



Safety in the Game Meat Chain

1st SafeGameMeat Conference

26–28 May 2025, Porto

Abstracts

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The event is based upon COST Action CA22166 – Safety in the Game Meat Chain (SafeGameMeat) founded by COST (European Cooperation in Science and Technology).

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Preface

Dear Ladies and Gentlemen,

It is a real pleasure to welcome you to the 1st SafeGameMeat Conference organised in the COST Action 22166 'Safety in the Game Meat Chain'. The upcoming conference days will spotlight different stages of the game meat supply chain and bring together experts, researchers, and other stakeholders to explore key aspects of game meat safety.

The primary objective of our COST Action is to promote the exchange of experiences and concepts on food safety standards through networking, applying a transnational and multidisciplinary One-Health approach. We regularly organise webinars, workshops and other networking events in the Action. Additionally, we award grants for conference attendance as well as Short-term Scientific Missions, promoting particularly young researchers. We invite you to actively engage in this growing network.

After 20 successful months of our COST Action, we are approaching mid-term. An excellent reason to make this conference come alive together with you. There are three fully booked days ahead of us with a comprehensive array of topics including hunting and processing, trade networks, chemical hazards, and biological hazards. We are fortunate that the conference is supported by excellent keynote speakers. With the programme comprising 30 oral presentations and 30 posters, the conference offers many opportunities to disseminate, discuss and discover new knowledge and science within our European Action network and beyond.

Welcome, we are pleased to meet you!

Dr Anneluise Mader, Action Chair
and the Scientific Committee of the conference

Dear Ladies and Gentlemen,

As president of the Action Grant Holder Institute of CA22166 I am proud that the Federal Institute for Risk Assessment has been successful in establishing this pan-European Action network and now organises the 1st SafeGameMeat Conference in cooperation with the Department of Veterinary Science of the University of Porto, Portugal.

With 7 million hunters, 115 huntable species and 88 million animals hunted per year in the EU alone, hunting is a commonly performed activity in most European countries. However, scientific knowledge on the food safety of game meat and the game meat production chain in Europe is limited. Although the game meat market is small compared to that of livestock meat, almost monthly a notification in the European Rapid Alert System for Food and Feed (RASFF) arises. This shows the need to work towards strengthening and harmonisation of food safety standards in a growing European game meat market by following a One-Health approach.

This 1st international conference of the COST Action 22166 contributes to making this valuable animal-derived food as safe as possible both in Europe and worldwide.

I wish you a good time in Porto and numerous meaningful discussions that further explore the subject of safety in the game meat chain!

Professor Dr Dr Dr h. c. Andreas Hensel
President of the Federal Institute for Risk Assessment (BfR), Grant Holder Institute

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1 Abstracts – Oral Presentations

1.1 Hunting and Processing

1.1.1 Keynote: Producing Safe Game Meat in the African Bush

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Wild game farming in South Africa and Namibia has developed into an established industry. South Africa's private wildlife ranches cover an estimated 17–20 million hectares of land, approximately 14–17 % of the country's landmass, with 16–20 million animals. Namibia's commercial/private wildlife ranches cover approximately 20.5 million hectares, or 16.8 % of the country's landmass. Excess animals are either sold at live auctions (for breeding purposes), hunted by trophy hunters or "biltong" hunters (for home consumption), or harvested commercially. The latter process consists of registered marksmen cull teams shooting the animals from a helicopter with a shotgun, or on land with a headshot using a rifle during either the day or night. Different wildlife species also require different hunting procedures. The numerous challenges associated with each harvesting method applicable to each species will be discussed. Research findings comparing the safety (biological and physical hazards such as micro-bacterial spoilage and bullet/bone fragments) of game harvested from a helicopter, or at night (headshot), or daytime (shoulder shot or headshot) will be shared. What the applicable regulations and challenges on home consumption and the selling/exportation of meat are will be explored.

1.1.2 Keynote: Hunting Deer and Wild Boar – Safe Game Meat in Italy

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In Italy, the populations of red deer (*Cervus elaphus*) and wild boar (*Sus scrofa*) have grown significantly, making their hunting and management crucial for ecosystems, crops, and biodiversity. The Italian Law 157/1992 and Regulations (EC) 852/2004 and 853/2004 govern game harvesting and meat use, ensuring high hygiene and sanitary standards across the supply chain.

Until the last decade, the red deer population was estimated at 67,000 individuals, with an annual harvest of about 10,000 (ISPRA 2013); more recent national data is unavailable. Management covers the entire Alpine region and the Tuscan-Emilian Apennines, with increasing hunting activity, while in central-southern Apennines, hunting is closed due to environmentalists' pressure. The destination of culled animals varies due to regional regulations. Wild boars are widespread across Italy, with an estimated population of 1.5 million and an annual harvest of 360,000 (ISPRA 2023). Hunting methods include collective techniques (girata and braccata) as well as individual selective control. In response to African Swine Fever, control is permitted year-round without limits, with the destination of carcasses regulated by restriction zone. Transforming game into high-quality meat requires proper hunting practices, specialized hunter training, and rigorous veterinary inspections. For this reason courses for "trained people" were held in every single region in accordance to Reg CE 853/2004. Game Collection Centres (GCC) have been also created in order to increase the capacity of the supply chain, both through direct sales and marketing. Slaughtering and processing in specialized facilities ensure excellent organoleptic properties and food safety. Growing consumer interest has increased the economic value of game meat, through an integrated approach, combining hunting tradition with risk management, essential for sustainable wildlife management and product quality.

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1.1.3 Hunting and Processing of Wild Game in Norway: Supply Chain, Risk Management, and Official Control

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Norway's rich hunting tradition plays a vital role in the nation's wildlife management, with approximately 130,000 hunters annually. Wildgame meat, especially from species such as red deer, moose, roe deer, geese, and ducks, is an integral part of the Norwegian diet. However, ensuring the safety and quality of wildgame meat throughout the supply chain is critical, as this meat is more often consumed unprocessed or lightly processed than ordinary meat.

The wildgame meat supply chain in Norway begins with hunters, who are responsible for both the ethical harvest and initial field dressing of game. In recent years, the volume of game harvested is for 2023/2024 over 20,000 moose, 30,000 roe deer, more than 180,000 birds, including 10,000 geese, and 10,000 ducks. The harvesting of wild ducks, including species such as mallards and teal, is an important part of both hunting traditions and wildlife management. Once harvested, the meat finds the way to consumers by different supply chains. Less than 50 % includes processing and inspection process at licensed game handling facilities.

Regular monitoring for diseases such as Chronic Wasting Disease (CWD), avian influenza, and testing for residues of harmful substances form a key part of Norway's regulatory framework. Public awareness campaigns also educate hunters on proper handling techniques, reducing the risk of contamination from field to table.

This presentation will explore the various stages of the Norwegian wildgame meat supply chain, from hunting to consumer, with a focus on regulatory frameworks and current challenges. In conclusion, ensuring safe wildgame meat requires a robust system that upholds the integrity of Norway's sustainable hunting traditions while meeting modern food safety standards.

Reference

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1.1.4 Characteristics of Finnish Game and Hunting and their Impact on Game Meat Quality

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Finland has the second highest number of hunters in Europe compared to the population, but the lowest compared to the area. Approximately 300,000 hunters pay yearly the national hunting licence, of which about 200,000 go hunting yearly. About 30 % of Finnish hunters are women. The right to hunt belongs to the landowners, who can lease that right to others. Private persons own 65 per cent of Finland's area. Hunters have established hunting associations which have leased areas for hunting and game management. There are currently about 10,000 hunting associations with hunting areas between 2,000 to 10,000 hectares. Almost all hunting associations have slaughter facilities of varying levels but only about 130 are registered for supplying small quantities of wild game or wild game meat directly. There are 33 officially approved game-handling establishments, mostly in southern Finland.

About 110,000 hunters hunt big game, cervids and bears annually. Total game catch is about 9 million kilograms of which more than half is venison. The calculated value of the game meat is approximately 70 million euros. Game consumption accounts for just under three % of total meat consumption (approx. 2.3 kg/person/year). Majority of the catch is consumed by the families of the hunters and their acquaintances. In hunter-households most of the meat eaten may be game. Only a fraction of the game catch, 5–6 %, ends up for general consumption. Demand exceeds supply, and high-quality game meat that can withstand critical scrutiny is available in limited quantities.

Large areas, lakes, rivers, roadless wilderness and long distances to slaughter establishments pose challenges to compliance with hunting hygiene and the quality and processing of game meat. In Finland game densities remain lower than in, e.g. Central Europe and thus the hunting of the game can be prolonged and, especially when dogs are used, lead to the creation of DFD meat. Transport to the slaughterhouse can take a very long time under varying climate and terrain conditions. Therefore, transport must be planned in advance to prevent cold or warm shortening of the meat or post contamination of the carcass. The techniques of bleeding and evisceration in field conditions are planned to aim for the same goal. In addition to these, chemical contamination and the spread of new parasites related to global warming are causing special attention. The training of hunters in Finland, currently numbering 3,000, are trained to solve these problems as well.

1.1.5 Between Zoonosis and the Law: a Case Study of Legal Game Meat Regulation and Control in Zambia

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There has been an increase in game meat production globally. In many countries, the game meat supply chain is not formally regulated. In addition, traceability issues have also been raised. These issues increase the risks of zoonotic disease outbreaks. Similarly, there is a growing call for a greater role of law and policy in game animals and game meat products in order to secure animal and human health. Zambia is one of the countries where game meat production is increasing and where it is legally traded. Still, there is little information on laws, regulations, and policies governing the game meat trade. To understand this phenomenon in light of environmental justice concerns, I analysed the Zambian regulatory framework and policies related to the game meat supply chain. In addition, I conducted seventeen in-depth interviews with stakeholders in the game meat supply chain to understand the game meat control mechanisms. The analyses determined the degree to which Zambian laws and policies address the game meat value chain, particularly with regard to game meat zoonosis risks. I also conducted a zoonoses vulnerability assessment of the value chain based on the absence of specific game meat regulations. Policy analysis results revealed a lack of specific game meat regulations. Regarding in-depth interviews, the study identified a legal framework for domestic livestock and livestock meat used for game and game meat inspections without adjustments. Game meat hunter training does not include game meat handling. Traceability mechanisms do not focus on zoonoses and game meat safety. There is better zoonotic and game meat safety control for farmed animals than for wild game. I propose a zoonotic control framework that can be used to increase game meat safety and reduce zoonotic disease transmission along the game meat supply chain. I concluded with a discussion of the international implications of this Zambian use case.

1.1.6 Hunting and Processing: *Status Quo* of the Hunting Sector in European Countries Based on a Questionnaire

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Hunting and processing wild game are rewarding practices where hunters can take responsibility from field to table. With basic tools, knowledge, and commitment to safety and legal guidelines, most hunters can successfully process their own game, saving money and deepening their connection to the hunt.

The aim of our study was to perform an assessment of the hunting practices in different European countries based on basic information concerning hunting and volumes of hunted wild game for food for the hunting year 2022–2023.

We distributed during summer 2024 an excel-based questionnaire based on previous work in BfR to one WG1 member or national contact point from each participating country. In addition, the main results were summarized by a member of WG1 from each country in a two-page written summary.

We received data on basic hunting information from 23 countries, on hunting bag from 22 countries and written summaries from 19 countries. The results showed that there is considerable variation in how hunting is regulated and performed in different European countries. In addition, the species hunted in different countries varies, likely due to differences in the geographical distribution of species and populations but also due to hunting traditions. The most important hunted species in Europe are ungulates, with roe deer, wild boar, and red deer being the most harvested species in weight. In small game, pheasants, certain ducks and geese, and the European rabbit and European hare being the most frequently hunted species. Only a small proportion of the hunted game is delivered to approved game handling establishments.

Hunting in Europe is a traditional and still popular recreation. The aim of hunting is mostly wildlife management using ethical hunting practices. Hunting supplies a lot of meat to the open market but even more to private consumption of the hunters.

