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Microbiological quality and regulatory compliance of ground game meat produced in central Italy under Regulation (EC) No 2073/2005

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Abstract

The establishment of structured supply chains for hunted game meat has fostered the development of a wide range of products intended for the food service sector. Among these, minced meat has gained particular prominence due to its practicality. Nonetheless, the grinding process can enhance microbial proliferation, posing potential challenges to product quality and safety. The hygienic profile of deep-frozen minced wild boar (*Sus scrofa*) and roe deer (*Capreolus capreolus*) meat remains insufficiently characterized. A total of 70 minced meat samples (corresponding to 10 batches from wild boar and 4 from roe deer) were collected over a 1-year period from a dedicated processing facility. The samples were processed and subjected to aerobic colony counts (ACC), β-glucuronidase-positive Escherichia coli counts, and the detection of *Salmonella* spp. and *Listeria monocytogenes*. The mean ACC was 4.64±0.75 Log CFU/g, with no significant differences between wild boar (4.65 Log CFU/g) and roe deer (4.61 Log CFU/g) samples. Differences were observed for *E. coli* counts, with mean values of 2.60±1.02 Log CFU/g for wild boar and 1.90±0.81 Log CFU/g for roe deer. Neither *Salmonella* spp. nor L. monocytogenes was detected in any of the samples. When compared against the process hygiene criteria established by European legislation, 95.71% of the samples were classified as satisfactory and 4.29% as acceptable for ACC. However, with respect to *E. coli*, 35.71% of the samples exceeded 500 CFU/g, a level regarded as unsatisfactory for minced meat set in Regulation (EC) No. 2073/2005.

Key words: food hygiene, food safety, game meat, wild boar, roe deer, microbiological profile, minced meat.

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Introduction

In recent years, consumer interest in the meat of wild ungulates has grown, even in territories traditionally less associated with hunting (Marescotti *et al.*, 2019). This trend may be explained both by the widespread perception that such meat is healthier (Tomasevic *et al.*, 2018) and by its organoleptic qualities (Kwiecińska *et al.*, 2017; Corradini *et al.*, 2022). Furthermore, some consumers are also motivated by ethical considerations, seeking a valid alternative to red meat derived from intensive livestock farming (Demartini *et al.*, 2018; Demartini *et al.*, 2021; Marescotti, *et al.*, 2020). Within this context, restaurateurs seek semi-processed products such as minced meat or minced meat preparations from game species to prepare a variety of dishes, and consumers increasingly demand culinary options that enhance the value of wild ungulate meat in innovative ways. However, due to its high nutrient content and water activity, minced meat is susceptible to significant microbial contamination and bacterial growth (Ercolini *et al*., 2011). It is important to emphasize that these products originate from carcasses of hunted animals that are processed within complex and frequently poorly standardized supply chains (Gaviglio *et al.*, 2017; Marescotti *et al.*, 2019; Peruzy *et al.*, 2022a), which may require specific regulatory adaptations to ensure consistency and safety (*e.g.*, microbial hygiene criteria for game meat carcass). Indeed, the regulation does not differentiate between ground meat obtained from farmed animals and that derived from hunted species, despite the substantial differences in the respective supply chains.

Vacuum packaging and freezing are common processes for ground meat, but there is limited information in the literature on the hygienic quality of the final product, particularly for game meat. To date, only two studies have been conducted on the hygiene level of ground meat from wild boar with high levels of aerobic colonies and *Escherichia coli*, as well as foodborne pathogens (Kautto *et al*., 2025; Sweden National Food Agency, 2025). However, these studies were performed in a different context from Italy, and there is no data available on roe deer ground meat. Accordingly, the objective of the present study was to evaluate the hygienic quality of vacuum-packaged, deep-frozen minced meat produced from wild boar and roe deer. *Salmonella spp.* and *Listeria monocytogenes* were also investigated as foodborne pathogens to assess some safety aspects of the products. In addition, the study compares the microbiological results with the process hygiene criteria set out in Regulation (EC) No. 2073/2005 (European Commission, 2005), which defines process hygiene criteria for minced meat regardless of the animal species.

