Content is avaliable at SCOPUS

Meat Technology — Special Issue 64/2

www.meatcon.rs ▪ www.journalmeattechnology.com

UDK: 637.55:639.112

ID: 126534921

https://doi.org/10.18485/meattech.2023.64.2.31

Review paper

The nutritional profile and technological properties of rabbit meat

Branko Suvajdžić[a], Nikola Čobanović[a], Nevena Grković[a], Ivan Vićić[a] and Dragan Vasilev[a]

[a] *University of Belgrade, Faculty of Veterinary Medicine, Department of Food Hygiene and Technology, Bulevar oslobođenja 18, 11000 Belgrade, Serbia*

ARTICLE INFO

Keywords:
Rabbit meat
Rabbit meat production
Chemical composition
Technological properties

ABSTRACT

The production and consumption of rabbit meat are declining worldwide, even though rabbit meat offers a nutritional profile that satisfies modern consumer aspirations. Consumers are not sufficiently familiar with the dietetic properties of rabbit meat and have prejudices about its consumption. From a nutritional and technological aspect, rabbit meat is suitable for the production of different meat products as well as products with added value. Therefore, this paper highlights the importance of rabbit meat, its nutritional and technological characteristics, and promotes the development of rabbit meat products that, due to their nutritional value, should conquer the market and break consumers' prejudices.

1. Introduction

Rabbit meat has excellent nutritional and dietetic characteristics. Its high levels of proteins and essential amino acids, moderately high energy value, low fat and cholesterol content, low sodium but high phosphorus levels, and significant content of B vitamins (especially vitamin B12), make it healthy (*Dalle Zotte & Szendrő*, 2011; *Szendrő et al.,* 2020). Therefore, rabbit meat is used in the production of baby foodstuffs and is highly recommended for adolescents, pregnant women, the elderly, and convalescents (*Cury et al.*, 2011; *Składanowska-Baryza & Stanisz*, 2019).

However, the rabbit meat industry is currently going through a difficult period, primarily because of a progressive decrease in consumption and structural weaknesses, as well as criticism concerning welfare conditions and other moral concerns (*Cullere & Dalle Zotte*, 2018). People reluctantly purchase rabbit meat due to its price and a typical gamey flavour, which is unacceptable for many consumers (*Hoffman et al.*, 2004). Many consumers, especially young people, refuse to buy a whole rabbit carcass, which is repulsive to them. Additionally, in many countries, consumption of rabbit meat is not common since rabbits are considered as pets (*González-Redondo & Contreras-Chacón*, 2012). In order to promote the consumption of rabbit meat and ensure the sustainability of the rabbit meat industry, new approaches are urgently needed. The development of innovative, healthier rabbit meat products can be a successful strategy to attract new consumers, particularly those who are health conscious (*Cullere & Dalle Zotte*, 2018). Consequently, this paper highlights the importance of rabbit meat, its nutritional and technological characteristics, and promotes the development of rabbit meat products

***Corresponding author:** Branko Suvajdžić, *brankos@vet.bg.ac.rs*

Paper received July 3rd 2023. Paper accepted July 19th 2023.
Published by Institute of Meat Hygiene and Technology — Belgrade, Serbia

that, due to their nutritional value, should conquer the market and break consumers' prejudices.

2. Rabbit meat production and trade

Today, rabbits can theoretically be characterized as the ultimate meat-producing animals, considering their short life cycle and gestation period as well as their high feed conversion capacity (*Lebas et al.*, 1997; *Honrado et al.*, 2022). Additionally, the nutritional value of rabbit meat can be greatly improved by dietary modifications and/or the inclusion of substances that promote health, since rabbits are monogastric animals (*Dalle Zotte & Cullere*, 2019). Although rabbits are bred all over the world, there are significant differences between continents or countries in terms of rabbit meat production (*FAOSTAT*, 2020).