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1.1.7 *Trichinella* Detection in Wild Boar Meat for Private Consumption: Insights from a Seven-Country European Pilot Study

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Private consumption of wild boar meat is increasingly common in Europe, raising concerns about food safety, particularly regarding *Trichinella* spp. infections. This study provides a comparative analysis of regulations and practices related to *Trichinella* detection in wild boar meat for private consumption across seven European countries: Belgium, Greece, Italy, Poland, Portugal, Romania, and Serbia. Differences were identified in monitoring, testing requirements, preventive measures, and hunter education. While Italy, Poland, Romania, Serbia, and Portugal mandate *Trichinella* testing under different regulatory frameworks, Belgium and Greece do not impose such requirements for private consumption. The absence of mandatory testing in some countries may pose a risk to consumer health. Hunter training programmes and public awareness campaigns are generally scarce and inconsistent, potentially leading to underreporting of positive cases, non-compliance with regulations, and inadequate risk perception among consumers. Financial aspects also vary, with some countries subsidizing testing while in others, hunters bear the costs. To enhance food safety, we propose harmonizing *Trichinella* testing strategies, expanding hunter education, and strengthening regulatory oversight. Additionally, improved coordination between veterinary authorities and hunting communities is essential to mitigate the risks associated with the private consumption of wild boar meat.

This publication is based upon work from COST Action Safety in the Game Meat Chain (SafeGameMeat, CA22166), supported by COST (European Cooperation in Science and Technology).

1.2 Trade Network and Supply Chain

1.2.1 Keynote: Trade Networks and Supply Chain of Game Meat in Spain

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This document provides a comprehensive overview of the structure, challenges, and opportunities of the game meat sector in Spain, led by the Interprofessional Association of Game Meat (ASICCAZA). It emphasizes the role of interprofessional organizations as effective coordination tools between producers and marketers to enhance product quality, traceability, commercialization, and sustainability.

Spain holds significant hunting potential: 85 % of its territory is designated as hunting grounds, and over 19 million animals were harvested in 2022. Yet only a small share of this production enters formal commercial channels. Despite its high nutritional and environmental value, game meat faces regulatory and distribution barriers that limit its availability in the domestic market, even as exports continue to grow.

The document also analyses hunting practices – particularly montería (driven hunts) – as efficient and sustainable methods for sourcing wild game meat. It outlines the sanitary, logistical, and commercial procedures involved from field to consumer, highlighting the requirement for dual veterinary inspections and the regulatory challenges encountered throughout the supply chain.

Game meat is framed within the broader “One Health” strategy, contributing to public health, the control of overabundant species such as wild boar, and the revitalization of rural economies. Initiatives like the VENARI platform and digital traceability tools aim to promote domestic consumption and improve consumer perception of the product.

In conclusion, the document advocates for more flexible legislation, enhanced promotion and training, and the development of supportive infrastructure to consolidate the sector’s role as a sustainable economic and nutritional driver.

1.2.2 Old-School Guns for New-School Hunters: Results from a Qualitative Study on Contemporary Hunting in an Archaic Context (Grisons, Switzerland)

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unpublished work

1.2.3 The European Game Meat Market

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The game meat market in the European Union is a niche yet evolving sector, shaped by a range of factors related to production, consumption, distribution, and regulation. This presentation provides a general overview of the main producing and exporting countries, highlighting the influence of hunting traditions, natural resources, and processing capacities that characterize the supply side of the market.

It also explores the profile of consuming and importing countries, focusing on dietary habits, lifestyle trends, and growing environmental awareness that drive demand. These elements reflect a fragmented yet promising market landscape, where local traditions coexist with new consumer expectations.

Particular attention is given to the various marketing and distribution channels, which include both traditional outlets and emerging platforms. These reflect shifting consumption patterns and the increasing interest in food products perceived as natural, sustainable, and ethically sourced.

The discussion concludes with a look at the general requirements that apply across the market, including standards for quality, hygiene, and traceability. Regulatory frameworks play a key role in ensuring consumer protection and facilitating trade, both within and beyond EU borders.

By offering a broad picture of current dynamics and key trends, this contribution aims to foster reflection on the opportunities and challenges facing the game meat sector in Europe.

1.2.4 Improving the Environmental Impact of Hunting through Regulatory Change: Evidence from the Val d'Ossola Case Study

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In 2015, a study (Fiala et al., 2020) assessed the ecological impact of red deer (*Cervus elaphus*) hunting in the Val d'Ossola region (Alpine Hunting District VCO2, Italy). The analysis found that the main environmental burden stemmed from hunting trips, with many hunters failing to harvest any game. To reduce this impact, the district authorities introduced a new hunting management plan in 2019 to incentivize skilled hunters. Previously, hunters could harvest up to four animals under a tiered pricing system, with costs ranging from €200 to €880, depending on the number and type of animals taken.

The revised regulation, implemented in 2019, introduced a fixed entry fee of €400 with no harvest limit, regulated by a point-based system balancing harvests across age and sex categories. This system was designed to encourage skilled hunters while discouraging less proficient ones, who would be less inclined to enrol due to the higher upfront cost. The objective was to increase overall harvest efficiency while reducing unnecessary hunting trips and their associated environmental impact. This study presents data on the effects of this regulatory change. Between 2015 and 2018, an average of 49 % of registered hunters in VCO2 failed to harvest any game per season. However, following the new policy, this proportion significantly decreased, averaging 34 % between 2019 and 2022. The total number of harvested animals increased, indicating improved hunting efficiency and potentially lowering the overall environmental footprint. Additionally, the increased harvest contributed to greater meat availability, enhancing both the ecological and economic sustainability of hunting in the region. These findings highlight the effectiveness of adaptive wildlife management policies in optimizing ecological outcomes while maintaining hunting traditions.

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1.2.5 Identification of Mislabelling/Adulterations in Game Meat Products by Molecular Tools: the Case of Roe Deer (*Capreolus capreolus*)

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Roe deer (*Capreolus capreolus*) meat is a prized game product in many European countries for its excellent flavour, texture and nutritional value. However, concerns exist regarding the accuracy of declared roe deer amount in processed game meat foods. This study aimed at proposing a reliable method for the detection and quantification of roe deer in commercialized game meat products. A TaqMan probe-based quantitative real-time PCR (qPCR) assay was designed targeting a single-copy, 120-bp region of the roe deer agouti signalling protein (ASIP) encoding gene. The method employed the normalised ΔCq approach to establish a calibration curve for roe deer detection and quantification within 0.05–50 % (w/w) in complex raw and processed matrices. The method proved to be specific for roe deer identification, achieving limits of detection and quantification of 0.04 ng of roe deer DNA and 0.05 % (w/w) of roe deer in simulated pâté [1]. Following validation with blind samples, highlighting the precision and trueness of the approach, the assay was applied to 46 market samples from four European origins (Poland, Portugal, France and Spain). The analysis revealed significant discrepancies between declared roe deer content and actual levels in all roe deer labelled products. The global analysis of results, combining the previous survey on red deer species [2] with present roe deer data, identified 61 % of mislabelled/adulterated samples due to the absence of deer species, substitution of roe deer with red deer, substitution of fallow deer with other deer species and red deer with pork, and undeclared addition of roe deer. This study demonstrates the effectiveness of the developed qPCR method for accurate roe deer meat authentication in foods, showing its usefulness as a tool for routine food inspection to ensure labelling compliance.

References:

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1.2.6 Captive Venison Production in the EU: the Potential of Sharing Information to Improve Collaboration and Reduce Knowledge Gaps in the Field of Animal Health

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Captive populations of wild species are bred in many countries in the EU with the purpose of producing goods (meat, fur, skin, pets) or repopulating hunting grounds. However, the levels of legislation and regulation are not harmonized at EU level and the standards of disease control and monitoring are lower than those applied to conventional domestic animals. These gaps can generate serious implications for animal or human health, free ranging wildlife populations and the environment and jeopardize confidence on the captive wildlife production industry. The aim of this study, performed in the context the EUPAHW (www.EUPAHW.eu) was to build up an EU database of aggregated data on wildlife production activities that could be used to develop networks between producers and end-users and provide a better overview of the sector at EU level. To this end, two surveys were designed for different stakeholder categories (public administrations and wildlife associations) to collect aggregated information on the occurrence, nature, scale and distribution of wildlife production in different countries. These surveys were distributed through project partners and networks in EU countries. For other countries data was collected on public administrations through web search engines using relevant search terms. For the database, selection criteria for database software and R scripts for data import, aggregation and harmonization were developed. The level of response through the first approach has been so far limited to 5 countries and the information obtained remains very limited and scattered. However, the web search suggests that different levels of wildlife production, including game species are widespread in at least 13 countries, suggesting that improvement to fill gaps of information on wildlife production at EU level is needed. The collaboration with EU PAHW initiative could have several benefits such as, among others, providing an overview on the importance of captive reared venison production at EU level, and the possibility to develop scientific collaborations in the field of animal health and welfare that could be of interest for the venison production sector in EU countries.

1.2.7 Slaughter Unit Adaptation for Effective and Sustainable Wild Boar Meat Processing

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The demographic expansion of wild ungulates is increasingly problematic worldwide. In Lazio, Italy, it causes annual agricultural damages of 800,000–900,000 € and contributes to African Swine Fever (ASF) spread. Road accidents and ecological impacts worsen the issue. Current control strategies are ineffective, partly due to a lack of carcass processing facilities, limiting hunter participation and fuelling illegal meat trade, which also poses health risks.

To improve efficiency, encourage hunters, and curb illegal trade, benefiting both wild boar management and agriculture, we proposed a project to design and prototype modular mobile wild boar slaughter units, funded by Submeasure 16.2 of the Lazio Rural Development Plan 2014–2020 (CUP F89H23000070009). Easily deployable in hunting and culling sites, this structure will be officially recognized as a game meat Processing Centre under CEE 853/2004 regulations. It will ensure proper meat processing, enhance product value, promote a short supply chain, and optimize costs and emissions.

Each unit will feature carcass treatment facilities, standardized hygiene checks, and product certification. A professional training program and necessary certifications are included.

The estimated start-up investment for the first five years is 213,000 €, covering depreciation, carcass procurement, equipment, training, skilled labour, certifications, and energy. Each unit can process 36 animals per week (1,872 annually), generating an estimated annual revenue of 253,000 €. The net income is projected at 40,000 € per year initially, rising to 53,000 € after the prototype payment is completed.

This project will help reduce wild boar populations, mitigate economic and health risks, and create new opportunities in agriculture and hunting.

1.2.8 Bush Meat Demand Among Staff in Research Institute Oyo Southwest Nigeria

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Due to its many positive qualities, like the nutritional and health benefits, bush meat consumption is on the rise in Nigeria. This study investigated bush meat demand among staff at National Centre for Genetic Resources and Biotechnology, Oyo, Southwest Nigeria. We carried out an enquiry into factors influencing bush meat demand through administration of questionnaires to respondents. Random sampling technique was used to select 200 staff out of which 196 responded to the questionnaire. Data were then analysed using simple percentages. From the finding, most respondents were male, (53.06 %) as against female (46.94 %) and they were between the ages of 18 and 65 years. 20.4 % were employed for less than a year, (6.12 %) 1–5 years, (26.53 %) 6–10 years while 10 years above were 44.90 percent. This work reveals the frequency of different types of bush meat in the study area. The commonly consumed bush meat types were in this sequence grasscutter (12.76 %), alligator (9.18 %), rabbits (8.16 %), giant rat (4.59 %), bush fowl (4.08 %), antelope (2.04 %), squirrel (1.53 %), bush buck (1.02 %) and others (0.51 %). It was also revealed that the primary reason for consumption were taste preference (44.89 %), health benefits (28.57 %), cultural/traditional (8.16 %), availability (18.36 %) and others (4.08 %). The respondents purchased their bush meat from local markets (34.69 %), supermarkets (4.09 %), hunting (22.44 %), friends/relatives (24.49 %) and personal domestication (2.04 %). The drivers that affected decision to buy were price (14.28 %) quality (51.02 %), availability (40.82 %) and ethical concerns (6.12 %). Staff were willing to pay less than N10,000 (65.31 %), N10,000–N20,000 (20.41 %), above N30,000 (6.12 %) for high quality bush meat. To promote sustainable alternatives and lessen dependency on wildlife consumption, a balanced strategy that takes into account conservation initiatives and public health issues is needed to address the demand for bush meat among research institute employees.

1.3 Chemical Hazards

1.3.1 Residues of Pesticides Biocides and Drugs in Game Species: Should We Worry?

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Wild game species are not regularly controlled for residues of pesticides, biocides or drugs. Nevertheless, several studies have been published looking at residues of such substances in various game species.

Old compounds such as organochlorine insecticides have been analysed in many different species, places and times. Some of the recent papers still deal with these compounds although most of them have long been banned in Europe. A brief overview of these studies will be presented.