Materials and Methods

The study was carried out in the province of Perugia (central Italy), specifically within the Alto Chiascio area, between March 2024 and June 2025, on a local production chain. The animals were collected during selective and population control hunting, which was carried out by local hunters without the use of dogs. They were shot with monolithic bullets and transferred to a nearby collection center within an hour, where they were eviscerated and inspected by a "trained person" in accordance with Regulation EC 853/2004. They were then stored at 4°C for a maximum of 3 days. The carcasses were transported under refrigerated conditions to the game handling establishment, where the skin was removed on the same day. The carcasses were then checked and approved by the competent veterinary authority, after which they were stored for 24 hours at 7°C. In the event of abnormalities to organs and tissues detected by the "trained person", the official veterinarian also carried out a *post-mortem* inspection of the viscera as required by European regulations. Subsequently, the carcasses were transported, while maintaining the cold chain, to the cutting plant authorized under Regulation (EC) No. 853/2004 (European Parliament and Council of the European Union, 2004), where it was promptly processed to obtain meat cuts to be sold as fresh or frozen meat. Shoulders and trimmings from the other cuts that were subjected to the grounding process. The processing temperature complies with the requirements set out in the current regulations for processing plants. The minced meat is usually vacuum-packed and deep-frozen at -40°C on the production line, ready for sale in 500 g or 1 kg packs. For this study, five samples of freshly ground game meat were collected from each daily production batch and deep-frozen at -40°C. The final samples for analytical purposes consisted of five sampling units of 50 g vacuum-sealed, deep-frozen packages (measuring 1 cm in thickness, 6 cm in width and 9 cm in length) for each batch. A total of 14 batches (10 from wild boar and 4 from roe deer) were analyzed, yielding 70 samples overall (50 from wild boar and 20 from roe deer). Samples were transported to the Microbiology Laboratory of the Department of Veterinary Medicine, University of Perugia, in an insulated container maintained at -18°C. Each sample was thawed overnight at 4±1°C before analysis, then 25 g of minced meat was diluted in buffered peptone water (Oxoid Ltd., Basingstoke, UK), followed by a homogenization with a Stomacher 400 Circulator (Seward Ltd., Norfolk, UK). Subsequent ten-fold serial dilutions were prepared in sterile physiological saline solution (Oxoid Ltd.). Aliquots were plated on selective media for aerobic colony counts (ACC), incubated aerobically at 30°C for 72 hours according to ISO 4833-1: 2013 (ISO, 2013) using Plate Count Agar (Biolife Italiana s.r.l., Milan, Italy). Enumeration of β-glucuronidase-positive *Escherichia coli* was performed on TBX medium (HiMedia™ laboratories Pvt Ltd.), incubated aerobically at 42°C for 24 hours following ISO 16649-1: 2018 (ISO, 2018). The same homogenized samples were incubated for 1 day at 37 °C to isolate *Salmonella* spp. according to ISO 6579-1: 2017 (ISO, 2017a). Subsequently, 0.1 mL of the pre-enriched solution was transferred into 9 mL of Rappaport-Vassiliadis broth (Biolife Italiana s.r.l.) and incubated again for 24±2 hours at 42°C to complete the enrichment phase. Following this step, isolation was performed by streaking the enriched broth onto a chromogenic agar selective for *Salmonella* (Biolife Italiana s.r.l.) using a sterile loop, and incubating the plates at 37°C for 24 hours. Qualitative detection of *L. monocytogenes* was carried out in accordance with ISO 11290-1 (ISO, 2017b). A 25 g sample was weighed and diluted in 225 mL of Half Fraser Broth (Biolife Italiana s.r.l.), then incubated at 30°C for 24±2 hours. Subsequently, 0.1 mL of the Half Fraser culture was transferred into 9 mL of Fraser Broth (Biolife Italiana s.r.l.) and incubated at 37°C for 48±2 hours. Finally, the culture was streaked onto ALOA (Oxoid Ltd.) plates with a sterile loop, and it was incubated at 37°C for 24±2 hours. Bacterial counts were expressed as CFU/g and subsequently transformed into logarithmic (Log) values. The limit of detection (LOD) for *E. coli* was set at 1 Log CFU/g; therefore, samples without detectable colonies were assigned this value. The enumeration results were subsequently compared with the threshold values established by Regulation (EC) No. 2073/2005 (European Commission, 2005) regarding the process hygiene criteria for minced meat. For the per-batch confrontation, the results were compared according to the definition of satisfactory, acceptable and unsatisfactory defined in the regulation. Despite the regulations stipulating five sample units per production batch, a per-sample comparison was also made to highlight the product's actual hygiene level. The hygiene criteria for the per-sample comparison are reported in Table 1. Furthermore, the isolation and identification of foodborne pathogens were performed to determine the safety of the final product, despite it being intended for cooking as indicated on the producer's label.

