Food Safety in Focus: BfR Research from the Hunt to the Plate

Part II

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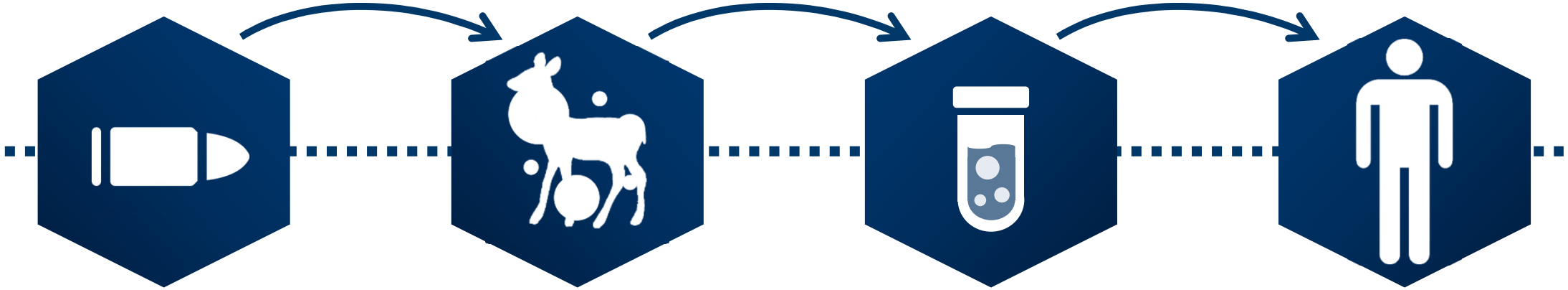
Introduction

- Analysis of number, size and spatial distribution of lead containing bullet fragments in game meat using computed tomography
- Food safety implications of metals from bullet fragments in game meat: An investigation on gastrointestinal solubility
- Bioavailability of lead - influence of kitchen preparation
- COST Action SafeGameMeat (CA22166)

Background



Bullet composition

Bullet fragments in game animals

Particle solubility and availibility

Exposure assessment

Icons – flaticon.com

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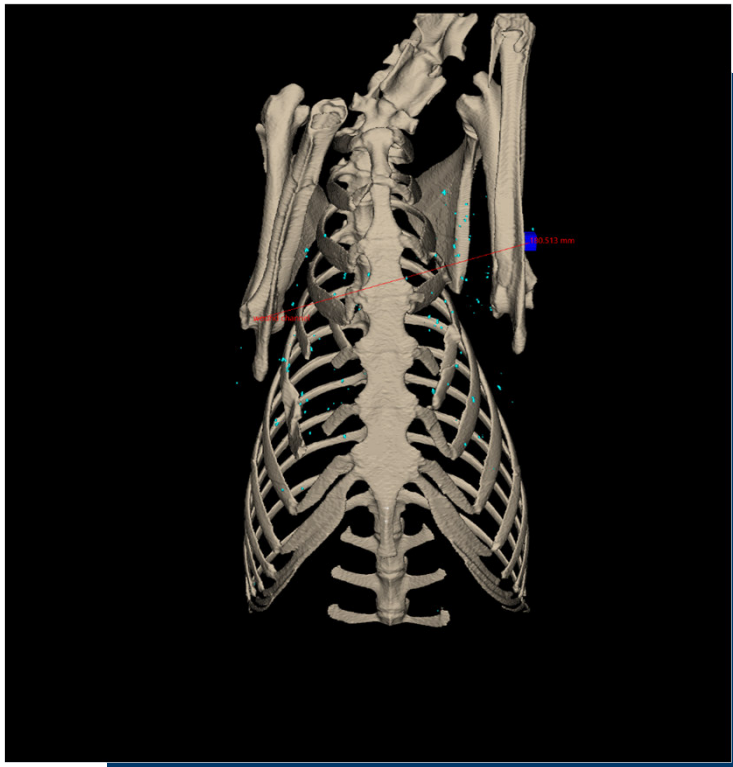
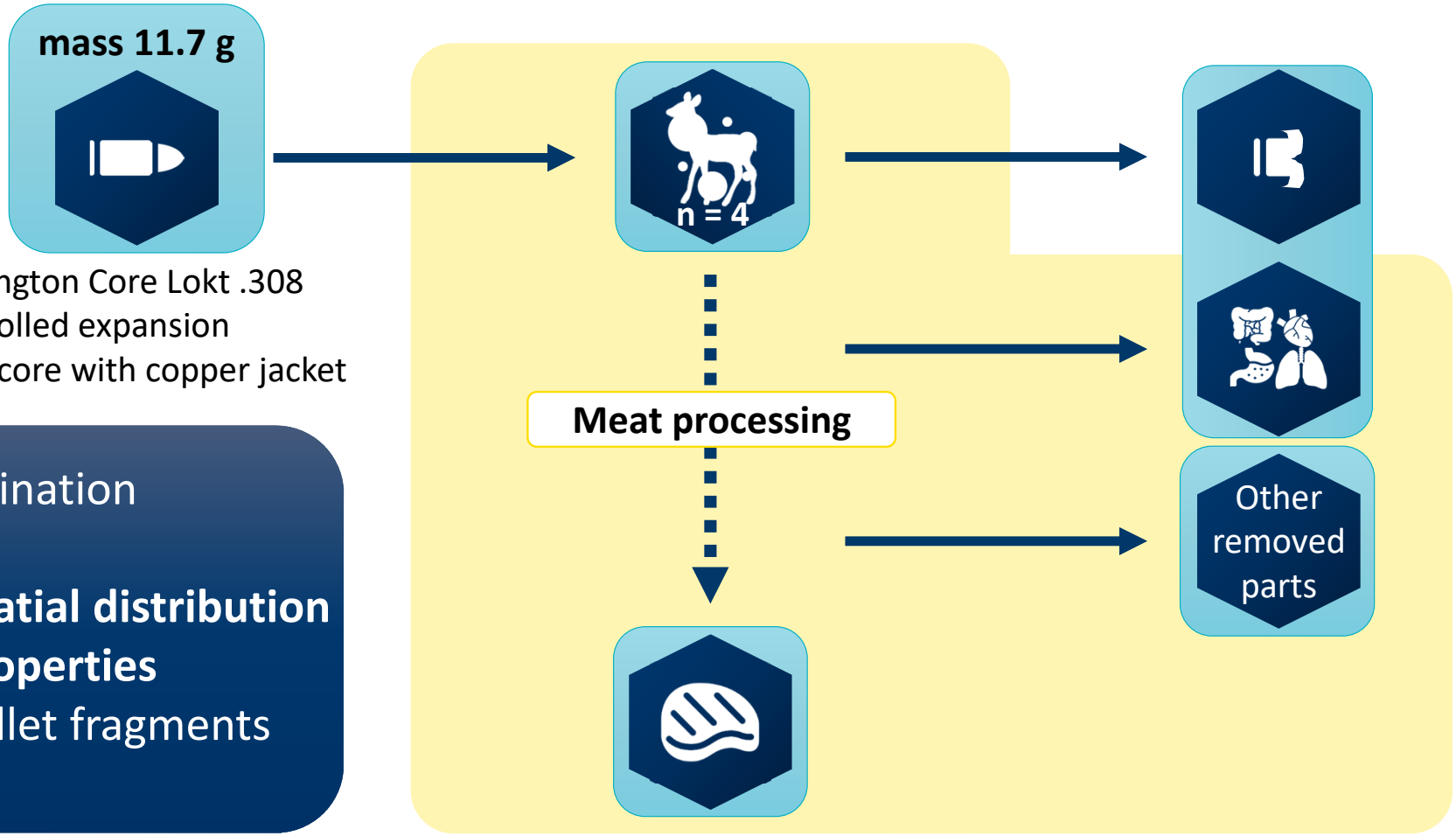
Analysis of number, size and spatial distribution of lead containing bullet fragments in game meat using computed tomography