More recently, several surveys have been conducted in European countries and pesticide residues have been analysed and detected in different places. There is evidence showing that some game birds or mammals are exposed to pesticides and carry pesticide residues. There is even a relationship with the presence of agricultural area close to the hunting places.

Among biocidal products, anticoagulant rodenticides have been analysed across Europe and other places in many different species. Wild game appears to be exposed to anticoagulant residues, with a relationship with the presence of cattle farms or urban sites.

Less commonly drug residues are detected in some wild species, not specifically game species, a special focus will be given to these limited reports.

Some unpublished data from our lab will also be included to present anticoagulant rodenticide contamination, but also pesticide and drug residues in some wildlife species. Questions arise with respect to human exposure and potential risk to consumers and will be discussed in this presentation.

1.3.2 Evaluating Environmental Contaminants in Frequently Harvested Migratory Waterfowl of the Northeast Atlantic Flyway

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In the Atlantic Flyway in the United States, roughly 200,00 hunters harvest upwards of 1.5 million ducks and geese, annually, and these waterfowl represent a pathway of contaminant exposure for hunters who consume them. In the northeast portion of the flyway (specifically New York, New Jersey, Pennsylvania, and Connecticut) data on baseline contaminant loads in waterfowl (i.e., contaminant loads not associated with highly polluted areas) are lacking, which has implications for waterfowl consumption recommendations devised by public health agencies. We tested five species of commonly harvested (and consumed) waterfowl for mercury, polychlorinated dibenzo-p-dioxins and polychlorinated dibenzofurans, polychlorinated biphenyls (PCBs), organochlorine pesticides (OCPs), and per- and polyfluoroalkyl substances (PFAS). In general, Canada geese (*Branta canadensis*) and wood ducks (*Aix sponsa*) contained lower contaminant burdens than mallards (*Anas platyrhynchos*), American green-winged teal (*Anas carolinensis*), and American black ducks (*Anas rubripes*), corroborating current guidance that these species are less polluted and therefore safer to eat. All waterfowl in this study contained detectable levels of PCBs and at least one OCP and PFAS. A probabilistic risk assessment indicated that lower consumption rates were required to reduce risks from PCBs compared to other contaminants. Determination of protective consumption rates depended in part on decisions regarding allowable cancer risk and approaches to chemical mixtures. Data from this study can be used to update waterfowl consumption advisories in the northeast Atlantic Flyway and inform future research into the health effects of contaminants on waterfowl populations.

1.3.3 Human Health Risk Assessment of Lead in Sausages Made with Large Game from the Central and Southern Iberian Peninsula

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The hypothesis in this study is that the consumption of meat products from large game species shot with lead ammunition may pose a health risk to average consumers and, especially, to the most vulnerable individuals such as children.

Analyses of lead residues were conducted on sausages from large game species (mainly red deer and wild boar) to assess its potential influence on human health. The products were randomly selected from those placed on market, both in grocery stores and online, seeking a variety of species of origin from the central and southern Spain (Autonomous Communities of Andalucía, Castilla-La Mancha and Extremadura).

X-rays and lead analysis were performed on a total of 86 samples. Descriptive statistical studies were conducted according to the species (wild boar or deer), type of food (chorizo, salchichón, ragout) and distribution of samples above or below the maximum concentration permitted (CMP) by European legislation for meat products. Metallic lead fragments were observed in all species and all types of game. Half of the pieces of venison, wild boar, and deer meat and sausages analysed had concentrations above CMP, and 12.5 % of the samples analysed had concentrations almost ten times above CMP. Finally, the risk of consuming these meat products for children's neurological development was assessed, as well as cardiovascular and renal effects in medium and high consumer adults.

Risk estimates based on the Margin of Exposure (MOE) model showed values below unity for cardiovascular effects and chronic nephrotoxicity, both for high and average consumers, which poses potential health risks from the ingestion of metallic lead present in these meat products.

Declaration of interest: This study was conducted in accordance with the terms established in the contract signed between WWF-Spain and the University of Murcia, entitled "Study of lead impregnation in sausages of game species".

1.3.4 Influence of Land Use on the Occurrence of Per- and Polyfluoroalkyl Substances (PFAS) in Wild Boar Livers in Brandenburg, Germany

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Per- and polyfluoroalkyl substances (PFAS) are a group of anthropogenic compounds that are ubiquitous in the environment. Wild boars (*Sus scrofa*) have been proposed as suitable bioindicators for PFAS. Furthermore, wild boar livers belong to the foods of animal origin that can contain particularly high levels of PFAS. The aim of this study was to investigate the association between PFAS concentrations in wild boar livers and land use characteristics of the hunting districts.

Livers of 166 wild boars were sampled in Brandenburg, Germany, and analysed for 16 perfluoroalkyl acids. The 18 investigated hunting districts were characterized by land use characteristics using publicly available geodetic data. Correlation to PFAS concentrations was tested using Spearman rank's analysis. Additionally, statistical analyses were performed to investigate the impact of potential PFAS sources on the liver concentrations in the wild boars.

Generally, PFAS levels in wild boar livers differed between hunting districts. Positive correlations were found between liver concentrations of perfluorobutanesulfonic acid (PFBS), perfluorooctanoic acid (PFOA), perfluorononanoic acid (PFNA), and perfluorodecanoic acid (PFDA) and the relative size of residential and industrial areas of the hunting location. Perfluoroundecanoic acid (PFUnDA) was statistically correlated with the level of agricultural land use in the study area. Furthermore, statistical analyses indicated significantly higher concentrations of PFOA and PFNA in the livers of wild boar hunted in a 10-km radius around a suspected PFAS source.

In conclusion, land use-based evaluations of PFAS levels in wild boar livers offer the potential to identify geographical patterns in PFAS distribution among wild boars. This approach can enhance both food safety assessments and risk-oriented environmental biomonitoring of PFAS.

1.3.5 Game Meat as a Source of PFAS for Polish Consumers

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Perfluoroalkyl substances (PFAS) were analysed in the meat of wild boar and deer, with 20 samples taken from each species. The sampling was carried out in the two voivodships of Kujawsko-Pomorskie (northern Poland) and Podkarpackie (southern Poland). The thirteen PFAS were investigated using LC-MS/MS on a Sciex Triple Quad 7500 system.

The maximum limits for $\Sigma 4$ PFAS established by Commission Regulation (EU) 2023/915 were not exceeded in any of the samples. The lower bound (LB) concentrations of $\Sigma 4$ PFAS (concentrations below the LOQ were replaced by the value of 0) were in the range of 0.000–0.034 and 0.16–2.20 $\mu\text{g}/\text{kg}$ wet weight (w.w.) in deer and wild boar, respectively. The LB concentration of $\Sigma 13$ PFAS ranged from 0.001 to 0.037 $\mu\text{g}/\text{kg}$ w.w. in deer muscles and from 0.26 to 2.71 $\mu\text{g}/\text{kg}$ w.w. in wild boar muscles. Among all PFAS, linear perfluorooctane sulfonic acid (L-PFOS) was found in the highest concentrations (range 0.01–1.86 $\mu\text{g}/\text{kg}$ w.w.) and the percentage share in the total concentration of $\Sigma 13$ PFAS was between 13–69 % in wild boar and between 53–85 % in deer.

The potential risk to consumers has been assessed in relation to the tolerable weekly intake (TWI) of 4.4 ng/kg body weight, established by the European Food Safety Authority in 2020. The body weight was assumed to be 70 kg for adults and 23.1 kg for children aged 3–10 years. Two consumption scenarios were assumed: 100 g and 200 g portion of game meat. Mean, lower bound of $\Sigma 4$ PFASs were used for calculations of exposure. Adult and child exposure associated with the consumption of 100 g and 200 g serving of deer meat was low <4 % of the TWI. The exposure of adults associated with the consumption of wild boar meat was 19 % of the TWI and 38 % of the TWI for 100 g and 200 g portions. A high level of exposure was found for children who consumed wild boar meat (59 % of the TWI for a 100 g portion and 118 % of the TWI for a 200 g portion).

1.3.6 Mercury in Hunted Waterbirds in Spain: Intra and Interspecific Differences, Temporal Trends and Risk Assessment for Human Consumers

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The total mercury (Hg) and selenium (Se) concentrations have been determined in liver samples from 10 species of waterfowl (n=537) hunted in the Ebro River delta. The liver samples came from two different sampling periods, 1993–1995 (n=102) and 2007–2011 (n=435). It has been observed a significant reduction of the mercury levels in the waterfowl species between these two periods. Liver mercury concentration in birds was marked by the diet of these species, thus a higher ingestion of invertebrates was associated with higher levels of mercury, as observed in species such as Northern shoveler (*Spatula clypeata*) or tufted duck (*Aythya fuligula*). Northern pintail (*Anas acuta*) and Northern shoveler were the species with highest concentrations of selenium in liver. Both mercury and selenium showed higher concentrations in adults and females than in juveniles and males. Significant correlations between mercury and selenium concentrations were found in some species, such as mallard (*Anas platyrhynchos*), but it was not significant in the Northern shoveler, despite being the species with the highest levels of mercury and selenium. To deterministically assess the risk for human consumers, we have considered the average and maximum mercury concentrations in Northern shoveler of 2 and 11 µg/g dry weight (dw), respectively. The provisional tolerable weekly intake (PTWI) has been established by FAO/WHO at 4 µg/kg body weight (bw) for inorganic mercury and 1.6 µg/kg bw for methylmercury. The Health Guidance Value (HGV) established by USEPA has been 0.1 µg/kg bw/day for methylmercury. Assuming that most of the mercury accumulated in animals is present in this organic form and a ratio of liver wet weight (ww)/dw of 3, a person of 50 kg bw should consume 120 g or 21 g ww/week to exceed the PTWI, and 7.5 g or 1.35 g ww/day to exceed the HGV with the average and maximum levels, respectively. More information about liver duck consumption is necessary to refine this risk assessment.

1.3.7 Will the UK Transition Away from Pb Ammunition Use for Game Shooting?

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The UK (under UK REACH) has been actively considering whether to ban (or phase out) Pb ammunition for game shooting. Following a detailed consultation, the UK's Health and Safety Executive (HSE) recently recommended that this was indeed the correct approach to take – to protect wildlife, the environment and human health. The UK Government is now in the process of deciding whether to accept this HSE proposal (a decision that was meant to have been made in mid-March 2025). In parallel, in 2020, leading organisations within the UK hunting sector also proposed that the sector should 'voluntarily' switch away from the use of Pb ammunition for shotguns, and if such a voluntary switch were to have been successful, this may (it was felt) have lessened the need to use UK legislation to ostensibly ban Pb. To monitor the effectiveness of this 'voluntary' approach, the SHOT-SWITCH project was instigated in 2020. This project has monitored the proportion of wild-shot common pheasants available to consumers across Great Britain that were killed using lead and non-lead shot in each of the shooting seasons since the beginning of the proposed transition in 2020. The project has now completed its 5th year of monitoring, and the findings from this work will be presented – alongside selected results from several other recent UK-led studies that have continued to assess the on-going risks posed by Pb ammunition within the UK and beyond.

1.4 Biological Hazards

1.4.1 Keynote: Processing Game Protocols from Field to Table

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When handling game there are fundamentally important processes that need to be followed to ensure food safety and due diligence. This starts from the point where the animals are harvested ensuring adequate bleeding, cleanliness and inspection of the carcasses. Hunters need to understand that this is food and therefore it must be treated as so at every step of the process. In 2024 at the estate of Vale Feitoso near Peña Garcia we looked to setting up a new system for the processing of deer carcasses from stalked animals as the estate made the transition from Monteria hunting to stalked hunting. These new protocols include setting rules and regulations governing everything from the point of harvest to the butchery and processing of the carcasses. This presentation we will explore every step of the process at Vale Feitoso:

- Shot to bleed: How to, best practice and why.
- Visual checks of carcasses: Initial checks for abnormalities.
- Carcass Evisceration: How to, best practice, why and time limits.
- Inspection of Viscera: Checks for abnormalities and notifiable diseases.
- Chiller to Larder: Temperature protocols, expelling heat from carcasses and setting meat.
- Carcasses arrival at main chiller: Temperature protocols for main chiller, processing on arrival, vet checks.
- Skinning and Corrective cuts: Temperature protocols for working area, removing skin and correctively trimming carcass and why.
- Carcasses Breakdown: Temperature protocols for working area, cuts and Joints.