In the period 2010–2020, the largest rabbit meat production was on the Asian continent, followed by Europe, Africa, and the Americas (Table 1). Asia accounted for 70.49% of global rabbit meat production in 2020. During the mentioned period, the world's top producer was China, followed by the North Korea, the European Union (EU), and Egypt. The largest producers in the EU were Spain, Italy, and France. According to data retrieved from *FAOSTAT*, in the period 2010–2015, global rabbit meat production increased by 9.32%, while after 2015 there was a decrease in production (−31.17%). However, trends varied between countries. Estimated values retrieved from *FAOSTAT* show that rabbit meat production in China has progressively decreased from 783457 tons in 2015 to 488000 tons in 2020 (−37.71%). A similar trend was estimated in North Korea and the EU, where rabbit meat production decreased by 7.20% and 45.60%, respectively. In recent years, countries in the Americas have maintained rabbit meat production at the same levels as previously. Going against the global regression in rabbit meat production during the mentioned period, an increase in rabbit meat production of 6.46% occurred in Africa's top producer, Egypt. Egypt accounted for 71.19% of Africa's rabbit meat output in 2020, followed by Algeria and Sierra Leone.

Table 1. Rabbit meat production in the world (FAOSTAT, 2020)

Continent/Country	Production Quantity (Tonnes)		
	2010	2015	2020
Asia	828,586.09	940,767.28	634,024.78
China	690,000.00	783,457.38	488,000.00
North Korea	133,900.00	153,878.11	142,793.92
Europe	260,672.91	256,647.84	153,150.08
European Union	230,582.91	223,237.64	121,433.79
Russian Federation	14,429.00	17,374.00	18,364.00
Africa	78,638.00	92,794.85	97,122.49
Egypt	52,282.00	64,946.00	69,144.76
Algeria	7,500.00	8,223.70	8,428.45
Sierra Leone	7,600.00	7,920.06	8,103.75
Americas	17,549.50	17,016.53	15,429.12
Mexico	4,350.00	4,399.96	4,481.78
Peru	3,360.00	3,359.13	3,402.13
Colombia	3,185.00	3,182.25	3,212.37
World	1,185,446.51	1,307,226.51	899,726.47

In 2020, Europe held 91.89% and 82.40% of the global rabbit meat imports and exports, respectively. The main importing countries were Germany (4,398.58 tonnes), Belgium (3,902.97 tonnes), and Portugal (1,884.2 tonnes), while Spain (6,771.64 tonnes), Hungary (4,783.22 tonnes), France (4,002.39 tonnes), and Belgium (3,319.25 tonnes) were the largest exporting countries in the Europe. As a world's top producer of the rabbit meat in 2020, China was just the third biggest exporting country in the world (4266.30 tonnes), while there were no official import data for this country (*FAOSTAT*, 2020).