Haase et al. 2023 (Discover Food): “Analysis of number, size and spatial distribution of rifle bullet-derived lead fragments in hunted roe deer using computed tomography”



3D-reconstruction of a roe deer shot with lead-based ammunition, Haase et al. 2023

Study design – Bullet fragments in game animals



Remington Core Lokt .308
controlled expansion
Lead core with copper jacket

Aim

Determination

- **of spatial distribution**
- **of properties**
  of bullet fragments

Haase et al. 2024

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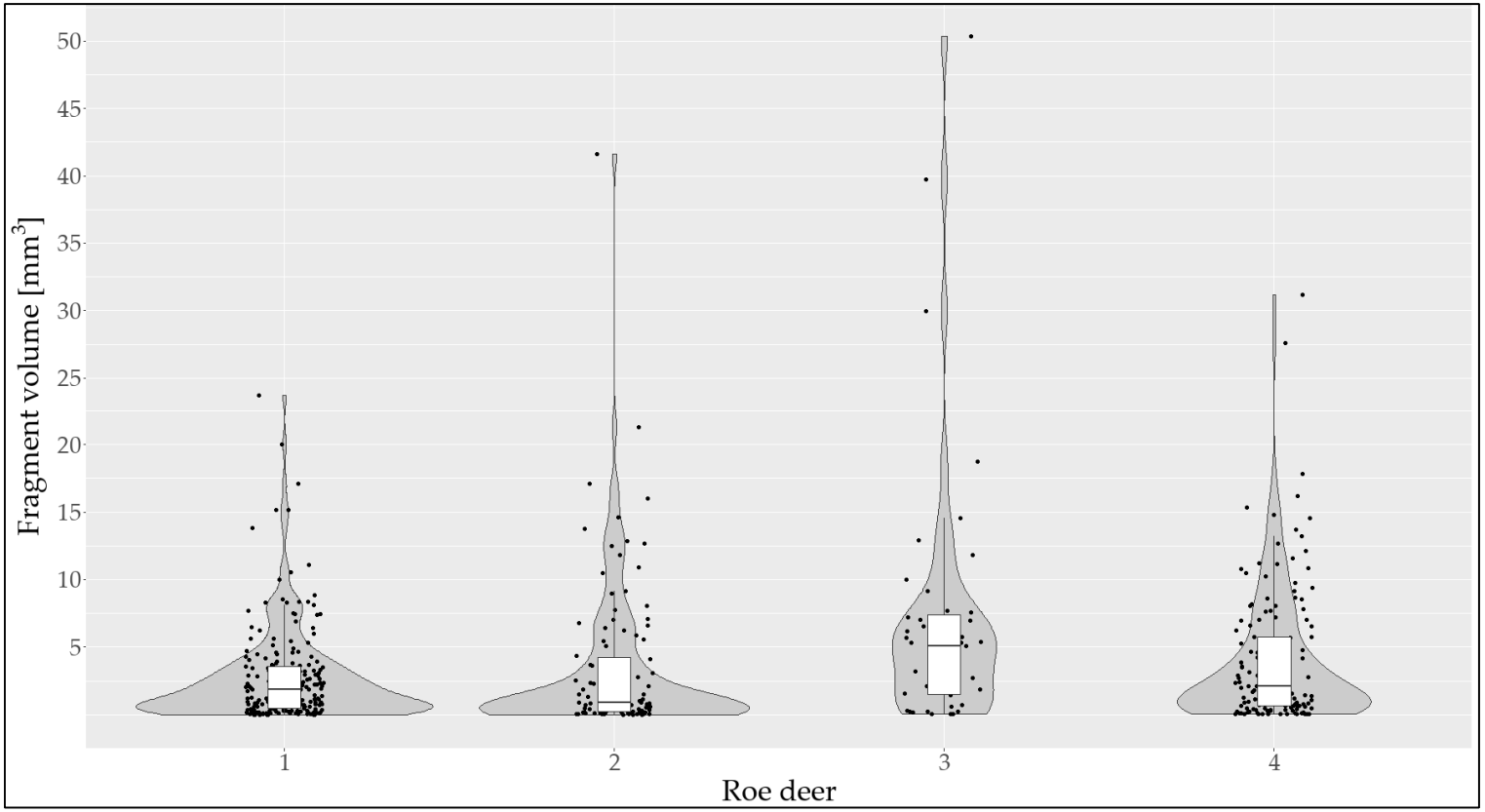
Results – Size of fragments in animal bodies



- Mean volume 3.71±5.49 mm^3
- 40% of fragments < 1 mm^3
- Lower size detection limit 0.01 mm^3
- Kollander et al. 2017: 40-750 nm in game meat (sp-ICP-MS)
- Leontowich et al. 2022: <10 µm in gelatin (synchrotron X-ray)