1.4.2 Zoonotic Hepatitis E Virus in Portuguese Wild Boar: Insights from Serological and Molecular Surveillance

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The zoonotic Hepatitis E virus (HEV) has a wide range of hosts, including both domestic and wild animals, and potential maintenance in environmental matrices. HEV is a significant infectious agent in wild boar, with zoonotic cases primarily associated with the consumption of raw or undercooked meat and liver. This study aims to assess the occurrence of HEV in the Portuguese wild boar population. During the 2021/2022 hunting season, 123 paired samples (liver, feces, blood, and meat juice) were collected from hunted wild boars across Portugal. HEV-RNA detection was conducted on liver and fecal samples using an RT-PCR assay, while blood samples were analysed using an Enzyme-Linked Immunosorbent Assay (ELISA).

Only one liver sample (0.8 %) and one fecal sample tested positive for HEV. However, 34 serum samples (26.7 %) were seropositive. Due to challenges in obtaining high-quality serum from hunted animals for ELISA testing, meat juice was simultaneously evaluated as a potential alternative for HEV detection via ELISA. In the laboratory, a commercial ELISA kit was used to test both serum and meat juice samples. Of the 123 paired samples, only 60 were analysed due to haemolysis. The overall agreement between the two sample types was 58 %. However, the paired meat juice sample with the only HEV RNA positive found out of our 123 livers analysed, was positive in the ELISA test.

Compared to previous studies in Portugal, the molecular prevalence of HEV in liver and feces appears to be lower, while the seroprevalence is higher. The potential use of meat juice as an alternative matrix for serological testing requires further investigation and validation.

A more detailed geographical analysis identified a potential HEV hotspot in the southeast of Central Portugal, representing a zoonotic risk for hunters in this region. These findings reinforce the importance of including HEV in large game disease surveillance programs to expand understanding of its zoonotic potential.

1.4.3 Pathogenic Potential of Shiga Toxin-producing *Escherichia coli* Isolated from Red Deer (*Cervus elaphus*)

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In 2023, human infections by Shiga toxin-producing *Escherichia coli* (STEC) were reported as the third zoonosis in EU/EEA countries. Symptoms in humans vary from non-bloody diarrhoea to haemorrhagic colitis and the life-threatening haemolytic uremic syndrome (HUS). STEC can produce two types of Shiga toxin (Stx1 and Stx2) comprising four subtypes for Stx1 (a, c, d and e) and 15 for Stx2 (a–o). Adhesion to the intestinal cells is mediated by the protein intimin, encoded by the *eae* gene, or by different mechanisms. In Europe, five serogroups named “top-5” (O26, O103, O111, O145 and O157) have been associated with most human cases for years. Nevertheless, other human pathogenic serogroups are emerging.

The major reservoir of STEC are ruminants, including wild species. The occurrence of STEC in red deer (*Cervus elaphus*) has been demonstrated in many European countries, with proportions ranging from 9.5 % (Portugal) to 19.9 % (Italy) in faeces and 7 % in carcasses (Spain). Among the top-5, *stx1* and/or *stx2*- and *eae*-harbouring STEC O157:H7 was found in red deer faeces with variable prevalences (12 %–0.35 %) among countries. Nevertheless, most STEC belongs to O27:H80 and O146:H28 serotypes and are positive for *stx2b* and negative for *eae* genes. Although they do not belong to the top-5, they have the potential to cause diarrhoea and HUS in humans, as reported in Belgium in 2023.

Currently, we are testing faecal and diaphragm samples from red deer hunted in Italy (Central-Western Alps) according to the ISO/TS 13136:2012 method. The study is ongoing and we only have preliminary results. However, whole genome sequencing of 11 isolates identified only the two *stx2b*-positive and *eae*-negative O27:H80 and O146:H28 serotypes. Since a recent EFSA classification of the most frequent serogroups of STEC from human infections includes O146, the wide distribution of STEC O146:H28 in red deer should alert the entire game meat chain to the possible risks for both hunters and consumers.

1.4.4 Detection of Viable *Toxoplasma gondii* in Retail Venison

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Consumption of infected, undercooked meat is a well-known risk factor for transmission of *Toxoplasma gondii*, and when comparing foodborne pathogens, *Toxoplasma* has been ranked as one of the most significant causes of disease burden both in Europe and the USA. Despite this, there have been few studies assessing the risk of infection from retail meat samples. The aim of this study was to investigate the presence of *T. gondii* in commercially available meat cuts, and to assess parasite viability in higher risk meats. Initially, 300 meat samples (beef, chicken, lamb, pork and venison) were purchased from retail outlets, and screened for *T. gondii* using quantitative PCR. Results revealed *T. gondii* DNA was present in 35.4 % venison samples, 6.9 % lamb samples, 4.8 % chicken samples, 4.2 % pork samples and 0 % beef samples. Partial PCR-RFLP genotyping revealed non-clonal genotypes. Given the high incidence of *T. gondii* in venison and the propensity to consume this meat undercooked, parasite viability was determined in this meat type. Twenty-three fresh venison products were purchased, and *T. gondii* DNA was detected in 5 samples (21.7 %). For each of the positive samples, 6 outbred CD-1 mice were inoculated and monitored for 28 days. Viable *T. gondii* was detected in 2 venison products. Tachyzoites were isolated and cultured from the positive mice, and PCR-RFLP analysis revealed a Type II-variant (#3) in both samples. These results highlight the potentially important role of game meat, specifically venison, in foodborne transmission of *T. gondii*.

1.4.5 Exploring the Microbial Contamination and Hygiene Issues in Wild Boar Meat from Unregulated Evisceration Facilities

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Private domestic production and hunters supplying meat to consumers or local retailers are exempt from Regulation CE 853/2004, with oversight managed by Member States or regional authorities. In Campania Region, Italy, hunters must take carcasses to registered collection centres under Regulation CE 852/2004, but establishments for eviscerating wild boars for private consumption face no specific requirements. In Campania, with 300 hunting teams and only 25 registered establishments, most wild boars are likely eviscerated in unregulated facilities. To assess the risk to humans, we analysed the microbial population of carcasses eviscerated in these facilities and compared them with those processed in collection centres.

Overall, we observed a high bacterial load (mean = 5.88 Log CFU/cm²) on wild boar carcasses, highlighting the need for improved slaughter hygiene.

Data on bacterial enumeration, published in 2022, showed that meat from private domestic slaughter tends to have lower hygienic quality. Carcasses from registered premises exhibited lower mesophilic counts, meeting the EU Regulation 2073/2005 criterium for pork, compared to those from non-registered premises. Moreover, the results suggested that wild boar may serve as a reservoir for pathogenic *E. coli*, as Enteropathogenic *E. coli*, Shiga toxin-producing *E. coli* and Enterohaemorrhagic *E. coli* were frequently detected on the carcasses, raising potential public health concerns.

Based on preliminary results from bacterial identification, *Escherichia*, *Staphylococcus*, and *Streptococcus* species were frequently identified among the mesophilic population using MALDI-TOF. However, microbial species did not appear to be influenced by the premises where the carcasses were processed.

In conclusion, the absence of regulation for wild boar evisceration in private facilities increases health risks due to absence of hygiene controls, underscoring the need for stricter oversight to ensure meat safety.

1.4.6 Game Meat Processing to Guarantee Consumers from Foodborne Diseases: Preliminary Results of a Systematic Reviews

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Although game meat is usually eaten fresh and cooked, it is customary to preserve meat by freezing or eat processed game meat. The impact of various processing methods on game meat hazards makes it essential to establish guidelines that ensure product safety and quality. It is still under investigation whether some foodborne pathogens are present in game meat products and how resistant they are to meat processing, since their resistance to treatments may differ from that one of pathogens found in meat from livestock. The preliminary results of a systematic review of the literature on this topic is therefore presented. PubMed was used as the primary database to find records, and Google Scholar was added to detect any other records not found in the prior platform. Articles in every database that discussed game meat products or associated processes, including maturing, aging, or packaging, without giving publication date priority were considered. Four level keywords were adopted: 1) game meat (game meat OR venison OR deer OR wild boar); 2) disease and control (food safety OR foodborne disease OR foodborne illness); 3) microbiological terms (e.g. foodborne pathogens OR *Salmonella*); 4) processing (e.g. Process OR cooking). Reviews were included in the research. A total of 26255 records were obtained but only 64 were relevant to the aim of the systematic review: Ten review papers discussed the occurrence of foodborne pathogens in game meat products; 48 papers discussed the presence or absence of particular hazards in specific products; and 6 described specific trials to define the impact of a product technology on foodborne pathogen survival. Concerning processing: 23 were on refrigerated or frozen meat; 8 on cooking process; 20 on cured/fermented products and 10 on the other processing. Targeted studies would be needed to evaluate useful tools to mitigate the presence of hazards and consequently reducing food poisoning from game products.

1.4.7 Sarcocystosis in Wild Game: Molecular Identification in Wild Boar and Red Deer Hunted for Human Consumption

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Sarcocystosis is a parasitic disease affecting both humans and animals. A growing attention has been paid to *Sarcocystis* spp. due to their supposed association with macroscopic pathological alterations leading to carcass condemnation and economic losses. According to EU Regulation 2019/627, meat containing visible parasites is unfit for consumption. Here we investigated a) the presence of the zoonotic *Sarcocystis suis hominis* and the canid-transmitted *Sarcocystis miescheriana* in wild boars hunted in Italy, Greece, and Poland and b) the presence of *Sarcocystis* spp. in red deer meat in Italy.

Muscle samples from 311, 100, and 125 wild boars were analysed from Italy, Greece, and Poland, respectively. The application of a multiplex-PCR resulted in the identification of *S. miescheriana* in 74 %, 75 %, and 93.6 % of wild boars from the three abovementioned countries; 6 wild boars (4.8%) hunted in Poland tested positive for *S. suis hominis*.

In parallel, semimembranosus muscle samples were collected from 75 red deer culled in three Italian Alpine Hunting Districts. *Sarcocystis* spp. were detected in 60 % of samples, with 71.1 % of infections classified as low, 20 % as moderate, and 8.9 % as high. No gross lesions were observed. Based on the molecular analysis, five species were identified: *Sarcocystis hjorti* (n=17), *Sarcocystis iberica* (n=7), *Sarcocystis linearis* (n=5), *Sarcocystis venatoria* (n=2), and *Sarcocystis truncata* (n=2).

The multiplex-PCR has allowed to easily detect and discriminate *S. suis hominis* and *S. miescheriana*, making it a valuable tool to ensure meat safety. Since ~5 % of wild boars in Poland carried *S. suis hominis*, consuming undercooked wild boar meat poses a potential risk for the consumer. While no zoonotic *Sarcocystis* species were detected in red deer, *S. truncata* has been linked to food poisoning, and other species have been associated with eosinophilic myositis. With the increasing consumption of wild game meat, the potential health risks of raw game meat consumption should not be ignored.

1.4.8 Molecular Detection and Characterisation of *Toxoplasma gondii* in Wild Boars Hunted for Human Consumption in Italy

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Wild boar populations are nowadays expanding in terms of both the number of animals and the habitat range. Apart from the ecological impact and the conflicts with human activities, the increased frequency of contacts among wild boars, livestock, and humans, and the increased human consumption of game meat could also influence the transmission of zoonotic pathogens.

Since wild boars are perfectly placed in the interface of domestic and sylvatic cycles, a study was planned to investigate the role of wild boar populations in the epidemiology of *T. gondii* infection from an anthropized area in Italy and the risks for humans.

A previous serological study (Villa et al. *Animals*, 13:1730, 2023) evidenced a wide exposure to *T. gondii* in wild boars hunted within the regional population management plan and destined for human consumption in the province of Cremona (Lombardy, Italy). Indeed, 68 animals were seropositive to the parasite with a serological prevalence of 53.1 %.

From the same animals, masseter muscle samples were collected. Molecular analyses (B1 RT-PCR and genotyping) were performed.

21 animals were positive for B1 RT-PCR with a molecular prevalence of 16.4 %. Of those, 11 were seropositive and 10 were seronegative, evidencing a low agreement between ELISA and PCR, confirming that the association between seropositivity and meat infectivity is not always demonstrated. A predominance of Type II genotype was revealed; as previously demonstrated, Type II strains are the dominant in Europe.

These results evidenced the role of wild boars as a source of risk for humans from the consumption of meat from these animals, and therefore, the need to increase awareness among hunters, wildlife professionals, and consumers. Indeed, even if game meat is usually consumed well-cooked, reaching the target temperature for tissue cyst inactivation, in some culinary traditions, the consumption of raw or undercooked meat and cured meats is a risk for parasite transmission.

