility and quality traits of transgenic rabbit. *Slovak Journal of Animal Science, 4*, 121–125.

Shemeis A. R. & Abdallah O. Y. 1998. Selection indexes for increased marketing body weight and advantageous body composition in New Zealand White rabbits. *Archiv Tierzucht, 41*, 597–605.

Skandro M., Tarig A., Alić B., Goletic T. & Kustura A. 2008. Qualitative and quantitative characteristics of New Zealand white rabbit meat. *Meat, 10,* 149–153.

Suradi K. & Yurmiaty H. 2011. The effect of giving ration with different level of fiber toward rabbit's leg and loin tender. Faculty of Animal Husbandry, Padjadjaran University.

Yalçın S., Onbaşılar E. E., Onbaşılar İ. 2006. Effect of sex on carcass and meat characteristics of New Zealand white rabbits aged 11 weeks. *Asian-Australasian Journal of Animal Science*, 19, 1212–1216.

Yurmiaty H., Wiedy G. A. & Kusmajadi S. 2010. Effects of electrical stimulation with different impulses on physical characteristics of rabbit meat. *Animal Production, 12,* 124–127.

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