Haase et al. 2023

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Results – Number of fragments during meat processing

in processed parts and removed tissues

Data Set		Fragment Numbers			
Processed Part	**Removed Tissues**	**Roe deer 1**	**Roe deer 2**	**Roe deer 3**	**Roe deer 4**
Animal Body (A.0)		199	107	43	152
Carcass (B.0)		77	22	20	11
	Thoracic Organs (B.1)	74	66	12	69
	Abdominal Organs (B.2)	5	9	6	41
Trimmed Carcass (C.0)		8	1	14	2
	Trimmings (C.1)	101	27	7	14
Skinned Torso (D.0)		3	0	1	2
	Skin, Head and Legs (D.1)	4	0	12	0
Edible Parts (E.0)		3	0	1	2
	Non-Edible Tissues (E.1)	0	0	0	0

Haase et al. 2023

Shoulder n = 3, Ribs n = 2, Haunch n = 1

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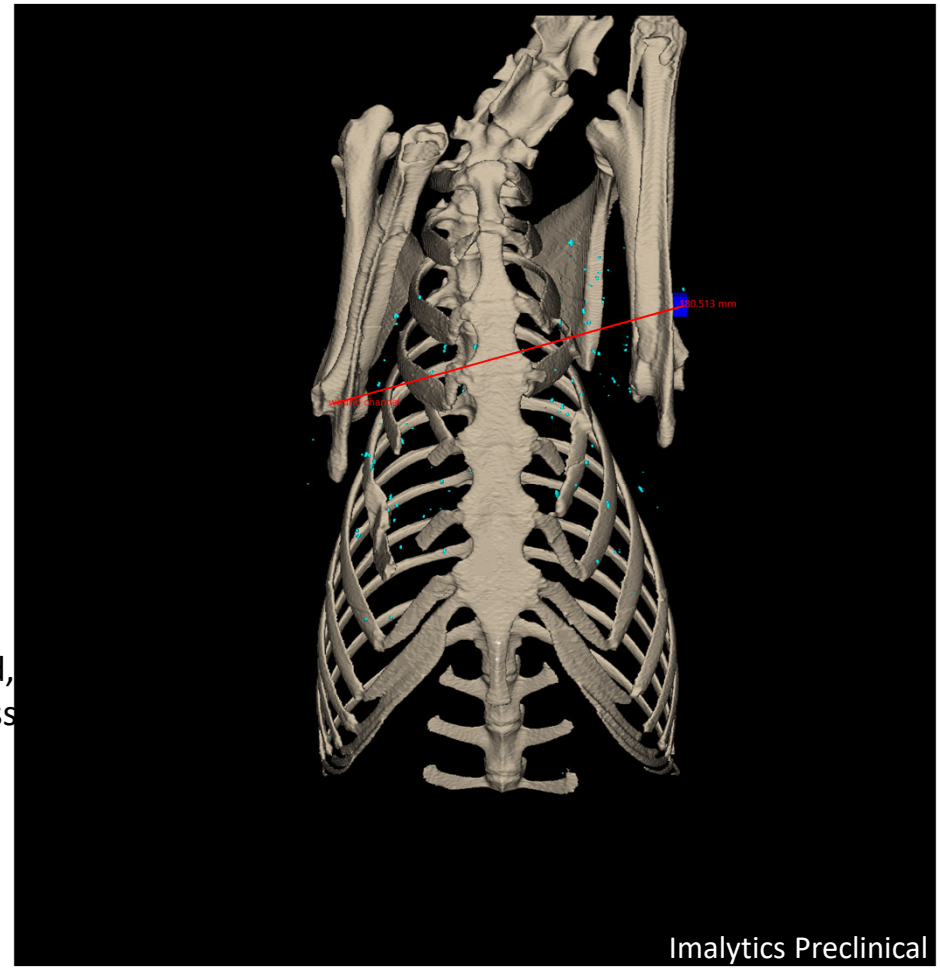
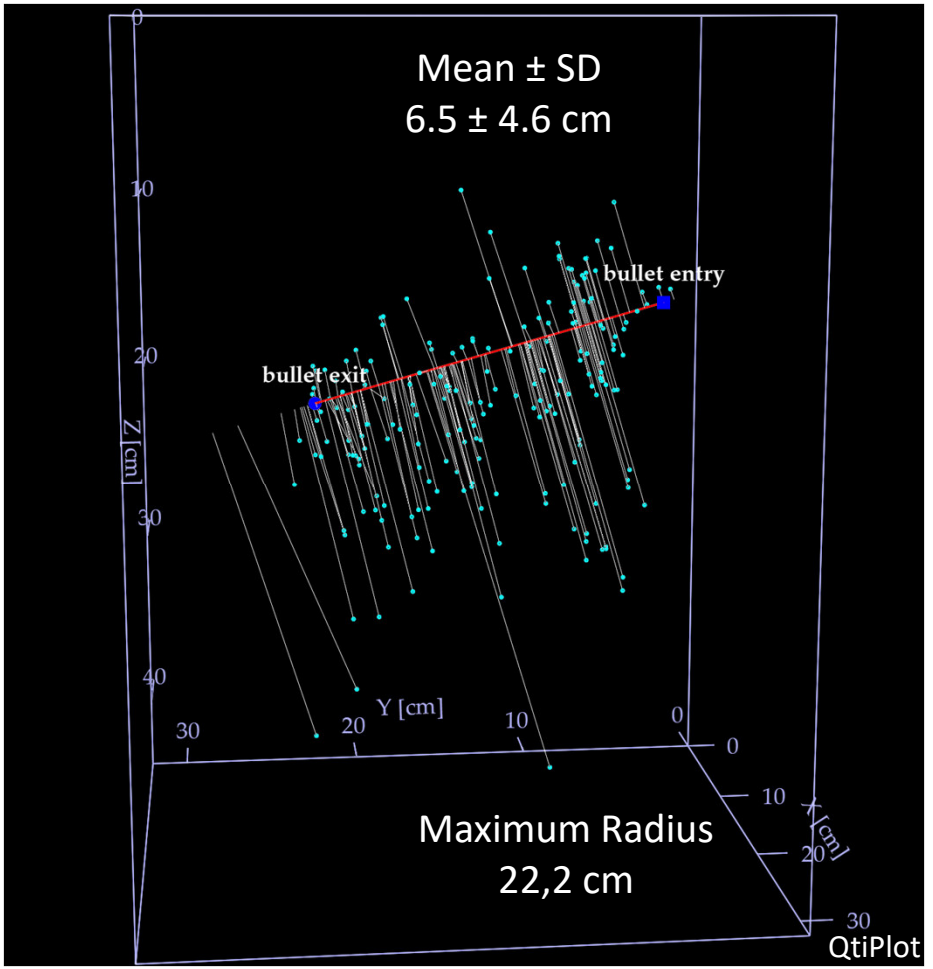
Results – Spatial distribution of fragments in roe deer bodies