2 Abstracts – Poster Presentations

2.1 Hunting and Processing

2.1.1 Game Meat Processing and Inspection: Ensuring Quality and Safety

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Game meat is a valuable source of protein with growing consumer interest due to its natural and organic attributes. However, proper processing and inspection are critical to ensure its safety, quality, and compliance with regulatory standards. Unlike conventional livestock, game animals are typically harvested in uncontrolled environments, making them more susceptible to microbial contamination and improper handling practices.

This study explores best practices in game meat processing, including field dressing, cold chain management, and hygienic handling during transport and storage. Additionally, the role of inspection procedures – such as microbiological testing, visual assessment for diseases, and compliance with food safety regulations – is examined. Special emphasis is placed on the impact of temperature control, post-mortem inspection techniques, and modern preservation methods in extending shelf life and reducing contamination risks.

Findings indicate that proper training of hunters and processors, coupled with stringent inspection protocols, significantly enhances game meat safety. Advanced techniques, such as rapid microbial detection and the use of natural antimicrobial treatments, offer promising solutions for minimizing foodborne risks. Regulatory frameworks play a crucial role in standardizing game meat processing, but challenges remain in harmonizing international guidelines.

Ensuring the safety and quality of game meat requires a comprehensive approach involving proper processing techniques, thorough inspections, and adherence to legal standards. Future research should focus on innovative decontamination methods and improved traceability systems to enhance consumer confidence and market expansion.

2.1.2 Effect of Slaughter Method on the Meat Quality of Fallow Deer (*Dama dama*)

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The objective of the study was to evaluate the effect of slaughter method on the meat quality of farmed fallow deer. Twenty bucks (19 months old) from the same herd were divided into two groups. Half of the animals were slaughtered by head and neck with a hunting rifle (calibre 0.308 Winchester, Brno Rifles, Czech Republic), while the other group was stunned in a restraint box with a captive bolt (JP6 9×20, Antreg, Czech Republic) and subsequently exsanguinated. The carcasses were immediately processed and chilled. Physical parameters (pH, colour, Warner-Bratzler shear force and cooking loss) of meat from three muscles (longissimus lumborum, triceps brachii, and biceps femoris) and carcass damage were measured. Slaughter method did not affect the pH of muscles, measured at 5 different intervals over 48 hours post-mortem. The carcasses from the free-bullet method had significantly less overall damage compared to the captive bolt method carcasses. The meat samples from animals slaughtered using free-bullet showed lower Warner-Bratzler shear force values (i.e. were more tender), with the greatest effect seen for the biceps femoris muscle. Overall, the observed differences in meat quality were not substantial, yet free-bullet slaughter may contribute to higher quality carcasses of farmed deer. This research was funded by projects: METROFOODCZ research infrastructure project [MEYS Grant No.: LM2023064], including access to its facilities, FTZ Internal Grant Agency at the Czech University of Life Sciences Prague, [IGA-20243112], and project MZE RO0723 is also acknowledged.

2.1.3 Veterinary Medicine Students' Perspectives on Hunting and Game Meat

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Game hunting is an important activity in many European countries. Hunting provides food, plays an important role in the regulation of wildlife populations, and provides a means of sport. According to EU Regulation 2019/627, veterinarians are responsible for the official control of game meat. They are also involved in the health and management of wildlife populations. However, hunting remains a controversial topic, particularly among future veterinary professionals, whose perspectives are shaped by ethical, ecological and animal welfare considerations.

This pilot study aims to assess the opinions of veterinary medicine students of ICBAS-University of Porto on hunting and game meat. A questionnaire of eleven questions was developed to characterise veterinary students and their attitudes, concerns and knowledge of the environmental and public health impacts of hunting and game meat.

The survey was submitted to the University's Ethics Committee and delivered online. To reach as many veterinary students as possible, the questionnaire was disseminated through the institutional e-mail, students' groups and representatives of each year. Over 150 students from a total of 391 veterinary students completed the questionnaire. Preliminary results indicate a diversity of opinions concerning the role of hunting and game meat consumption. Regarding the role of veterinary professionals in hunting and game meat control, the opinions were more similar. These results will support a wider project targeting other European veterinary medicine schools.

This study contributes to the consideration of how issues related to hunting, wildlife conservation and animal welfare can be incorporated into undergraduate veterinary education to better prepare students for professional roles at the interface of public health, biodiversity and ethics.

2.1.4 Particularities of the Hunting in Romania

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Introduction

Hunting in Romania is a regulated activity, practiced both to maintain ecological balance and for recreational and sporting purposes. The hunting is regulated by a national hunting law (Law No. 407/2006 on hunting and protection of the hunting fund, which establishes the legal framework for the management of wildlife of hunting interest, the organization of hunting activities and environmental protection).

Aims

The aim of our study was to perform an assessment of the hunting particularities in Romania.

Materials and Methods

The research material was represented by primary data provided by Romanian General Association of Hunter. The aim was to analyse the same data in different years.

Results

The results showed a variation in particularities of the main species hunted due expanding of predator animals or infectious diseases.

Conclusion

Hunting in Romania primarily targets ungulates, with roe deer, wild boar, and red deer being the most harvested, supplying thousands of tons of meat to the market. Small game represents a minor share, with pheasants, certain ducks and geese, and the European hare being the most frequently hunted.

2.1.5 Current Status of Game and Wildlife in Türkiye

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In Türkiye, hunting and wildlife are managed by the General Directorate of Nature Conservation and National Parks, which is affiliated with the Ministry of Agriculture and Forestry. In Türkiye, many laws and regulations are implemented to protect hunting and wildlife.

- Law No. 4915 on Land Hunting
- Regulation on the Possession, Production and Trade of Game and Wild Animals and Products Obtained from Them
- Regulation on the Procedures and Principles for Hunter Education and Granting of Hunting Certificates
- Regulation on the Procedures and Principles Regarding Hunting within the Scope of Hunting Tourism
- Regulation on the Establishment, Management and Supervision of Game and Wild Animal Breeding Places and Stations and Rescue Centres
- Regulation on Wildlife Protection and Wildlife Development Areas
- Directive on Participation Fee in Hunting Tourism

2.1.6 Hunting and Processing of Game Meat: Best Practices and Regulatory Insights

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Background

Game meat is a valuable source of protein, but its safety and quality depend on proper hunting and processing techniques. Compliance with regulations and best practices is essential to minimize biological risks and ensure consumer health.

Objective

This study explores best practices in hunting and processing game meat while examining key regulatory frameworks that govern its safety and trade.

Methods

A comprehensive review of guidelines and regulations related to game meat hunting, handling, and processing was conducted. Best practices in hygiene, storage, and transport were analysed to determine their impact on food safety and quality.

Results

Findings indicate that proper field dressing, temperature control during storage, and adherence to hygiene protocols are crucial for maintaining game meat safety. Regulatory frameworks vary by region but generally emphasize traceability, microbiological testing, and sustainable hunting practices. Challenges include inconsistent enforcement and the need for standardized guidelines across different jurisdictions.

Conclusion

Implementing best practices in hunting and processing, along with strict regulatory compliance, is essential for ensuring safe and high-quality game meat. Further efforts are needed to harmonize international regulations and promote education among hunters and processors to enhance food safety standards.

2.1.7 Annual Sampling of Game Animals Allows Continuous Investigation on Pathogens and Contaminants

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Continuous monitoring projects on the distribution of biological and chemical hazards in wildlife are rare. In most cases, the limitations of specific research projects (e.g. funding, project duration) do not allow observations over a longer period of time.

Since 2017/18, the BfR-Centre for Land Use Related Evaluation Methods, One Health Approaches, German Federal Institute for Risk Assessment (BfR) has been collecting samples for monitoring and for retrospective investigations in food-producing wildlife (biobank). The fieldwork is mainly based on a framework agreement with the German Institute for Federal Real Estate (BImA) and a standardized sampling approach for driven hunts (Maaz et al. 2022). The main sampling areas are located in the federal state of Brandenburg, however samples were also taken in Bavaria, Lower Saxony, and Baden-Wuerttemberg. Data such as approx. age class, carcass weight, sex, and hunting district are recorded for each individual.

During the hunting season 2024/25, 190 wild boars (*Sus scrofa*), 154 roe deer (*Capreolus capreolus*), 62 red deer (*Cervus elaphus*), and 18 fallow deer (*Dama dama*) were sampled at 26 driven hunts, resulting in a total of 2,012 samples (liver, kidney, muscle, faeces, blood, tonsils, as well as nasal and rectal swabs). Since the BfR started monitoring, approximately 150 hunts have been visited and more than 2,000 ungulates have been sampled, corresponding to about 9,000 samples.

The BfR-Centre is, beside its other tasks, a central coordinator of sampling activities and a stable supplier of sample material for studies on a wide range of pathogens such as hepatitis E virus, *Toxoplasma gondii*, *Cryptosporidium* spp., *Campylobacter* spp., shigatoxigenic *Escherichia coli* (STEC), methicillin-resistant *Staphylococcus aureus* (MRSA), *Yersinia* spp. as well as chemical contaminants such as per- and polyfluoroalkyl substances (PFAS), pesticides and heavy metals in wild ungulates. In addition, these obtained data can be correlated with land use data related to the location of game harvesting, allowing retrospective analysis of potential links to food safety risks.

This unique long-term monitoring effort contributes significantly to gain new scientific knowledge. The field insights are used to support risk assessment and improve public health protection, particularly for consumers of wild game meat.

Reference:

Maaz D., et al. 2022. *Animals* 12(7): 888.

2.2 Trade Network and Supply Chain

2.2.1 Large Game Meat Production and Consumption in Serbia

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The main objective of this study is to enhance knowledge and understanding of large game meat production and consumption in Serbia. This study uses official data from the Statistical Office of the Republic of Serbia, supplemented by data collected from consumer survey. Serbia has a relatively small number of hunters, yet hunting grounds are extensive, covering nearly 92.6 % of the country's territory. Among large game species, roe deer represents the most numerous populations in Serbia. This population is of medium size and density, with a low harvest rate compared to European countries. Wild boars are the most frequently hunted large game species in Serbia. Although their population density is low, it varies significantly across different hunting grounds, and the harvest rate remains high. The red deer population is comparable in size to that of neighbouring countries, but has low density and a low harvest rate due to population increase programmes. The fallow deer population is steadily declining, and in some areas, this species has been exterminated. Serbia is one of the smallest producers of large game meat in Europe. On average, a Serbian resident consume only 0.132 kg of game meat annually, accounting for just 0.4 % of total meat consumption. In hunting families, the average game meat consumption is 3.73 kg per family member. Both general population and hunter families' consumption rates in Serbia are lower than in most European countries. These findings represent the first quantitative data on game meat consumption in Serbia. Our results indicate that there is potential to popularise large game meat and increase consumption in Serbia, especially considering the lower price of game meat – such as wild boars compared to domestic pork, and venison compared to beef.

2.3 Chemical Hazards

2.3.1 Environmental Chemical Risks in an Integrated One Health Approach Using Wild Game to Monitor Risk Assessment

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Under the One Health framework, chemical environmental monitoring is crucial to identify contaminants of emerging concern, understand the risks within food webs, and support management measures. In this context, detecting chemical contaminants in wild game (WG) can be an important way of monitoring the degree of pollution in the ecosystem. However, there is only limited knowledge concerning chemical contamination in WG and the potential risks of trophic transfer to human consumers. Therefore, this study aims to discuss the current state of heavy metal (HM) levels and emergent contaminants, such as microplastics (MP), in WG.

European studies have shown metal levels, including lead, cadmium, and mercury, in the tissues of game species, and which have been linked to agricultural runoff, lead-based ammunition, and different industry process. However, most of the studies have only given a partial picture of WG contamination. Also, since exposure to these metals is influenced by local environmental conditions, it has been difficult to establish average concentrations between areas and countries. In addition, emerging contaminants such as MP may widespread detected. However, there is a notable gap in research concerning MP contamination in terrestrial ecosystems, highlighting the need for further investigation into this emerging environmental issue.

Considering the literature review, it is possible to identify some significant challenges of HMs and MP risk assessment in WG, including the necessity to: its evaluation in consumers and toxicological impacts in terrestrial wildlife to establish safe pollution standards; develop standardized methodologies for detecting MPs in terrestrial wildlife; evaluate potential impacts on reproduction, immune function, and overall population dynamics of WG; assess these pollutants implications for food safety and conservation strategies.