3. Nutritional profile of rabbit meat

Rabbit meat is characterized by high levels of proteins, essential amino acids, and polyunsaturated fat acids, low fat and cholesterol content, low sodium but high phosphorus levels, and a significant content of vitamin B12 (*Dalle Zotte & Szendrő*, 2011). Its moderately high energy value (603–899 kJ/100 g, depending on the carcass part) depends mostly on high protein content, which provides 80% of the energy value (*Dalle Zotte & Szendrő*, 2011). Protein content in rabbit meat ranges from 18.6 g/100 g in forelegs to 22.4 g/100 g in the loin. Looking at the whole carcass, rabbit meat has approximately 20.3 g/100 g of proteins (*Dalle Zotte & Szendrő*, 2011). As a source of valuable proteins, rabbit meat provides all essential amino acids, especially lysine (2.12 g/100 g), threonine (2.01 g/100 g), leucine, (1.73 g/100 g), valine (1.19 g/100 g), isoleucine (1.15 g/100 g), and phenylalanine (1.04 g/100 g) (*Hernàndez & Dalle Zotte*, 2010). Furthermore, rabbit meat is a lean meat with a fat content ranging from 1.8 g/100 g to 8.8 g/100 g, depending on the part of carcass (*Dalle Zotte & Cullere*, 2019). Rabbit intramuscular fat contains mostly unsaturated fatty acids (60.5%), while saturated fatty acids are less represented (38.9%) (*Dalle Zotte & Szendrő*, 2011). Among the unsaturated fatty acids, polyunsaturated fatty acids are predominant, primarily linoleic (18:2 n-6) and α-linolenic fatty acid (18:3 n-3), both essential fatty acids. Linoleic acid is accounts for >20% of all fatty acids in rabbit meat (*Hernàndez & Dalle Zotte*, 2010). In addition, rabbit meat contains significantly more linolenic acid (3%) than do beef (0.70%), pork (0.95%), and lamb (1.37%) (*Enser et al.*, 1996). Long-chain n-6 and n-3 polyunsaturated fatty acids are synthesized from the aforementioned essential fatty acids. Rabbit meat also contains long-chain n-3 polyunsaturated fatty acids, such as docosahexaenoic acid (0.31 mg/100 g) and eicosapentaenoic acid (0.15 mg/100 g) (*Dalle Zotte & Szendrő*, 2011). Mainly, n-3 polyunsaturated fatty acids have an antiatherogenic effect and, consequently, reduce the risk of cardiovascular diseases. Additionally, balancing the ratio of n-6/n-3 polyunsaturated fatty acids is essential for the normal course of different physiological processes (*Park et al*., 2022). The optimal n-6/n-3 ratio should be about 1–2:1, since n-6 and n-3 polyunsaturated fatty acids are metabolized by competitive, common enzymatic reactions (*Tortosa-Caparrós et al.*, 2017; *Park et al*., 2022). Compared to meats of other animal species, rabbit meat offers a fairly low n-6/n-3 ratio, which amounts to 7:1 for the loin (*Dalle Zotte & Szendro*, 2011). Through the rabbit's diet, it is possible to increase the level of n-3 polyunsaturated fatty acids in the rabbit meat and, consequently, decrease the n-6/n-3 ratio, which would be closer to the optimal. Moreover, rabbit meat has a lower cholesterol content compared to other meat types, which amounts about 47 mg/100 g and depends on the rabbit's diet (*Hernàndez & Dalle Zotte*, 2010). Taking into account the potential consequences for human health of cholesterol intake, this fact is significant, and all feeding strategies for rabbits must aim to achieve the lowest cholesterol content in the meat (*Dalle Zotte & Szendro*, 2011). As a white meat type, rabbit meat contains lower levels of iron (1.1–1.3 mg/100 g) and zinc (0.55 mg/100 g) than do the red meats, beef, lamb, and pork (*Parigi Bini et al*., 1992; *Lombardi-Boccia et al*., 2005). Furthermore, rabbit meat has very low sodium content (37–47 mg/100 g), which makes it suitable in diets for hypertension (*Dalle Zotte & Szendrő*, 2011; *Dalle Zotte & Cullere*, 2019). On the other hand, rabbit meat is rich in other minerals, such as potassium (428–431 mg/100 g), phosphorus (222–234 mg/100 g), and selenium (9.3–15 μg/100 g), which are included in the regulation of different physiological functions (*Dalle Zotte & Szendrő*, 2011; *Dalle Zotte & Cullere*, 2019). In terms of vitamins, rabbit meat is a good source of B vitamins. Accordingly, 100 g of rabbit meat provides 8% of daily vitamin B2, 12% of daily vitamin B5, 21% of daily vitamin B6, and 77% of daily vitamin B3 needs, as well as the fulfilment of daily vitamin B12 needs (*Combes,* 2004). Compared to meats of other animal species, rabbit meat is richer in vitamin B12 (8.7 mg/100 g), which is essential for the formation of red blood cells, DNA synthesis, and the proper development of nervous system functions

(*Dalle Zotte & Szendro*, 2011). It is known that vitamin B12 prevents pernicious anaemia and disorders of the nervous system (*Stabler & Allen*, 2004).