A descriptive statistical analysis was performed on each batch and on the overall sample, with mean values and standard deviations reported. Differences between species were evaluated using an unpaired Student's t-test with a statistical significance threshold of $p<0.05$ (Microsoft Office Excel Statistic Data Tool Pack).

Table 1. Hygiene criteria considered for minced meat in the per-sample comparison with Regulation (EC) N° 2073/2005.

CFU/g	Satisfactory	Acceptable	Unsatisfactory
ACC	$x<5\times10^5$	$5\times10^5<x<5\times10^6$	$x>5\times10^6$
Escherichia coli count	x<50	50<x<500	x>500

ACC, aerobic colony count.

Table 2. Mean values (± standard deviation) of vacuum-packaged, deep-frozen minced meat microbial counts (Log CFU/g).

Log CFU/g	Wild boar	Roe deer	Total
ACC	4.65±0.74	4.61±0.52	4.64±0.75
Escherichia coli count	2.60 ± 1.02^b	1.90 ± 0.81^a	2.40±0.91

ACC, aerobic colony count. n=70. Different letters (a, b) in the same row indicate statistically significant differences among mean values for the analyzed species ($p<0.01$).

Results

The results obtained for the enumeration of ACC and *E. coli* are presented in Table 2. Five samples were under LOD for *E. coli* (all belonging to roe deer samples). No significant differences were observed between wild boar and roe deer minced meat with respect to ACC; however, a significant difference was found for *E. coli* counts ($p<0.01$). None of the analyzed samples tested positive for *Salmonella spp.* or *L. monocytogenes*.

No seasonal variation was detected in wild boar samples, both for ACC (average values of 4.84 *vs.* 4.46 Log CFU/g in autumn/winter and spring/summer season, respectively) and *E. coli* ACC (average values of 2.48 *vs.* 2.66 Log CFU/g in autumn/winter and spring/summer season, respectively). Roe deer were hunted only during the spring/summer time.

The comparison between the data obtained for minced meat from individual species and the process hygiene criteria established by Regulation (EC) No. 2073/2005 (European Commission, 2005), on a per-batch basis reveals that, for ACC in wild boar, there were 8 satisfactory and 2 acceptable batches, and for *E. coli* enumeration, there were 3 satisfactory, 1 acceptable, and 6 unsatisfactory batches. All four batches of roe deer ground meat were satisfactory for ACC, while two of the *E. coli* batches were satisfactory and two were unsatisfactory.

The results obtained on a per-sample basis for this product are shown in Figures 1 and 2. As reported in Figure 1 for ACC, none of the samples was classified as unsatisfactory; 95.7% were deemed satisfactory, and 4.3% acceptable. All roe deer samples were classified as satisfactory, whereas 94% were satisfactory and 6% were considered acceptable in wild boar. For *E. coli* enumeration (Figure 2), 42.86% of the samples were classified as satisfactory, 21.43% as acceptable, and 35.71% as unsatisfactory.