2.3.2 Pilot Study of Lead in Estonian Game Meat Products

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Pilot study was done to assess the presence of lead contamination in Estonian game meat products due to the use of lead-based hunting ammunition. A total of 33 commercially and privately sourced game meat products (18 canned, 15 sausages) were collected and examined between 2021 and 2023. Each product underwent radiographic imaging to detect metallic fragments, followed by chemical analysis on 12 selected samples to quantify lead content.

Radiographic evaluation revealed radiodense materials in 13 out of 33 products (39 %). Fragments were primarily <1 mm in size and frequently undetectable without radiographic imaging. Of the 12 chemically analysed samples, lead was detected in 9, with 4 exceeding the EU's maximum residue limit of 0.1 mg/kg for livestock meat. The highest lead concentration measured was 0.53 mg/kg, found in a moose meat sausage containing six visible fragments.

Products containing visible fragments were not the only ones with elevated lead levels – some fragment-free samples also showed contamination. This highlights that radiographic absence of metal does not guarantee safety. Additionally, products often included mixed-origin meats, raising concerns about cross-contamination during processing.

The findings confirm that lead contamination in Estonian game meat products is both prevalent and significant. Given the lack of specific regulatory limits for lead in wild game meat, the study supports the urgent need for standardised monitoring and tighter regulation. Transitioning to lead-free ammunition and improving handling protocols during processing could significantly reduce exposure risk.

2.3.3 Chemical Pollutants in Game Animals in Spain: a Review

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Studies on game meat contamination in Spain have focused on detecting the presence and assessing the risks of toxic trace elements, pesticides or biocides, and other types of organic substances of industrial or domestic origin. Metal and metalloid contamination has been addressed in two main scenarios: pollution caused by mining (mainly Pb, Hg and Cd) and its impact on game species, particularly wild ungulates; and contamination from lead-based ammunition. Lead has been the most extensively studied metal in game meat, as both mining activities and ammunition-related contamination (through ingestion of shot pellets in gamebirds and metal transfer from shooting to the meat in all types of game) result in hunted animals having tissue concentrations exceeding the maximum levels established for meat and offal intended for human consumption. Another group of contaminants studied in game species includes those highly bioaccumulative and persistent chemicals. This includes legacy pesticides like the organochlorines (DDT, HCHs, cyclodienes) and PCBs, as well as other dioxin-like compounds. Some studies have also examined PBDEs and PAHs in game species. In these cases, contamination levels tend to be lower in game species, which are mostly primary consumers, than in predators. Among current pesticides or biocides, second-generation anticoagulant rodenticides have been detected in Spain in wild ungulates, lagomorphs, and game birds, mainly in peri-urban areas, around livestock farms, and some years ago in agricultural areas affected by common vole plagues. Some studies have also monitored organophosphate and pyrethroid pesticides. There is still a need for further research on other contaminants in game animals, such as PFAS and veterinary drugs.

2.3.4 Danish Studies of PFAS in Game Animals

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Birds (n=188) distributed across 6 huntable species were collected in the autumn and winter of 2023–2024 from 14 locations in Denmark for analysis of per- or polyfluorinated alkyl substances (PFAS) in muscle tissue to assess the risk of human exposure from consuming these birds. Significant geographical differences were observed for the three species – teal, mallard, and greylag goose – across the examined locations. The highest concentrations were found in bird samples from Harboøre Tange (teal: average: 55.3 ng/g wet weight (ww); range: 9.2–211.9 ng/g ww; mallard: average: 33.0 ng/g ww; range: 8.7–60.3 ng/g ww). The second-highest concentrations were found at Agger Tange, a few kilometres north of Harboøre Tange, which was expected due to the significant bird movement between these two locations. Among the examined birds, 22 (12 %) exceeded the maximum acceptable limit (MAL=9.0 ng/g ww) for human consumption of Σ 4PFAS (sum of PFOS, PFOA, PFNA and PFHxS), while concentrations in 88 % of the collected bird samples were below the MAL. However, at Harboøre Tange, 15 (94 %) out of 16 birds had Σ 4PFAS values exceeding the MAL, and only 1 (6 %) were below it. Concentrations of Σ 4PFAS as well as the substances PFOS and PFOA were significantly higher in the examined waterfowl species such as teal and mallard collected at Harboøre Tange and Agger Tange compared to other investigated areas in Denmark. The assessment supports the Danish Nature Agency's decision not currently to allow hunting lease at Harboøre Tange and Agger Tange. During the hunting season 2024–2025 we collected muscle samples of red, fallow, and roe deer (total 300) to assess risks to human consumption of these huntable species. These samples are not yet finally tested. However, preliminary results and sampling methodology will be presented.

2.4 Biological Hazards

2.4.1 Emerging Food-borne Pathogen: Results from a Two-Year Survey of HEV in Wild Boar in Two Regions of Central Italy

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Viral hepatitis E represents a significant global health issue caused by the hepatitis E virus (HEV) with a steady increase in human cases reported worldwide. In Italy, HEV infections are primarily acquired locally and are caused by the zoonotic genotype HEV-3, which is transmitted through close contact with infected animals or the consumption of contaminated food products, including raw or undercooked wild boar meat. In order to deepen the understanding of HEV circulation and more effectively address the public health concerns associated with foodborne transmission in central Italy, we conducted a study on the prevalence of HEV in wild boars in the Umbria region over two consecutive hunting seasons (autumn–winter 2021–2022 and 2022–2023) at hunters' level. Additionally, a random two-year sampling (2022–2023) was carried out, with specimens collected during the years from two Game Handling Establishments in the Umbria and Marche regions. Since the liver is the primary target organ for HEV infection, a detailed sampling strategy was implemented, and the collected wild boar liver samples were analysed for HEV presence using real-time RT-qPCR. In wild boar populations, data from two-year surveys on HEV prevalence ranged from 43.6 % (78/179, 95 % CI: 36.5–50.9 %) to 10.8 % (12/111, IC95 %: 6.3–17.9 %). Moreover, a preliminary analysis of a limited number of wild boar muscle samples (n = 110) was conducted during the survey, and the results revealed the presence of HEV RNA in meat intended for human consumption, with a positivity rate of 16.36 % (18/110, 95 % CI: 9.46–23.26 %) that may mainly be attributed to improper slaughtering practices that promote cross-contamination. Our data emphasize the importance of continuous monitoring of virus circulation in wildlife, which poses a potential zoonotic risk, and the need for good hygiene practices during wild boar meat processing to reduce HEV-related risks to consumers.

2.4.2 Detection of Hepatitis E Virus (HEV) in Wild Boars in Greece: Preliminary Results

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Objective

The aim of this ongoing study is to investigate the prevalence of the zoonotic Hepatitis E virus (HEV) in carcasses of wild boars (*Sus scrofa scrofa*) hunted in various regions in Greece (Epirus, Western Central Greece, and Western Macedonia) over a two-year period (2024–2026).

Materials and methods

A total of 60 tissue samples were analysed, namely liver (n=30), diaphragm (n=12) and myocardium (n=18), originating from 34 wild boars and collected between September 2024 and January 2025 by hunters who had been previously trained in tissue sampling. The samples were stored under freezing until laboratory analysis. A real-time reverse transcriptase polymerase chain reaction (RT-PCR) assay targeting the open reading frame (ORF) 3 region of HEV was used to amplify the targeted RNA in samples, which was previously extracted using fine quartz grains (2 mm, Labbox Labware). All PCR analyses were performed in a QuantStudio™ 6 Pro Real-Time PCR system (Applied Biosystems™, Thermo Fisher Scientific). Samples exhibiting a cycle threshold (Ct) value < 40 were considered positive.

Results

In total, HEV was detected in six out of the 60 tissue samples analysed (10 %), namely four liver tissue samples (13.3 %), one (5.6 %) heart and one (8.3 %) diaphragm tissue sample, originating from six wild boar carcasses (17 %). The mean Ct value of positive samples was 35.3 with an SD of 0.99.

Conclusion

These preliminary results indicate a rather high prevalence of HEV in wild boars hunted in various Greek regions and its detection in different types of edible tissues, emphasising the need for further research to obtain more HEV-relevant epidemiological data among wild boar populations in Greece and to explore potential public health implications.

2.4.3 *Trichinella* spp. and *Alaria alata* – a Risk of Wild Boar Consumption for Human Health in Latvia?

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Trichinella spp. is a zoonotic, food-borne nematode and is usually transmitted via consumption of raw or undercooked wild boar meat. So is *Alaria alata*, which is considered a potentially zoonotic trematode, for which a human could be a paratenic host; however, a risk of infection for humans has been previously estimated to be low. The aim of this study was to report *Trichinella* spp. and *A. alata* prevalence in wild boars from 2020 to 2024 and do a qualitative risk assessment for *Trichinella* spp. from wild boar meat.

From 2020 to 2024, individual wild boar muscle samples (50 g) were routinely tested for *Trichinella* larvae using the *Trichinella* inspection method as per EC regulation 2015/1375. All *Trichinella* larvae and *A. alata* mesocercariae observed in the samples were counted. Furthermore, a qualitative risk assessment (QRA) pathway was developed to illustrate the overall risk of getting infected with *Trichinella* larvae from consuming wild boar meat in consumers in Latvia. The main inputs for the QRA, for the probability of illness for an individual, were the prevalence and concentration of *Trichinella* larvae, dose-response, legislation, and *Trichinella* survival while cooking.

During 2020–2024, 117,158 wild boars were officially hunted, of which 38,588 (32.9 %, 95 %CI: 32.6–33.2) were officially tested for presence of *Trichinella* larvae. *Trichinella* spp. was detected in 0.2 % (95 %CI: 0.19–0.29), with the average larvae per gram of 8.8 (min 0.02; max 247.4) of the examined wild boar, but *A. alata* was detected in 13.8 % (95 %CI: 13.5–14.2), with average mesocercariae per gram of 0.05 (min 0.02; max 1.94). The QRA revealed that the risk of a consumer being infected with trichinella larvae is low.

Trichinella spp. and *A. alata* are observed in wild boars in Latvia. Similar to previous risk estimate for *A. alata*, the risk for the consumers of being infected with *Trichinella* spp. is low if proper precautions are followed.

2.4.4 Impact of Climate and Geography on the Distribution of *Trichinella* in Wild Boars in Poland

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Trichinellosis, a parasitic disease described in 1863, led to the introduction of meat inspection rules in 1879. While many countries have controlled the infection in pigs and wild animals, Poland has more complex situation, with both low-risk and high-risk areas. Four *Trichinella* species are present in Poland: *T. spiralis*, *T. nativa*, *T. britovi*, and *T. pseudospiralis*. In recent years, wild boar meat has replaced pork as the primary source of human infections, with approximately 170,000 wild boars hunted annually for consumption. Poland records about 10 human cases of trichinellosis per year (for the last 10 years) and over 70 for last 20 years. This study we assessed the relationship between climate and *Trichinella* infection risk. Poland's temperate climate transitions from oceanic in the northwest to continental in the southeast, with diverse geographical regions, including the Baltic coast, post-glacial lake districts, and mountainous areas. Samples were collected in 2016–2021, samples for the study were provided by the Veterinary Inspection and analysed at NVRI using magnetic digestion PCR and GIS tools, mapped *Trichinella* distribution by climate subprovinces. The highest concentration of *T. spiralis* (1514 cases) was recorded in the Southern Baltic Coastlands and Lake Districts (1296 cases), where it accounted for 85 % of infections. The prevalence of *T. britovi* (304 cases) was five times lower but had a more distinct geographical distribution. The highest number of infected wild boars per km² was observed in the Southern Baltic Lake Districts (233) and Central Poland Lowlands (29). The largest wild boar populations were found in Katowice (12,746) and Olsztyn (12,728) in 2016, while in 2018, the highest numbers were recorded in the West Pomeranian (34,000) and Greater Poland (25,000) Voivodeships. The study highlights the influence of climate, geography and population density on the spread of *Trichinella* in wild boars, posing a challenge for disease prevention.

2.4.5 *Trichinella* spp. in Game Meat in Greece. What Do We Know So Far?

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The parasites of the genus *Trichinella* are amongst the most important foodborne pathogens. The most common source of human infection is pig and wild boar meat. The last decade in developed countries trichinellosis has significantly declined as zoonosis mainly due to a reduction in the domestic cycle. However, the risk still remains since most *Trichinella* species continue to exist in wildlife. In Greece, wild boar meat is traditionally consumed after sport hunting. Wild boar is a native species and its population density has increased the last years. Furthermore, the fact that, occasionally, and against the European Commission regulation 2015/1375, home slaughter might be performed makes matters more complicated.