4. Technological properties of rabbit meat

As known, the pH value is crucial parameter during the selection of meat for processing and also is an indicator of meat quality and shelf life (*Carrillo-Lopez et al.*, 2021). The pH of rabbit meat is mainly measured in *Musculus biceps femoris* and *Musculus longissimus dorsi*, 45 minutes and 24 hours after slaughter (Kumar et al., 2023). *Musculus biceps femoris* has expressed oxidative metabolism, lower glycolytic potential and, consequently, higher pH compared to *Musculus longissimus dorsi* (Kumar et al., 2023). During the conversion of muscle to meat under normal conditions (without stress), the muscle pH gradually decreases due to the accumulation of lactic acid, and 45 minutes after the slaughter of rabbits, it ranges between 6.1 and 6.9 (*Carrillo-Lopez et al.*, 2021). In comparison to meat of other animal species, rabbit meat has an inferior shelf life since its pH after 24 hours is between 5.6 and 5.85 (*Kozioł et al.*, 2015). The meat pH directly affects water holding capacity, which is essential parameter for meat processing, since poor water holding can result in technological and economic losses (*de Oliveira Paula et al.*, 2020). A low ultimate pH leads to decreased water holding capacity and increased drip losses as well as cooking losses (*Sampels & Skoglund*, 2021). Consequently, rabbit meat with such characteristics is not suitable for use in heat treated products, but may be considered for production of dried meat products and fermented sausages. Rabbit meat with a high (rather than low) water holding capacity has intact, more soluble proteins, and consequently greater protein binding and fat emulsifying capacities, so it is suitable for emulsified sausages production (*Ramos & Gomide*, 2017).

Rabbit meat is especially tender because of its lower elastin content and the high solubility of its collagen, compared to other meat types. Collagen content in rabbit meat ranges from 5.71 to 7.97 mg/g, depending on the carcass part (*Bueno et al*., 2023). Collagen is the main protein of the intramuscular connective tissue, and its quantity and solubility contribute to the development of meat toughness and/or tenderness. High collagen content leads to increased meat toughness (*Pascual & Pla*, 2008). Collagen solubility in muscles is determined by the presence of trivalent thermo-stable collagen crosslinks, which increase during animal growth. Additionally, the low amount of collagen in the meat batter favours the fat globule stabilization and water retention abilities during the production of emulsified sausages (*Bueno et al*., 2023).

Rabbits have a low quantity of adipose tissue, which is necessary for the production of rabbit meat sausages. In order to replace fatty tissue, numerous hydrocolloid systems, such as alginate, carrageenan, xanthan gum, cellulose derivatives, starches, and pectins, have been examined for their ability to form gels and replace fat. However, fat replacement with functional ingredients such as vegetable fibre, is more beneficial due to their technological and dietetic characteristics (*Petracci & Cavani*, 2013). Vegetable fibre can be utilized for replacement alone or in combination with plant oils, which are rich in n-3 polyunsaturated fatty acids, the significance of which has already been highlighted (*Petracci & Cavani*, 2013).

Meat colour is an essential indicator of the processing suitability of meat. As known, meat colour derives from the main pigment of muscle tissue, myoglobin, and also from its chemical state (oxymyoglobin, reduced myoglobin, or metmyoglobin). Compared to other animal species, rabbit meat contains a low amount of myoglobin (0.02% of wet muscle weight) (*Carrillo-Lopez et al.*, 2021) and, consequently, it has relatively light (L*), with a low redness (a*) and yellowness (b*) contribution. According to *Ignacio et al*. (2019), the lightness of meat products increases significantly with the addition of rabbit meat, while the redness significantly decreases. Moreover, the low myoglobin content in rabbit meat limits the development of nitrosyl-myoglobin, which is created in the reaction between myoglobin and nitrites. As already mentioned, rabbit meat is rich in polyunsaturated fatty acids, which are unstable and susceptible to oxidation, the products of which lead to the metmyoglobin formation and, consequently, a decrease in redness (*Ignacio et al*., 2019). However, lipid oxidation is less expressed in rabbit meat than in red meats, since it is poorer in iron, which acts as a pro-oxidant (*Cullere & Dalle Zotte*, 2018). Additionally, the oxidative stability of rabbit meat can be improved by adding 200 mg of α-tocopheryl acetate/kg of feed to the rabbit diet (*Dalle Zotte & Szendrő*, 2011).