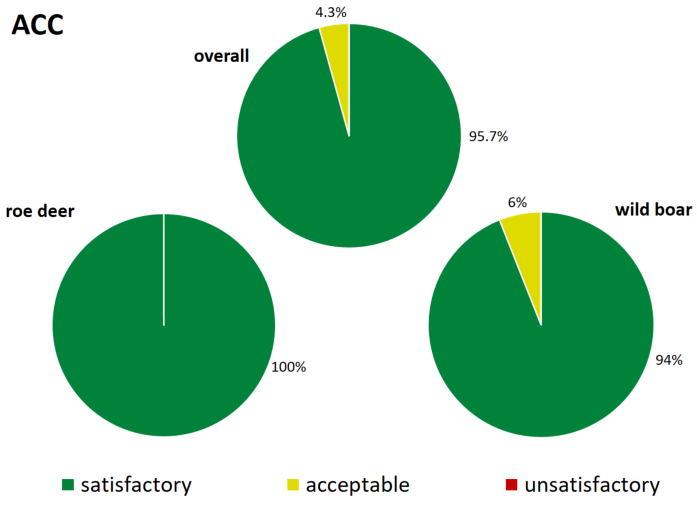

Figure 1. Percentage of compliance with Regulation (EC) No 2073/2005 limits set for aerobic colony count (ACC) of minced meat samples.

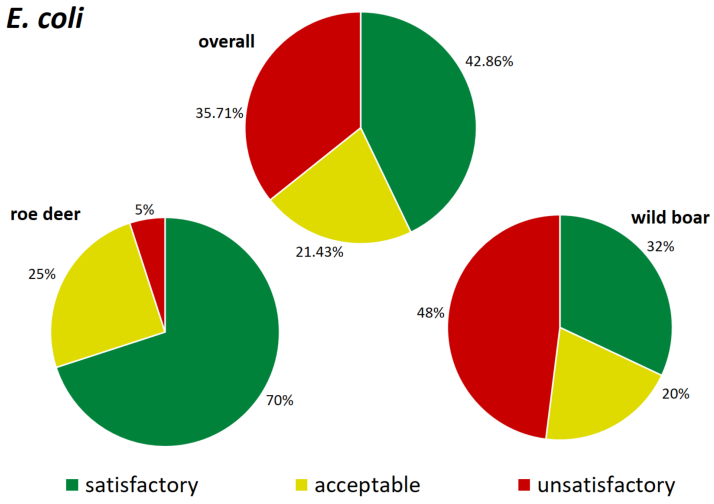

Figure 2. Percentage of compliance with Regulation (EC) No 2073/2005 limits set for *Escherichia coli* count of minced meat samples.

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Specifically, 48% of the wild boar samples were unsatisfactory, compared with only 5% of the roe deer samples.