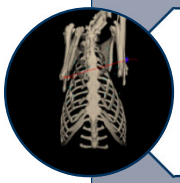
Haase et al. 2023

- Skeleton (thorax, spine, front legs)
- Fragments
  a) reconstructed,
  b) center of mass
- Bullet entry
- Bullet exit
- Wound channel





Summary and outlook



Wide distribution in animal body

Edible parts can contain fragments

Recommendations to minimise the exposure of game consumers to lead complicated

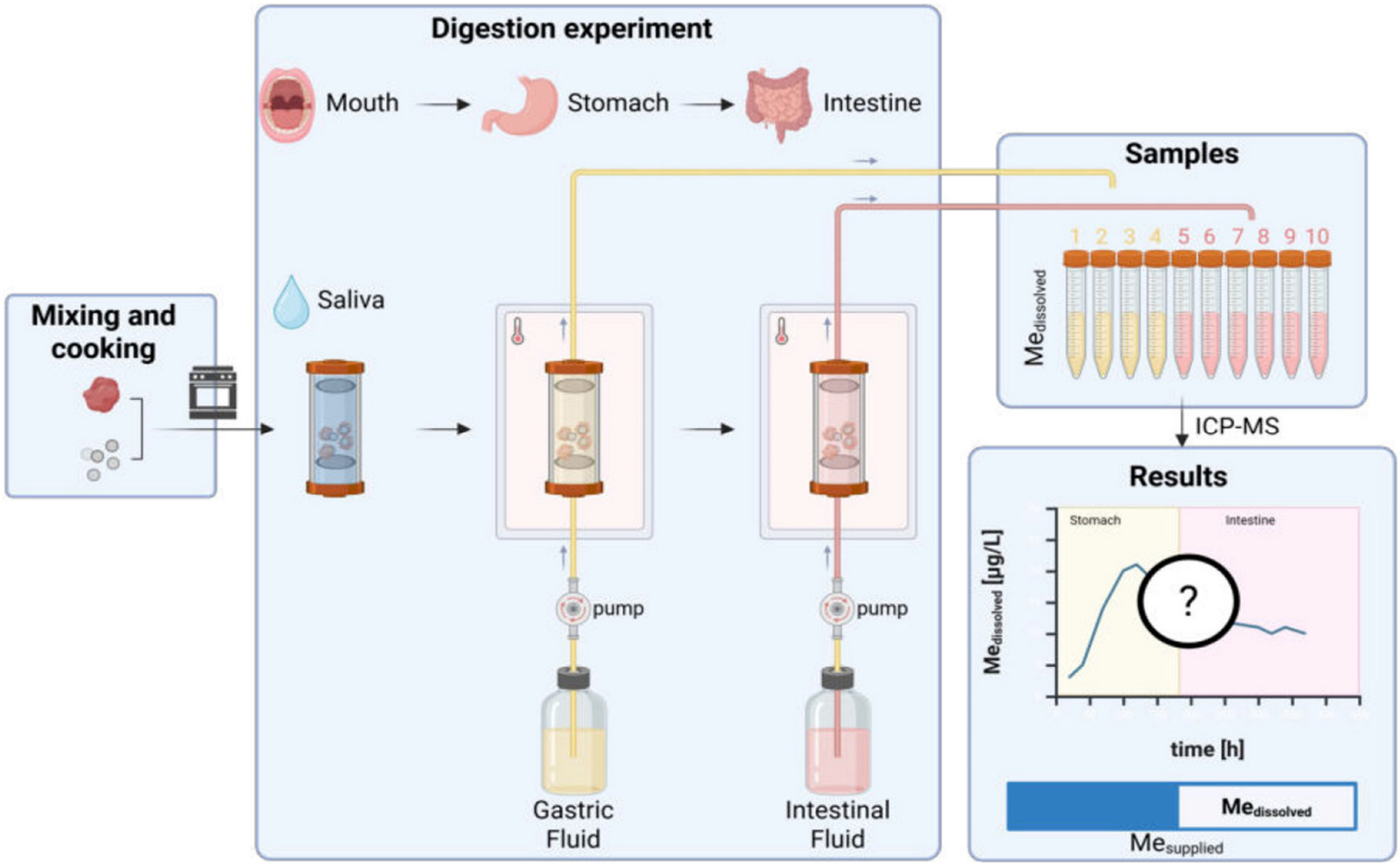
Other measures required to minimize lead exposure

Food safety implications of metals from bullet fragments in game meat: An investigation on gastrointestinal solubility

Haase, A. (2025) Food safety implications of metals from bullet fragments in game meat: An investigation of bullet composition, bullet fragmentation and gastrointestinal solubility. Dissertation Technische Universität Berlin