5. Conclusion

Taking into account the nutritional profile and technological properties of rabbit meat, it can be concluded that rabbit meat is a good raw material for meat processing. Its nutritional profile makes it suitable for incorporation into added value products that satisfy modern consumer aspirations for healthy food. The development and promotion of new rabbit meat products could be a successful strategy to attract consumers who are not sufficiently familiar with the dietetic properties of rabbit meat and have prejudices about its consumption.

Disclosure statement: No potential conflict of interest was reported by the authors.

Funding: The study was supported by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia (Contract number 451-03-47/2023-01/200143).

References

Bueno, L. O., Bittencourt, M. T., Machado, L. C., Ramos, A. D. L. S. & Ramos, E. M. (2023). Technological performance of different rabbit meat cuts in processing cured cooked ready-to-eat meat products. *Ciência Animal Brasileira*, 24, https://doi.org/10.1590/1809-6891v24e-73917E

Carrillo-Lopez, L. M., Robledo, D., Martínez, V., Huerta-Jimenez, M., Titulaer, M., Alarcon-Rojo, A. D. ... & Garcia-Flores, L. R. (2021). Post-mortem ultrasound and freezing of rabbit meat: Effects on the physicochemical quality and weight loss. *Ultrasonics Sonochemistry,* 79, 105766, https://doi.org/10.1016/j.ultsonch.2021.105766

Combes, S. (2004). Valeur nutritionnelle de la viande de lapin. *INRAE Productions Animales*, 17(5), 373–383. (in French) https://doi.org/10.20870/productions-animales.2004.17.5.3610

Cullere, M. & Dalle Zotte, A. (2018). Rabbit meat production and consumption: State of knowledge and future perspectives. *Meat Science,* 143, 137–146, https://doi.org/10.1016/j.meatsci.2018.04.029

Cury, K., Martínez, A., Aguas, Y. & Olivero, R. (2011). Characterization of rabbit meat and sausage production. *Revista Colombiana de Ciencia Animal*, 3(2), 269–282.

Dalle Zotte, A. & Szendrő, Z. (2011). The role of rabbit meat as functional food. *Meat Science,* 88(3), 319–331, https://doi.org/10.1016/j.meatsci.2011.02.017

Dalle Zotte, A. & Cullere, M. (2019). Carcass traits and meat quality of rabbit, hare, guinea pig and capybara. In *More than Beef, Pork and Chicken–The Production, Processing, and Quality Traits of Other Sources of Meat for Human Diet*, 167–210.

de Oliveira Paula, M. M., Bittencourt, M. T., de Oliveira, T. L. C., Bueno, L. O., Rodrigues, L. M., Soares, E. R. ... & Ramos, E. M. (2020). Rabbit as sustainable meat source: carcass traits and technological quality of meat and of mechanically deboned meat. *Research, Society and Development*, 9(11), e5029119906-e5029119906, https://doi.org/10.33448/rsd-v9i11.9906

Enser, M., Hallett, K., Hewitt, B., Fursey, G. A. J. & Wood, J. D. (1996). Fatty acid content and composition of English beef, lamb and pork at retail. *Meat Science,* 42(4), 443–456, https://doi.org/10.1016/0309-1740(95)00037-2

FAOSTAT, (2020), https://www.fao.org/faostat/en/#data

González-Redondo, P. & Contreras-Chacón, G. M. (2012). Perceptions among university students in Seville (Spain) of the rabbit as livestock and as a companion animal. *World Rabbit Science*, 20(3), 155–162, https://doi.org/10.4995/wrs.2012.1147

Hernández, P. & Dalle Zotte, A. (2010). Influence of diet on rabbit meat quality. In *Nutrition of the Rabbit* (pp. 163–178). Wallingford UK: CABI, https://doi.org/10.1079/9781845936693.0163

Hoffman, L. C., Nkhabutlane, P., Schutte, D. W. & Vosloo, C. (2004). Factors affecting the purchasing of rabbit meat: A study of ethnic groups in the Western Cape. *Journal of Consumer Sciences*, 32.