Discussion

Overall, the ACC values were within the satisfactory and acceptable limits set out in EC Regulation 2073/2005 (European Commission, 2005), whether batch or single samples were considered. However, a substantial proportion of the samples exceeded the maximum limits established by the current regulation for *E. coli*, particularly those from wild boar. Only two studies have been reported in the literature that specifically evaluate the hygiene quality of vacuum-packed, deep-frozen minced wild boar meat. This study, conducted in Sweden, found that 25 out of 33 plants had unsatisfactory results for either ACC or *E. coli*, or both. The median values were 5.6 log CFU/g for ACC and 1.8 log CFU/g for *E. coli*, with significant variation between establishments (Kautto *et al*., 2025), and a high number of unsatisfactory samples from *E. coli* in ground wild boar meat (Swedish National Food Agency, 2025). These results were similar to those obtained in the present survey in Central Italy, which unfortunately relied on data from just one producer. With regard to game meat, one study assessed the hygienic status of frozen minced beaver meat. When compared with the findings of the present study, the results reported by Ziomek *et al.* (2021) exhibited higher ACC and lower *E. coli* levels. Although no other studies have specifically evaluated the hygienic status of minced meat from large game species, the results obtained in the present study can be compared with those reported by other authors for minced meat derived from livestock ungulates. Indeed, with regard to ACC, several studies have reported higher counts than those observed in the present work, with values reaching up to 6.8±1.0 log CFU/g (Andritsos *et al.*, 2012; Bishop *et al.*, 2022), whereas for *E. coli*, the results obtained in this study appear, on average, higher than those reported in the literature, where the maximum values reached approximately 1.4±0.7 log CFU/g (Andritsos *et al.*, 2012; Bishop *et al.*, 2022). Some authors investigated refrigerated whole muscle cuts from wild ungulates, finding considerably higher average values of both ACC (6.69 log CFU/g) and *E. coli* (3.02 log CFU/g) (Asakura *et al.*, 2017). Lower mean *E. coli* levels (2.03 log CFU/g) in both frozen and refrigerated meat cuts (forequarter and haunch) from wild boar and roe deer were reported by Membré *et al.* (2011), but slightly higher values (2.78 log CFU/g) were observed in the case of fresh stewing meat and roast beef cuts. It is important to note, however, that the last two aforementioned studies considered meat cuts from wild ungulates, for which no legal microbiological limits are established, unlike minced meat to which the process hygiene criteria set out in Regulation (EC) 2073/2005 (European Commission, 2005) can be applied.

In terms of food safety, it should be noted that no *Salmonella spp*. was isolated from the samples in the present work. In line with previous studies, the isolation of *Salmonella spp*. from wild ungulate carcasses appears to be sporadic (Bonardi *et al*., 2021; Altissimi *et al*., 2024; Floris *et al*., 2024). However, other studies have detected *Salmonella spp*. in minced meat from domestic ungulates (Delhalle *et al*., 2009; Zaiko *et al*., 2021), with prevalence rates reaching 18% (Rašeta *et al*., 2017). Furthermore, a report from the Swedish National Food Agency revealed the presence of foodborne pathogens such as *Salmonella spp*. and *Yersinia enterocolitica* in wild boar minced meat, in association with high *E. coli* counts (Swedish National Food Agency, 2025).

Regarding the detection of *Listeria monocytogenes*, none of the samples in the present study tested positive. This finding contrasts with previous outcomes on minced meat from livestock ungulates, with high prevalence rates up to 22% (Andritsos *et al.*, 2012; Andritsos *et al.*, 2013; Hadjilouka *et al.*, 2014).

The *E. coli* contamination emerged as the most critical issue observed in these samples, particularly in wild boar meat. It is well known that the method of carcass retrieval can be an influential factor; specifically, abdominal shots as well as carcass evisceration, which may result in gut rupture (Mirceta *et al.*, 2017). Indeed, particularly for ground meat, the initial hygienic conditions of the carcasses used as raw material are crucial. Several authors have evaluated the hygienic status of game carcasses by applying standards established for domestic ungulates and have reported higher levels of contamination compared to those found in carcasses from livestock (Avagnina *et al.*, 2012; Mirceta *et al.*, 2017; Orsoni *et* al., 2020; Peruzy *et al.*, 2022b). However, roe deer carcasses generally show lower contamination levels than wild boar ones (Obwegeser *et al.*, 2012; Branciari *et al.*, 2020). Moreover, the delay in carcass refrigeration is equally impactful. Regarding the production process, ground meat may also become contaminated during grinding. Nevertheless, the processing plant examined in this study is registered under Regulation (EC) 853/2004 (European Parliament and Council of the European Union, 2004), meaning it maintains an effective self-monitoring plan based on the implementation of the HACCP system. This ensures compliance with hygiene and safety standards through prerequisite programs and critical control point monitoring. However, the facility operates on a small scale, processing only a limited number of carcasses per working day. For such a condition, in cases of unsatisfactory samples, it is quite difficult to reassess the origin of the raw materials, prescribed by legislation, together with proper sanitisation of the structures, in relation to the hunting availability. A proper formation of hunters, as well as of food business operators of the chain, could help improve hygienic production and reduce the need to be performed (at collection centres, game handling establishments, and transport) (Mirceta *et al*., 2017; Abrantes *et al*., 2023). The differences in hunters'formation and in the hunting practices for wild boar and roe deer could explain the results observed.