Fraunhofer IMM

Particle solubility – Overview on dynamic digestion



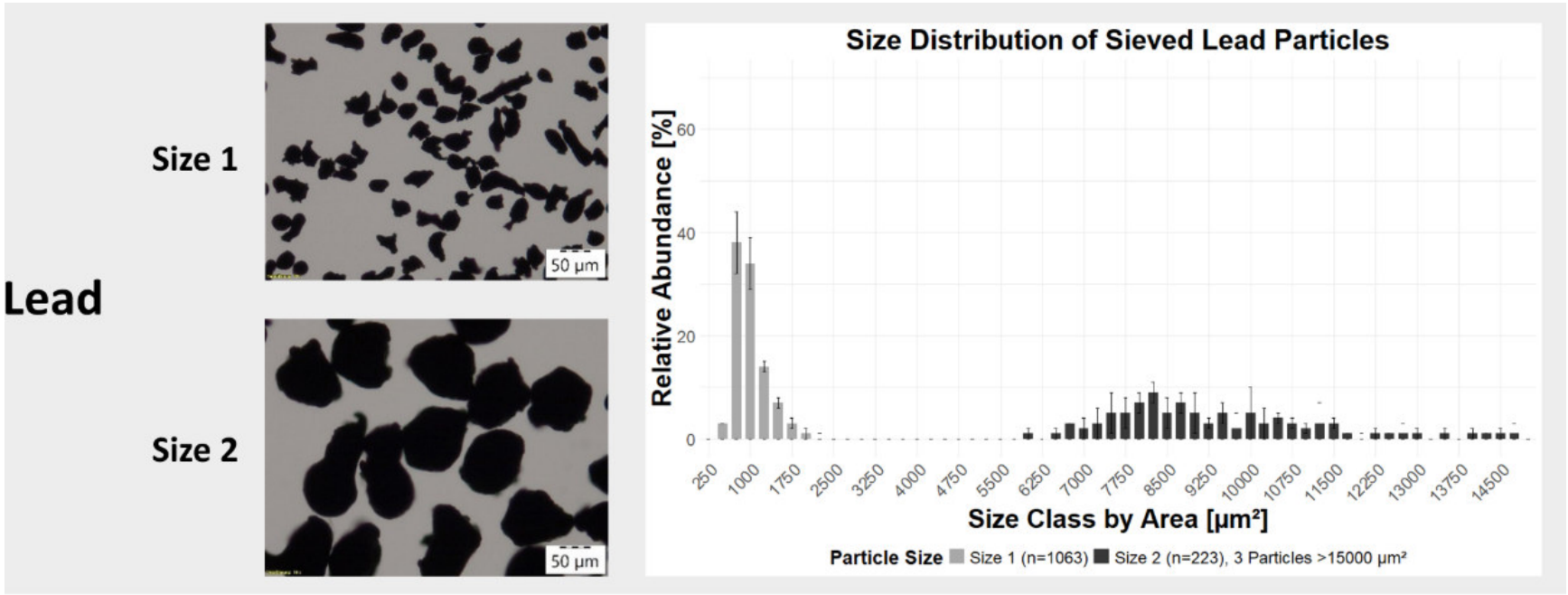
Intestinal fluids according to INFOGEST (Brotkorb et al. 2019)

Hasse (2025). Created in BioRender (https://BioRender.com/w78g750

Microscopic images and histogram of Pb particles in size 1 and 2

Small

26 × 43 µm (875 µm2)

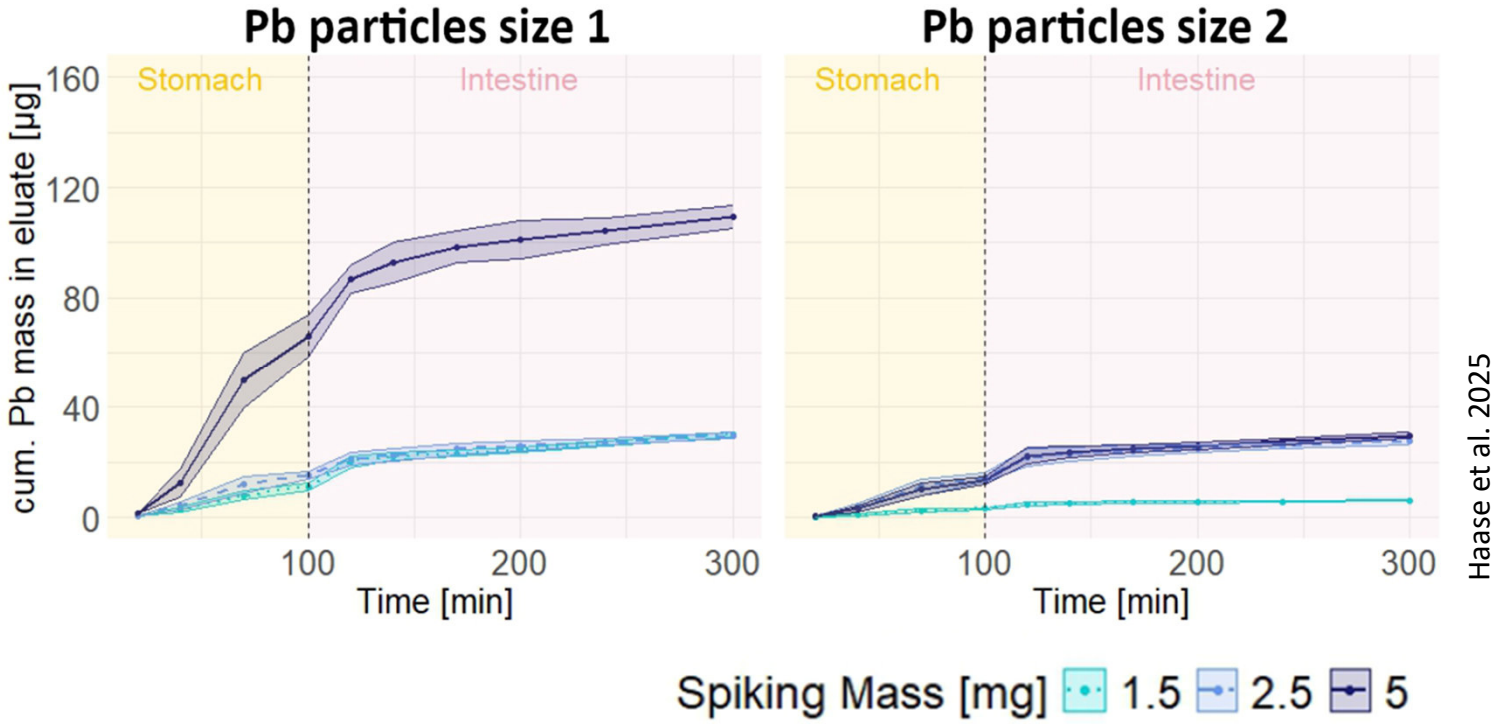


Large

90 × 136 µm (9580 µm2)

Haase et al. 2025

Cumulative Pb release during in vitro gastric and intestinal digestion at different spiking masses.