Honrado, A., Aínsa, A., Marquina, P. L., Beltrán, J. A. & Calanche, J. B. (2022). Low-fat fresh sausage from rabbit meat: An alternative to traditional rabbit consumption. *Meat Science*, 194, 108973, https://doi.org/10.1016/j.meatsci.2022.108973

Ignacio, E. O., Santos, J. M. D., Santos, S. E. D. J., Souza, C. V. B. & Barretto, A. C. D. S. (2019). Effect of the addition of rabbit meat on the technological and sensory properties of fermented sausage. *Food Science and Technology*, 40, 197–204, https://doi.org/10.1590/fst.02019

Kozioł, K., Maj, D. & Bieniek, J. (2015). Changes in the color and pH of rabbit meat in the aging process. *Medycyna Weterynaryjna*, 71(2), 104 –108.

Lebas, F., Coudert, P., Rouvier, R. & De Rochambeau, H. (1997). *The Rabbit: husbandry, health, and production* (Vol. 21). Rome: Food and Agriculture Organization of the United Nations.

Lombardi-Boccia, G., Lanzi, S. & Aguzzi, A. (2005). Aspects of meat quality: Trace elements and B vitamins in raw and cooked meats. *Journal of Food Composition and Analysis,* 18(1), 39–46, https://doi.org/10.1016/j.jfca.2003.10.007

Parigi Bini, R., Xiccato, G., Cinetto, M. & Dalle Zotte, A. (1992). Effetto dell'età, del peso di macellazione e del sesso sulla qualità della carcassa e della carne cunicola. *Zootecnica e Nutrizione Animale,* 18, 173–190. (in Italian)

Park, S., Lee, J. J., Lee, J., Lee, J. K., Byun, J., Kim, I. & Ha, J. H. (2022). Lowering n-6/n-3 ratio as an important dietary intervention to prevent LPS-inducible dyslipidemia and hepatic abnormalities in ob/ob mice. *International Journal of Molecular Sciences*, 23(12), 6384, https://doi.org/10.3390/ijms23126384

Pascual, M. & Pla, M. (2008). Changes in collagen, texture and sensory properties of meat when selecting rabbits for growth rate. *Meat Science*, 78(4), 375–380, https://doi.org/10.1016/j.meatsci.2007.07.009

Petracci, M. & Cavani, C. (2013). Rabbit meat processing: historical perspective to future directions. *World Rabbit Science*, 21(4), 217–226, doi.org/10.4995/wrs.2013.1329

Ramos, E. M. & Gomide, L. A. M. (2017). Meat quality assessment: fundamentals and methodologies (2nd ed.). Viçosa: Editora UFV. (in Portuguese)

Sampels, S. & Skoglund, J. (2021). Quality of carcasses and meat from male and female rabbits. *Теория и практика переработки мяса*, 6(3), 255–258.

Składanowska-Baryza, J. & Stanisz, M. (2019). Pre-slaughter handling implications on rabbit carcass and meat quality–A review. *Annals of Animal Science,* 19(4), 875–885, https://doi.org/10.2478/aoas-2019-0041

Stabler, S. P. & Allen, R. H. (2004). Vitamin B12 deficiency as a worldwide problem. *Annual Review of Nutrition*, 24, 299–326.

Szendrő, K., Szabó-Szentgróti, E. & Szigeti, O. (2020). Consumers' attitude to consumption of rabbit meat in eight countries depending on the production method and its purchase form. *Foods*, 9(5), 654, https://doi.org/10.3390/foods9050654

Tortosa-Caparrós, E., Navas-Carrillo, D., Marín, F. & Orenes-Piñero, E. (2017). Anti-inflammatory effects of omega 3 and omega 6 polyunsaturated fatty acids in cardiovascular disease and metabolic syndrome. *Critical Reviews in Food Science and Nutrition*, 57(16), 3421–3429, https://doi.org/10.1080/10408398.2015.1126549