Conclusions

The results of this study, even if preliminary and based on one single producer, suggest that ground meat from game meat may exceed the microbiological process hygiene criteria set out in legislation, particularly the *E. coli* threshold values for minced meat established in Regulation (EC) No. 2073/2005. This issue can be attributed to the complex supply chain of wild game and raises the question of whether the initial level of contamination can be considered a relevant factor in process hygiene, even when prerequisite programs related to production hygiene are followed and shown to be effective. Further studies are needed to address hygiene and microbial contamination at every stage of the production process.

As compliance with Regulation (EC) 2073/2005 is mandatory for producers, and as the hygienic quality of raw materials can vary greatly due to factors such as the level of hunter training, products that commonly fail to meet process hygiene criteria may need to be excluded from production. Indeed, the producer can use the same cuts of minced game meat for ready-to-cook meat preparations, such as hamburgers, or for other meat products that possess higher

hygiene criteria thresholds set by European regulation. In conclusion, for certain products, legal microbiological limits have previously been revised when the production of such foods could not reasonably be achieved under the existing criteria, accompanied by appropriate risk communication measures. In similar situations, the adoption of a risk-analysis approach would be necessary to ensure the safety of the final consumer.

References

Abrantes AC, Canotilho J, Vieira-Pinto M, 2023. Hygiene knowledge and practices of Portuguese hunters using wild boar meat for private consumption. Zoonotic Dis 3:307-15.

Altissimi C, Primavilla S, Roila R, Gavaudan S, Morandi B, Di Lullo S, Coppini M, Baldinelli C, Cai D, Branciari R, Valiani A, Paulsen P, Ranucci D, 2024. Salmonella in wild boar meat: prevalence and risk assessment in central Italy (Umbria and Marche Region). Foods 13:1156.

Andritsos ND, Mataragas M, Mavrou E, Stamatiou A, Drosinos EH, 2012. The microbiological condition of minced pork prepared at retail stores in Athens, Greece. Meat Sci 91:486-9.

Andritsos ND, Mataragas M, Paramithiotis S, Drosinos EH, 2013. Quantifying Listeria monocytogenes prevalence and concentration in minced pork meat and estimating the performance of three culture media from presence/absence microbiological testing using a deterministic and stochastic approach. Food Microbiol 36:395-405.

Asakura H, Kawase J, Ikeda T, Honda M, Sasaki Y, Uema M, Kabeya H, Igimi S, Takai, S, 2017. Microbiological quality assessment of game meats at retail in Japan. J Food Protect 80:2119-26.

Avagnina A, Nucera D, Grassi MA, Ferroglio E, Dalmasso A, Civera T, 2012. The microbiological conditions of carcasses from large game animals in Italy. Meat Sci 91:266-71.

Bishop H, Evans J, Eze JI, Webster C, Humphry RW, Beattie R, White J, Couper J, Allison L, Brown D, Tongue SC, 2022. Bacteriological survey of fresh minced beef on sale at retail outlets in Scotland in 2019: three foodborne pathogens, hygiene process indicators, and phenotypic antimicrobial resistance. J Food Protect 85:1370-9.

Bonardi S, Tansini C, Cacchioli A, Soliani L, Poli L, Lamperti L, Corradi M, Gilioli S, 2021. Enterobacteriaceae and Salmonella contamination of wild boar (Sus scrofa) carcasses: comparison between different sampling strategies. Eur J Wildl Res 67:88.