Haase et al. 2025

Conclusion

- Lead particle solubilization is strongly influenced by particle size and the physicochemical form of Pb.
- Smaller particles exhibited higher Pb solubility, posing a greater potential for gastrointestinal absorption.
- Understanding the solubility and bioaccessibility of lead is essential for assessing potential health risks associated with the consumption of lead residues originating from bullet fragments in game meat.

Fraunhofer IMM

Bioavailability of lead - influence of kitchen preparation

Bundesinstitut für Risikobewertung

Schulz K, Brenneis F, Winterhalter R, Spolders M, Fromme H, Dietrich S, Wolf P, Gremse C, Schafft H, Pieper R, Lahrssen-Wiederholt M. Marination increases the bioavailability of lead in game meat shot with lead ammunition. J Nutr Sci. 2021 Apr 6;10:e24. doi: 10.1017/jns.2021.15. PMID: 33996037; PMCID: PMC8080222.

Kitchen preparation

Preparation of feeding portions for the feeding trial with pigs

- Marinaded meat (*pickle*): ¼ litre cider vinegar, ½ litre red wine, ½ litre water, marinated for 24 hours at +7°C
- Roasted meat
- Homogenization of meat and sauce

Schulz et al. 2021

Fotos: Bundesinstitut für Risikobewertung

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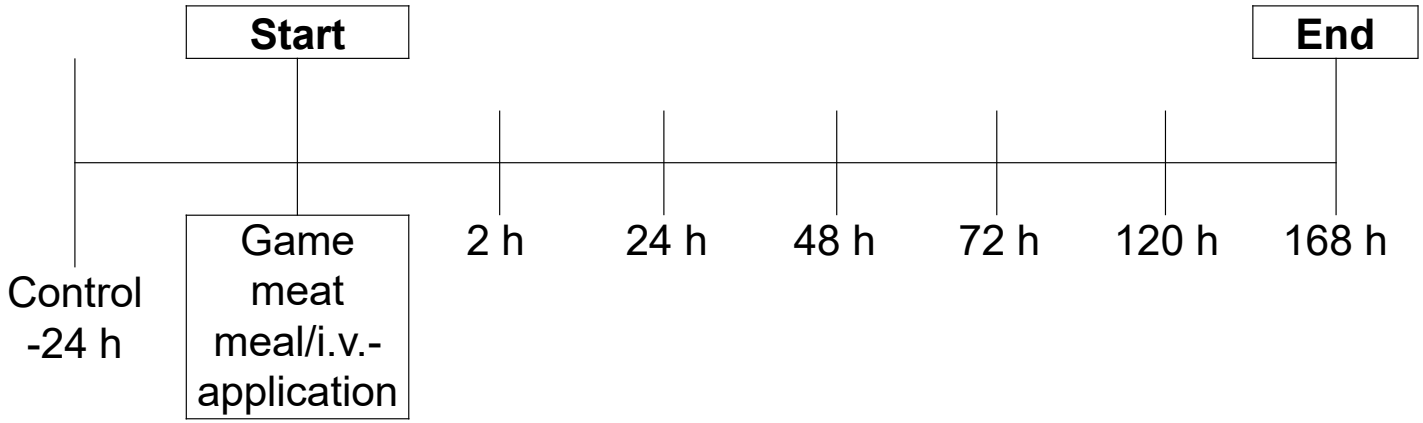
Blood sampling & Calculations



Statistical analysis via IBM SPSS Statistics 21

- Multivariate Linear Model
- normal distribution test: Kolmogorov–Smirnov test
- significance level: $P < 0.05$

The area under the curve (AUC) was calculated using the linear trapezoidal rule:

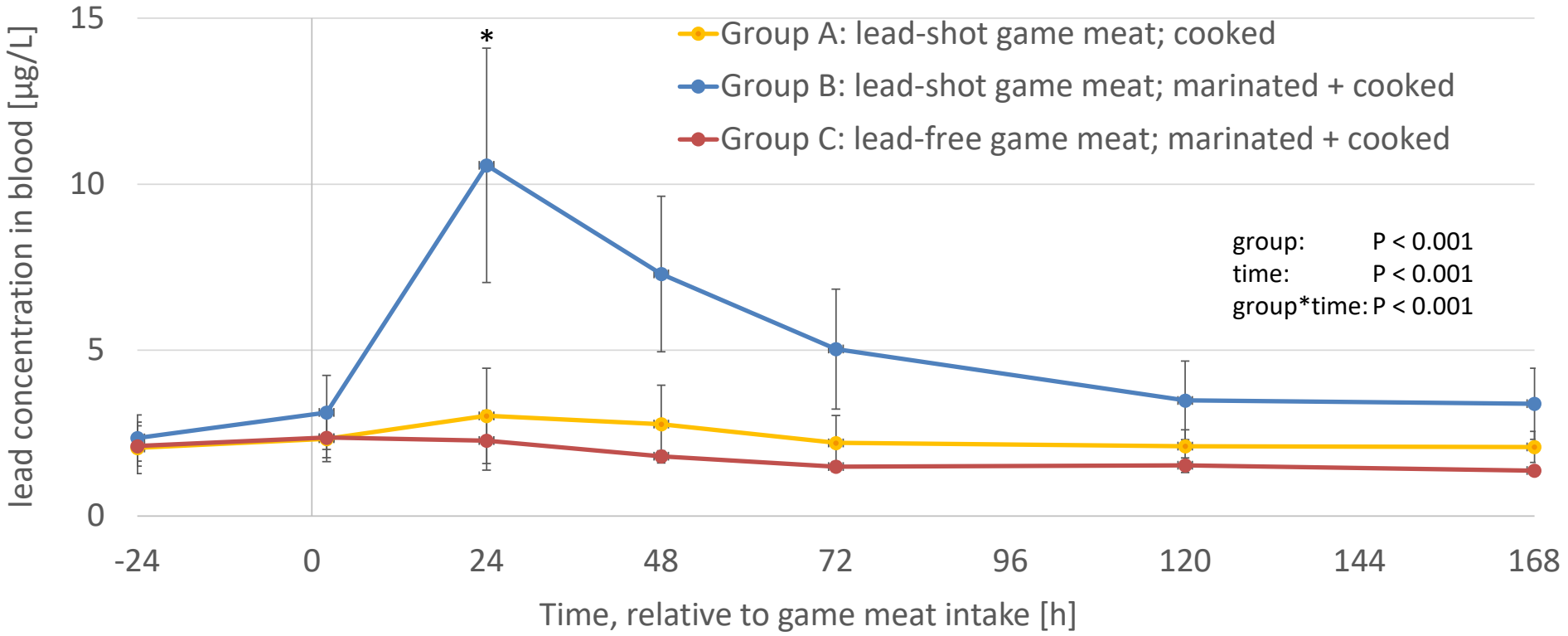
$$AUC = \sum_{n=1}^{N} \frac{C_n + C_{n+1}}{2}(t_{n+1} - t_n)$$