Trichinella infections in humans have been sporadically documented in Greece. Nevertheless, epizootiological studies on trichinellosis in Greece are limited leaving a significant gap in our knowledge on the frequency of infection in animals, as well as the species involved. Concerning wild boars, a serological study in Greece recorded a 6.4 % seropositivity in samples originating from different areas of the country. This seropositivity value may be of particular importance for surveillance, although it has been suggested that serological tests in wild boar might overestimate *Trichinella* prevalence. The latter is in accordance with the two other studies dealing with the prevalence of *Trichinella* spp. in wild boar meat in Greece. In the first study, no positive animals were detected in any of the 232 hunted wild boars subjected to routine testing. In the second, tissue samples from 128 wild boars were examined by tissue compression and magnetic stirrer artificial digestion for the presence of *Trichinella* larvae and all samples resulted negative. Further large and cross-sectional surveys in wild boar meat in Greece are needed. The Greek Public Health Authorities should focus on expanding the training of hunters and public to avoid transmission.

2.4.6 Could Harmonised Epidemiological Indicators for *Toxoplasma gondii* in Farmed Game Be Implemented in Hunted Wild Boar? A Case Study

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The European Commission has requested the European Food Safety Authority to provide technical assistance on harmonization of epidemiological indicators (HEIs) for specific public health hazards in animal-based food, particularly in cases where risk managers assess that current meat inspection procedures do not adequately address the relevant risks. Game meat (especially ungulates) may act as a significant source of *Toxoplasma gondii* infection for humans. However, the parasite cannot be detected by visual inspection of carcasses, and other approaches are needed to define the risk for game meat consumption. In 2013, the EFSA proposed two HEIs for meat inspection of wild boars and deer concerning the risk of *T. gondii* infection, consisting in the assessment of antibodies in meat juice at the slaughterhouse level: HEI1 involving all farmed deer and wild boar or HEI2 focused on detecting antibodies in animals older than one year of both farmed deer and wild boar. These HEIs were considered in a survey performed on hunted wild boar in 2 local Game Handling Establishments (GHEs) in Umbria and Marche Regions (Central Italy) in 2021–2023. A total of 100 Sternomandibular muscle samples were collected from 70 adults (>1 year) and 30 young (<1 year) hunted wild boars (about 10 % of the animals processed in the GHEs). Meat juice was extracted from the muscle and screened by Immunofluorescent Antibody Test for specific *T. gondii* IgG. No positive samples were detected in wild boars younger than 1 year, but 11 adults (prevalence 15.71 %, IC 24.23–7.18) tested positive. Similar data were recorded in a survey conducted in 2009–2011 in the same area and highlight the stability of the infection over the years in the region. These findings suggest either that young animal may present a limited risk, or that appropriate control strategies must be established for the meat of adult wild boar, or the EFSA-proposed HEI2 could be applied to hunted wild boar at GHEs.

2.4.7 High Infection Rate of *Toxoplasma gondii* in Wild Boars (*Sus scrofa*) from Northern Tunisia

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Wild boars, *Sus scrofa*, of wide distribution considered as a potential source of parasitic protozoan *Toxoplasma gondii*. The current study aimed to assess the seroprevalence and molecular prevalence of *T. gondii* in wild boars from Northern Tunisia.

Seroprevalence of *T. gondii* antibodies was assessed using enzyme-linked immunosorbent assay (ELISA), employing a commercial kit (Calbiotech), whereas molecular detection was carried out through polymerase chain reaction (PCR) targeting the B1 gene of *T. gondii* on tissue samples (tongue, muscle, diaphragm and heart). Fifty wild boars were sampled from the regions of Sejnane, and Tabarka, and both blood and tissue samples were analysed.

In this study, the seroprevalence of *T. gondii* antibodies was found to be 88 % (44/50) among wild boar serum samples using ELISA. Molecular detection through PCR identified *T. gondii* DNA in 38 % (19/50) of tissue samples, with the highest detection rates in tongue tissues (64 %), followed by muscle (21 %) and diaphragm (14 %). No positive results were found in heart samples, and no animal had multiple tissues testing positive. All PCR-positive cases corresponded with positive ELISA results, and a statistically significant difference was observed in parasite prevalence across different tissues ($p = 0.002$).

Although consumption of wild boar meat is rare in Tunisia, illegal hunting and consumption remain a concern. The high prevalence of *T. gondii* in wild boars poses a potential risk for transmission through the illegal consumption of undercooked or raw meat. This study highlights the need for public health interventions to control the illegal trade of wild boar meat and reduce the risk of toxoplasmosis transmission. Further research is recommended to investigate *T. gondii* distribution in other tissues, including the brain, and to better understand the parasite's epidemiology in this region.

2.4.8 Detection of Zoonotic *Sarcocystis suis hominis* in Wild Boar Meat Intended for Human Consumption in Poland

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Sarcocystis spp. are intracellular protozoa parasites with an obligatory prey-predator life cycle. Domestic and wild pigs may act as intermediate hosts for two species of *Sarcocystis*, *S. miescheriana* and the zoonotic *S. suis hominis*. Humans can get infected by the consumption of raw or insufficiently heat-treated pork. In this study, 125 diaphragmatic muscle samples were collected from wild boars hunted in different regions of Poland to evaluate the presence of *Sarcocystis* spp. in game meat. Samples were molecularly tested for the presence of *S. miescheriana* and *S. suis hominis* by a multiplex-PCR protocol targeting the mtDNA *cox1* gene. Samples resulted positive for the presence of the zoonotic *S. suis hominis* were sequenced to confirm species identification and further processed by homogenization and direct microscopy to collect single *Sarcocystis* spp. cysts. Single-cyst DNA was analysed by PCR targeting the *cox1* mtDNA and the complete 18S rRNA gene and sequencing. Out of 125 wild boars, 117 resulted positive for the presence of *S. miescheriana* DNA (93.6 %), six of which were also positive for *S. suis hominis* (4.8 %). Sanger sequencing of the six amplicons resulted in 374–377 bp fragments showed a percentage of identity of 97.3–98.1 % with *S. suis hominis* GenBank entries. A single *S. suis hominis* cyst and 12 *S. miescheriana* cysts were individually collected; amplification and sequencing of the *cox1* mtDNA gene yielded a 1049 bp sequence with a percentage of identity of 98.7 % with *S. suis hominis* and twelve 1015–1055 bp sequences with a percentage of identity of 94.1–99.9 % with *S. miescheriana* GenBank entries, respectively. The amplification and sequencing of the complete 18S rRNA gene of the *S. suis hominis* cyst yielded a 1840 bp sequence with a percentage of identity of 98.9–100 % with *S. suis hominis* GenBank entries. This is the first study investigating the prevalence of *Sarcocystis* spp. in wild boars intended for human consumption in Poland; as around 5 % of wild boars tested positive for the presence of *S. suis hominis*, the risk for the consumer of raw or undercooked wild boar meat cannot be excluded.

2.4.9 Game Meat and Antibiotic Resistance: Are Hunters and Consumers at Risk?

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Antimicrobial resistance (AMR) is a growing global concern to human health and its presence in wildlife, including wild game meat, raises new challenges for consumers. Hunters, who frequently handle and consume wild game meat, are at increased risk of encountering antibiotic-resistant bacteria. Wildlife can acquire AMR bacteria through environmental contamination, agricultural activities and contact with domestic animals. Studies have found multidrug-resistant *Escherichia coli*, *Salmonella* and *Campylobacter* in wild boar, deer and birds, highlighting potential routes of transmission. Hunters can be exposed to contamination through direct contact with animal tissues, consumption of undercooked meat or cross-contamination during meat processing. To reduce these risks, good hygiene practices, precautions during meat handling and thorough cooking of wild game meat are essential. This review examines the prevalence of AMR in wild game, the mechanisms of bacterial transmission and the potential health risks to hunters and consumers. Understanding these interactions is critical for developing policies and guidelines to reduce the spread of AMR from wildlife to humans.

2.4.10 Biological Hazards in Game Meat: Microbial Risks and Prevention Strategies

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Background

Game meat is a valuable source of protein but poses significant biological hazards due to microbial contamination. Pathogens such as *Salmonella* spp., *Escherichia coli*, and *Listeria monocytogenes* can compromise food safety if proper handling and prevention strategies are not implemented.

Objective

This study examines microbial risks associated with game meat and explores effective prevention strategies to ensure its safety.

Methods

A literature review was conducted on microbial contamination in game meat, focusing on risk factors, detection methods, and mitigation strategies. Emphasis was placed on hygiene practices, cold chain management, and novel decontamination techniques.

Results

Findings indicate that inadequate processing, improper storage, and cross-contamination are key contributors to microbial risks in game meat. Effective strategies, including strict hygiene protocols, rapid microbial detection methods, and the use of organic acids or high-pressure processing, significantly reduce contamination levels. Additionally, proper training for hunters and processors is essential for maintaining food safety standards.

Conclusion

Ensuring the microbiological safety of game meat requires a combination of preventive measures, technological advancements, and regulatory oversight. Further research is needed to optimize decontamination techniques and develop sustainable microbial risk management strategies in the game meat industry.

2.4.11 Postbiotics (Enterocins) – Their Effectivity Against *Buttiauxella* spp. from Roe and Red Deer

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Microbiota of gastro-intestinal tract (fecal) microbiota can be associated with wild ruminants meat contamination after/during their processing. These undesirable bacteria can represent environmental bacterial pollution with negative impact on animals and humans. Therefore, new strategies are searched how to prevent/eliminate those bacteria. Promising approach seems to be use of bacteriocins which have been belonged to the group of postbiotics. Based on our previous studies, among bacteriocins also enterocins are widely effective. Therefore, the aim of this study was to use enterocins (studied and characterized in our laboratory) against Gram-negative representatives of the genus *Buttiauxella* isolated from roe and red deer living in Poland (the Strzalowo Forest District, Piska Primeval Forest 53° 36' 43.56 sec N, 21 30' 58.68 sec E). Twenty-one free living animals (9 *Cervus elaphus*-red deer, adult females) and 12 roe deer (*Capreolus capreolus*), young females were culled by selective-reductive shooting during winter season of 2014/2015 approved by Polish Veterinary Administration. The isolated strains were allotted to three *Buttiauxella* species using MALDI-TOF mass spectrometry such as *B. garviniae*, *B. ferraguttiae*, and *B. agrestis*. They were deoxyribonuclease negative, not forming biofilm and they were resistant at least to one out of 13 tested antibiotics. However, they were susceptible to seven (7) enterocins used (Enterocin-Ent 4231, Ent M, EntA/P, Ent55, Ent 2019, Ent 9296, and Ent 412) with inhibitory activity ranged from 100 to 25 600 AU/ml. The strain *B. garviniae* BG8/143/2 from red deer was the most susceptible to enterocins (activity 800–25 600 AU/ml). Also based on this information, postbiotics (enterocins) represent a promising tool to prevent/treat bacterial contamination in wild animals which can be also applied for their meat. Those studies are in processing.

2.4.12 Lantibiotic Gallidermin-Tool to Treat Staphylococci from Roe and Red Deer

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Staphylococci are one of a major groups of bacterial commensals. The dissemination of antimicrobial/antibiotic resistance among staphylococci is an emerging problem in both, veterinary and human medicine. The colonisation of any species by methicillin-resistant staphylococci may present a risk for the plasmid-encoded transfer of antibiotic resistance determinants between staphylococci and other bacterial organisms. This condition is associated also with wild ruminants such as roe and red deer. The facts introduced leads to a challenge for studying novel alternatives to inhibit spoilage bacteria. One alternative supposed to be gallidermin. This bacteriocin-lantibiotic represents a polypeptide antimicrobial substance with proteinaceous character originally produced by the *Staphylococcus gallinarum* Tu 3928. It is known to inhibit predominantly Gram-positive species strains, a group to which staphylococci belong. The aim of this study was to test susceptibility to gallidermin of staphylococci from roe and red deer as a possible tool in treatment/prevention. Sixteen staphylococcal strains were identified from 21 free-living roe and red deer living in Poland. The variability in staphylococcal species was detected with seven different species belonging to five cluster groups. The strains were haemolytic-negative and also DNase-negative. They were without biofilm-forming ability and/or they were with low-grade ability to form biofilm. They were urease-positive and mostly susceptible to commercial antibiotics. All CoNS (coagulase-negative staphylococci) characterized in this study were susceptible to gallidermin with a MIC 0.0156 µg (6 400 AU/ml). This study as a first reported more detail characterization of staphylococcal species in red and roe deer with original tool for their elimination. To develop this condition is in processing. The study was supported by the project COST22166 (Safety in the game meat chain) and VEGA no.2/0009/25.