Branciari R, Onofri A, Cambiotti F, Ranucci D, 2020. Effects of animal, climatic, hunting and handling conditions on the hygienic characteristics of hunted roe deer (Capreolus capreolus L.). Foods 9:1076.

Corradini A, Marescotti ME, Demartini E, Gaviglio A, 2022. Consumers' perceptions and attitudes toward hunted wild game meat in the modern world: a literature review. Meat Sci 194:108955.

Delhalle L, Saegerman C, Farnir F, Korsak N, Maes D, Messens W, De Sadeleer L, de Zutter L, Daube G, 2009. Salmonella surveillance and control at post-harvest in the Belgian pork meat chain. Food Microbiol 26:265-71.

Demartini E, Vecchiato D, Marescotti ME, Gibbert M, Viganò R, Giacomelli S, Gaviglio A, 2021. The more you know: the equivocal effects of prior knowledge on preferences for hunted vs. farmed wild boar meat. Int J Gastron Food Sci 24:100325.

Demartini E, Vecchiato D, Tempesta T, Gaviglio A, Viganò R, 2018. Consumer preferences for red deer meat: a discrete choice analysis considering attitudes towards wild game meat and hunting. Meat Sci 146:168-79.

Ercolini D, Ferrocino I, Nasi A, Ndagijimana M, Vernocchi P, La Storia A, Laghi L, Mauriello G, Guerzoni ME, Villani F, 2011. Monitoring of microbial metabolites and bacterial diversity in beef stored under different packaging conditions. Appl Environ Microbiol 77:7372-81.

European Commission, 2005. Commission Regulation (EC) No 2073/2005 of 15 November 2005 on microbiological criteria for foodstuffs. In: Official Journal, L 338, 22/12/2005.

European Parliament, Council of the European Union, 2004. Regulation (EC) No 853/2004 of the European Parliament and of the Council of 29 April 2004 laying down specific hygiene rules for food of animal origin. In: Official Journal, L 139, 30/04/2004.

Floris I, Vannuccini A, Ligotti C, Musolino N, Romano A, Viani A, Bianchi DM, Robetto S, Decastelli L, 2024. Detection and characterisation of zoonotic pathogens in game meat hunted in Northwestern Italy. Animals 14:562.

Gaviglio A, Demartini E, Marescotti ME, 2017. The creation of a local supply chain for large wild ungulates' meat: opportunities and limitations from an Italian alpine case study. Calitatea 18:215-22.

Hadjilouka A, Andritsos ND, Paramithiotis S, Mataragas M, Drosinos EH, 2014. Listeria monocytogenes serotype prevalence and biodiversity in diverse food products. J Food Protect 77:2115-20.

ISO, 2013. Microbiology of the food chain - horizontal method for the enumeration of microorganisms—colony count at 30 degrees C by the pour plate technique. ISO Norm 4833-1:2013. International Organization for Standardization ed., Geneva, Switzerland.

ISO, 2017a. Microbiology of the food chain - horizontal method for the detection, enumeration and serotyping of Salmonella - part 1: detection of salmonella spp. ISO Norm 6579-1:2017. International Standardization Organization ed., Geneva, Switzerland.

ISO, 2017b. Microbiology of food and animal feeding stuffs-horizontal method for the detection and enumeration of Listeria monocytogenes - part 1: detection method. ISO Norm 11290-1: 2017. International Standardization Organization ed., Geneva, Switzerland.

ISO, 2018. Microbiology of the food chain - horizontal method for the enumeration of beta-glucuronidase-positive Escherichia coli. Part 1: colony-count technique at 44 degrees C using membranes and 5-bromo-4-chloro-3-indolyl beta-D-glucuronide. ISO Norm 16649-1:2018. International Standardization Organization ed., Geneva, Switzerland.

Kautto AH, Rosengren Å, Flink, Domeij C, 2025. Microbiological control project of minced meat of wild boar (Sus scrofa L.) in approved establishments in Sweden. Acta Veta Scand 67:53.