The absolute bioavailability F was calculated:

$$f = \frac{AUC_{post\ oral} * Dosis_{i.v.}}{AUC_{i.v.} * Dosis_{post\ oral}} * 100$$

Schulz et al. 2021

Results – Blood concentrations of Feeding groups (mean ± SD)



Schulz et al. 2021

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Conclusion

- Residues of ammunition lead are bioavailable
- Acidic marination increases bioavailability of lead
- Use of leadfree hunting ammunition has to be preferred in the light of consumer prodection

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Thank you

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Bundling expertise and knowledge

Safe Game Meat

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Safety in the Game Meat Chain COST Action (SafeGameMeat) CA22166

Game meat chain in Europe

About 7 million hunters in Europe (www.face.eu)

Game meat chain differs significantly from that of livestock meat

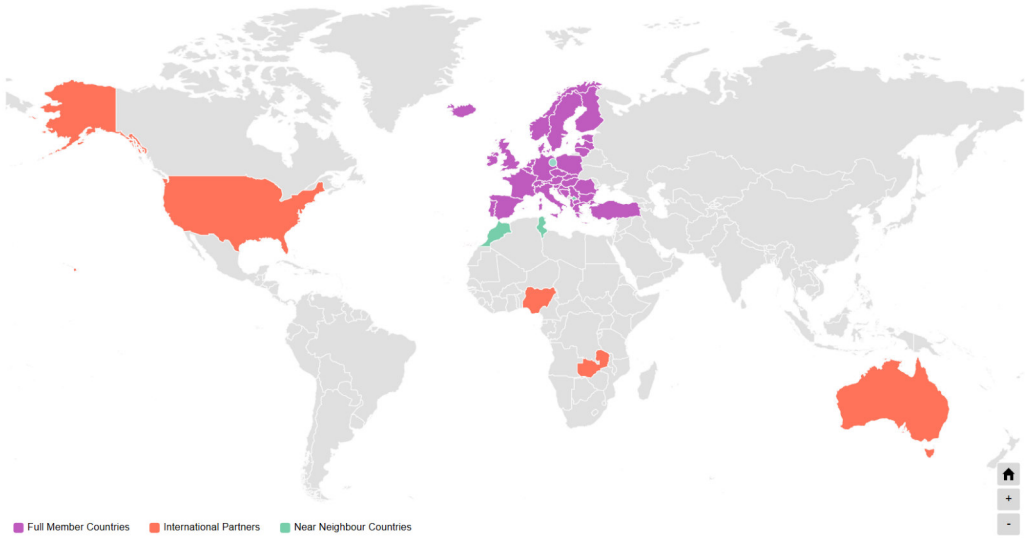
- Primary production done by private persons
- Dominated by traditions, rituals and personal preferences of hunters
- Numerous meat-producing game species

Image sources: wikipedia.org

COST Action SafeGameMeat (CA22166)

Main aim

- To establish a (long-lasting) network of experts.
- To promote and harmonize food safety standards in a growing European game mea market.

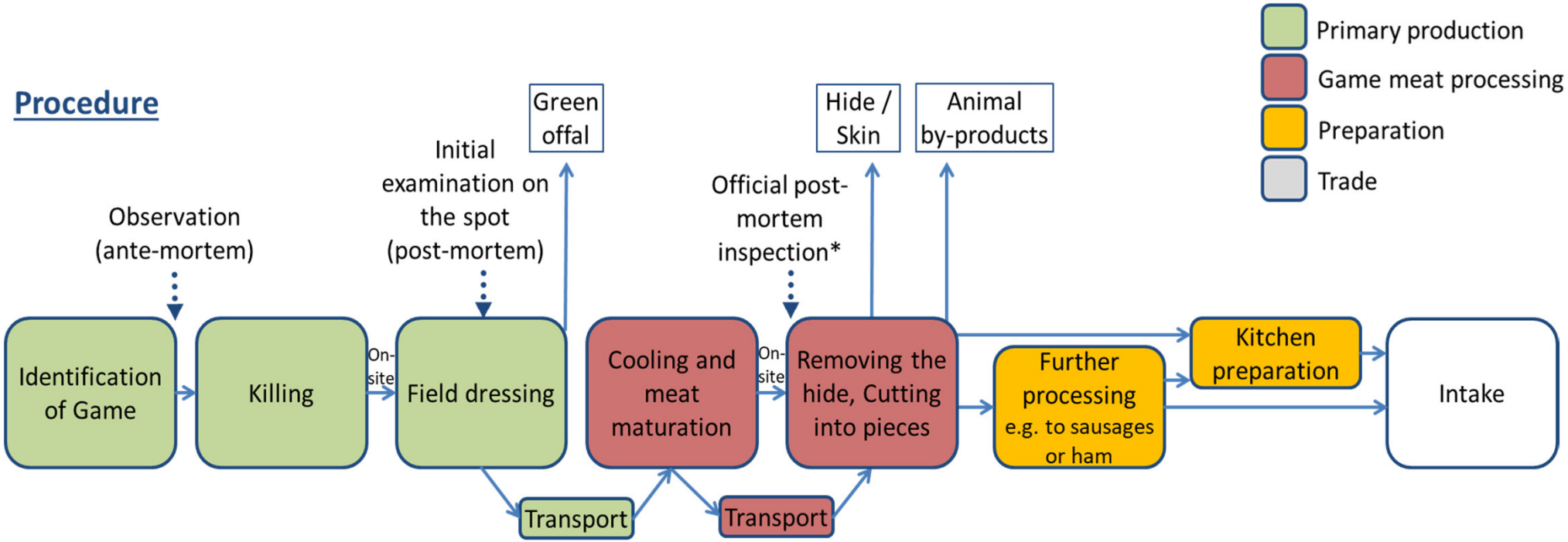


Start	**29th September 2023**
Duration	**4 years**
Currently	**221 members from 47 countries**
Budget	**about 700 000 Euros**