2.4.13 Wild Ruminants as a Source of Bacteria with Postbiotic Potential

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Information associated with wild ruminants microbiota has been reported especially regarding the gut/rumen microbiota. However, although studies with next-generation sequencing detection in the total fecal microbiota have been started, it is different way to work handly with individual bacterial strains and their properties aiming their further usage. Therefore, the aim of the present study was to find among the species strains *Enterococcus mundtii* from roe and red deer those strains with postbiotic (bacteriocin) potential. *E. mundtii* were identified using 16S rRNA analysis. They were found with low-grade biofilm formation and they were absent of virulence factor genes. Postbiotic potential of the bacteriocin substance produced by those *E. mundtii* revealed indicator bacteria inhibition up to 48 %. There mostly Gram-positive bacteria were inhibited. The most active strain revealed inhibitory activity up to 86 % and the other most active strain up to 81 %. The substance remained active at -20 °C for month. This evaluation is in processing. The study was supported by the project COST22166 and VEGA no.2/0009/25.

2.4.14 Current Status of Wildlife-Related Foodborne Hazards in the Balkan Countries

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Hunting has probably contributed to the evolution of human kind, playing an important role in human nutrition and formation of social bonds, while still being a well-established tradition in many countries worldwide. However, game meat can serve as a reservoir for important foodborne pathogens, and the lack of standardized inspections makes its improper consumption a significant public health issue. Many countries, particularly in North America and Central, Western, and Northern Europe, actively investigate foodborne pathogens in game meat. However, such data is notably lacking in the Balkan region. Therefore, the aim of this study is to evaluate the current status of wildlife-related foodborne hazards in the Balkans by analysing studies from the global literature. Most studies focused on foodborne parasites in game meat and organs (75.0 %), followed by foodborne pathogenic bacteria (21.1 %) and viruses (7.7 %). *Trichinella* spp. were the most commonly reported foodborne parasites (40.4 % of studies), followed by *Toxoplasma gondii*, *Alaria alata*, *Sarcocystis* spp., *Echinococcus granulosus* and *Gongylonema pulchrum*. Among foodborne pathogenic bacteria, *Salmonella* spp. were the most frequently identified (13.5 % of studies), followed by *Escherichia coli*, *Mycobacterium bovis*, *Listeria monocytogenes*, and *Bacillus cereus*. Hepatitis E virus was the most commonly investigated foodborne virus in Balkan game meat. Wild boars were the most frequently studied wildlife species (80.8 % of studies), though research also covered wild bears, wild deer, wild birds, wild hares/rabbits, and other wild ruminants. The studies retrieved report findings from Romania (26.9 %), Serbia (17.3 %), Croatia (17.3 %), Greece (15.4 %), Slovenia (11.5 %), Bulgaria (7.7 %) and Bosnia & Herzegovina (3.9 %). However, the number of available studies is still limited, underscoring the need for further research to accurately assess the true extent of foodborne hazards in game meat in the Balkans.

2.4.15 A New Approach in Biocontrol of Foodborne Pathogens in Game Meats: Bacteriophages

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The World Health Organization (WHO) reports that 1 in 10 people worldwide become ill every year due to the consumption of food contaminated with pathogens, and therefore an average of 420 thousand people die every year due to this. Among these pathogens, *Escherichia coli*, *Salmonella*, *Listeria monocytogenes* and *Staphylococcus aureus* are the leading foodborne outbreaks. *Enterococcus faecalis* and *E. faecium* are among the 5 most important nosocomial infection agents as well as foodborne pathogens.

Game meat can be contaminated with these pathogens during skinning, removal of internal organs, shredding of carcasses, and transportation of meat. In addition, meats can be contaminated as a result of contact with food processing surfaces at different stages along the food chain, especially during processing and packaging. Foodborne infections can occur as a result of the consumption of these contaminated meats. In this context, the control of pathogenic microorganisms in game meats and ensuring food safety are important for public health.

Bacteriophages, which represent the “green technology”, which is the most common in nature, harmless to health, can exist wherever the host bacteria are found, is non-chemical, and has recently emerged as an environmentally friendly alternative antimicrobial approach, are suitable candidates for the biological control of food pathogens.

In this study; 324 bacteriophages that were isolated from various provinces in different regions throughout Türkiye from wastewater were characterized. As a result of the analysis, 315 of them were detected as lytic to enterohemorrhagic *Escherichia coli* (EHEC), the most common *Salmonella* serotypes, *Listeria monocytogenes*, *Staphylococcus aureus*, *Enterococcus faecalis* and *E. faecium*. The determination of the lytic effect spectra of phages was carried out by host susceptibility test by spot planting method. In the studies, bacteriophages with the widest spectrum of lytic effects specific to each host planned to be obtained in the project were characterized and determined to be used as biocontrol agents. As a result of this analysis, lytic bacteriophages were obtained for *E. coli* serotypes (8 serotypes), *Salmonella* serotypes (5 serotypes), *L. monocytogenes*, *S. aureus* and *Enterococcus* species (2 species) within the scope of the project. Whole genome sequence analysis was performed on all 18 bacteriophages determined in order to reveal their molecular differences. In the whole genome sequencing study performed using the Illumina NovaSeq 6000 system, all 18 phages were found to be unique and no previously identified phages were found. In addition, it has been determined that phages do not have important antibiotic resistance and virulence genes. TEM imaging was performed to identify bacteriophages morphologically. According to the characteristics of the head, neck and tail; 4 of the 5 *Salmonella* phages are Siphoviridae, 1 is Myoviridae, 6 of the 7 *E. coli* phages are Myoviridae, 1 is Siphoviridae, 2 *L. monocytogenes* phages are Myoviridae; It was determined that 2 *S. aureus* phages were from the Siphoviridae family and 2 *Enterococcus* phages were from the Siphoviridae family. In this study, the

lytic effects of bacteriophage cocktails on target bacteria were investigated. In an in-vitro study, the *E. coli* phage cocktail had a significant increase in the number of *E. coli* O157 in 1.58 to 5.30 log cfu/ml; *Salmonella* phage cocktail S. It was observed that the number of enteritidis decreased by 2.15 to 9.28 log cfu/ml, the *S. aureus* phage cocktail by 0.70 to 4.31 log cfu/ml in the number of *S. aureus*, the phage cocktail by 0.48 to 4.22 log cfu/ml in the number of *L. monocytogenes*, and the *Enterococcus* phage cocktail by 2.06 to 9.12 log cfu/ml in the number of *E. faecalis*. In addition to the colony counts, it has been determined that *S. aureus*, which is the intoxication agent as a result of incubation, can form staphylococcal enterotoxin A in the control groups, but it has been determined that the formation of enterotoxin is successfully prevented by preventing the growth of *S. aureus* in the phage groups.

As a result, it has been determined that all phage cocktails successfully provide biocontrol by showing a high level of lytic effect on target pathogens.

2.4.16 16S Bacterial Metagenomic Analysis of Yak (*Bos grunniens*) Meat Samples Collected from Kyrgyzstan

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Yak (*Bos grunniens*) meat is one of the most important staple foods in people's diets, especially in Asian countries such as western China and Nepal. However, it is also becoming increasingly popular, and its production is on the rise in other Asian countries, such as Kyrgyzstan. In this study, yak meat samples (n = 63) were investigated for the first time using Next-Generation Sequencing and metabarcoding analysis, originating from two different plateaus in Sary Jaz (n = 33) and Ysyk-Ata (n = 30) in Kyrgyzstan. Our initial data showed that Firmicutes (31.2 %–60.5 %), Proteobacteria, and Bacteroidota (12.3 %–17.4 %) were the dominant bacterial phyla in yak meat samples. In addition, Vagococcaceae (24.3 % to 59.7 %), Erwiniaceae (23.9 % to 46.7 %), and Lactobacillaceae were identified as the dominant bacterial genera. *Lactococcus*, *Klebsiella*, *Cronobacter*, and *Enterococcus* spp. were also detected in the meat samples. In conclusion, it is essential to consider that undercooked yak meat may pose a risk to consumers in terms of some pathogens and emerging pathogens.

2.4.17 Assessment of Effectiveness of Disinfectants Against *Salmonella typhimurium* and *Salmonella* Senftenberg Strains

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In accordance with Regulation (EC) No 2073/2005 on microbiological criteria for foodstuffs, *Salmonella* spp. bacteria are one of microorganisms classified as requiring monitoring to ensure the safety of food of animal origin. Disinfection plays a crucial role in maintaining safe and hygienic conditions in food processing environments. The aim of the study was evaluation of antibacterial efficacy of disinfectants (formaldehyde, Virusolve+[®], Eau de Javel) on *S. Typhimurium* ATCC 14028 and *S. Senftenberg* strains, tolerant to Desprej[®] (V, variant). The minimal inhibitory concentration (MIC) of biocides and minimal bactericidal concentrations (MBC) were determined using the method described by Andrews et. al. (2001). Additionally, influence of Virusolve+[®] on biofilms formed by tested strains were studied using BOAT test by Junka et. al. (2014). In the research, the tolerance of *Salmonella* strains (V, variants) to Desprej[®] was confirmed, and the other substances were tested against them. While testing formaldehyde, Virusolve+[®], and Eau de Javel it has been shown that three Desprej[®] variants showed 4-times higher resistance to formaldehyde compared to WT strains. Data noted for Virusolve+[®] showed 2-times higher concentration needed to inhibit growth and to eradicate V strains. It has been observed that Eau de Javel was the best choice to eradicate both WT and V groups without increasing its concentration. The effectiveness of Eau de Javel is probably caused by presence of sodium hypochloride and sodium hydrochloride, which were absent in other disinfectants. The results obtained with BOAT method revealed that using of Virusolve+[®] in 10-times higher concentration than MIC didn't killed the bacteria in biofilms. Concluding, bacteria can develop cross-resistance to disinfectants, but it is possible to eradicate them with disinfectant containing chlorine compounds.

3 Abstracts – Short-Term Scientific Mission

3.1 Chemical Hazards

3.1.1 Short-term Scientific Mission: Collation and Assessment of Data and Risks Posed by Chemical Contaminants in Game Meat

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Short-Term Scientific Missions (STSMs) are research exchange visits carried out within the framework of an EU COST Action. They offer valuable opportunities for researchers to collaborate, exchange knowledge, and acquire new techniques or skills that may not be accessible at their home institution or laboratory. This STSM is a collaboration between the Environmental Research Institute, University of the Highlands and Islands in Scotland (Anna McWilliam and Mark Taggart) where I'm based and Aarhus University in Denmark (Niels Kanstrup) where the STSM is taking place and the Instituto de Investigación en Recursos Cinegéticos in Spain (Rafael Mateo). A central output of the EU COST Action CA22166 – "Safety in the Game Meat Chain (SafeGameMeat)" project within WG3 is to report on levels and risks associated with chemical hazards present within game meat. Over 90 days (April–June), this will be achieved by information seeking, data collation, and critical review of current knowledge regarding chemical contaminants in game meat (principally within the European context), identifying pathways for selected contaminants into game, known levels present, factors affecting their occurrence, risks to consumers, and outlining knowledge gaps and needs for future research or surveillance.

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The German Federal Institute for Risk Assessment (BfR) is a scientifically independent institution within the portfolio of the Federal Ministry of Food and Agriculture (BMEL) in Germany. The BfR advises the Federal Government and the States ('Laender') on questions of food, chemicals and product safety. The BfR conducts independent research on topics that are closely linked to its assessment tasks.

Safety in the Game Meat Chain Network

Under the leadership of the German Federal Institute for Risk Assessment (BfR), the European network 'Safety in the Game Meat Chain' (COST Action 22166, 2023-2027) promotes the exchange of knowledge regarding the health risks associated with game meat from hunted animals for consumers. The main aim and objective of the Action is to determine differences and similarities between European countries in terms of hunting practices, game meat processing and inspection, legislation, game meat commodity flows, trade and game meat consumption, investigating all stages of the supply chain from the wild animal to the consumer, "from forest to fork". The growing network currently includes around 200 members from 40 countries, encompassing EU and non-EU member states.

www.safegamemeat.eu