Kwiecińska K, Kosicka-Gębska M, Gębski J, Gutkowska K, 2017. Prediction of the conditions for the consumption of game by Polish consumers. Meat Sci 131:28-33.

Marescotti ME, Caputo V, Demartini E, Gaviglio A, 2019. Discovering market segments for hunted wild game meat. Meat Sci 149:163-76.

Marescotti ME, Caputo V, Demartini E, Gaviglio A, 2020. Consumer preferences for wild game cured meat label: do attitudes towards animal welfare matter? Int Food Agribus Manag Rev 23:599-618.

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Membré JM, Laroche M, Magras C, 2011. Assessment of levels of bacterial contamination of large wild game meat in Europe. Food Microbiol 28:1072-9.

Mirceta J, Petrovic J, Malesevic M, Blagojevic B, Antic D, 2017. Assessment of microbial carcass contamination of hunted wild boars. Eur J Wildl Res 63:37.

Obwegeser T, Stephan R, Hofer E, Zweifel C, 2012. Shedding of foodborne pathogens and microbial carcass contamination of hunted wild ruminants.Vet Microbiol 159:149-54.

Orsoni F, Romeo C, Ferrari N, Bardasi L, Merialdi G, Barbani R, 2020. Factors affecting the microbiological load of Italian hunted wild boar meat (Sus scrofa). Meat Sci 160:107967.

Peruzy MF, Murru N, Smaldone G, Proroga YTR, Cristiano D, Fioretti A, Anastasio A, 2022a. Hygiene evaluation and microbiological hazards of hunted wild boar carcasses. Food Control 135:108782.

Peruzy M F, Cristiano D, Delibato E, D'Alessio N, Proroga Y T, Capozza R L, Rippa A, Murru N, 2022b. Presence of enteric bacterial pathogens in meat samples of wild boar hunted in Campania region, southern Italy. Ital J Fodd Saf 11:9967.

Rašeta M, Mrdović B, Janković V, Bečkei Z, Lakićević B, Vidanović D, Polaček V, 2017. Prevalence and antibiotic resistance of Salmonella spp. in meat products, meat preparations and minced meat. In: van Ginkel L, Hennekinne JA, Velebit B. IOP Conference Series: Earth and Environmental Science. Proceedings 59th International Meat Industry Conference MEATCON2017, 2014, 1–4 October, Zlatibor, Serbia. IOP Publishing, Bristol, UK, p 012028.

Sweden National Food Agency, 2025. Kartläggning av mikrobiologiska faror i malet kött av vildsvin. Livsmedelsverket. Ottoson JL, 2025 nr 16, Livsmedelsverkets rapportserie, Livsmedelsverket, Uppsala, Sweden. [Material in Swedish].

Tomasevic I, Novakovic S, Solowiej B, Zdolec N, Skunca D, Krocko M, Nedomova S, Kolaj R, Aleksiev G, Djekic I, 2018. Consumers' perceptions, attitudes and perceived quality of game meat in ten European countries. Meat Sci 142:5-13.

Zaiko EV, Bataeva DS, Yushina YK, Grudistova MA, Velebit B, 2021. Prevalence, serovar, and antimicrobial resistance of Salmonella isolated from meat and minced meat used for production smoked sausage. IOP Conf Ser Earth Environ Sci 854:012108.

Ziomek M, Drozd Ł, Gondek M, Pyz-Łukasik R, Pedonese F, Florek M, Domaradzki P, Skałecki P, 2021. Microbiological changes in meat and minced meat from beavers (Castor fiber L.) during refrigerated and frozen storage. Foods 10:1270.

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Conflict of interest: the authors declare that they have no competing interests, and all authors confirm accuracy.

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Declaration of generative artificial intelligence and artificial intelligence-assisted technologies in the writing process: no the artificial intelligence was limited used only to verify the english only in few phrase

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