- Gender balance
- Inclusiveness Target Countries (ITC)
- Young Researchers and Innovators (YRI)

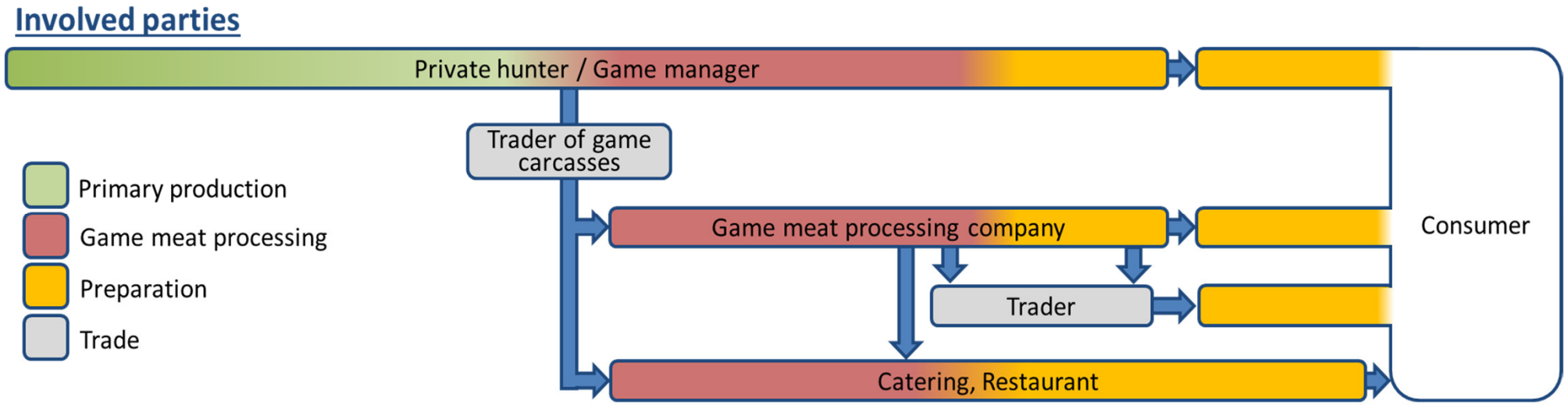
The game meat chain

product flows in Europe

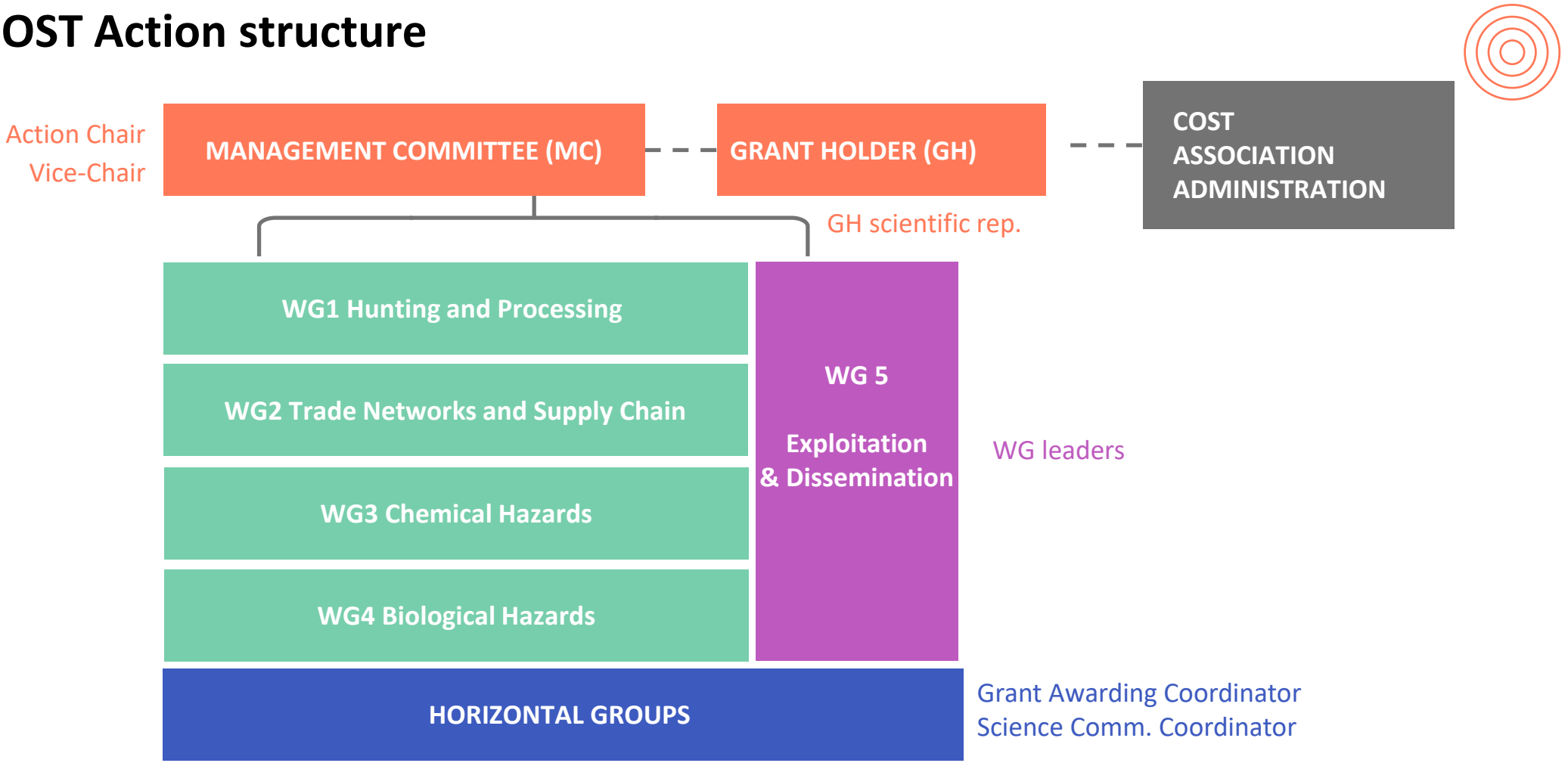


The game meat chain

product flows in Europe and parties involved



COST Action structure



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