Journal of Consumer Protection and Food Safety (2023) 18:199–204
https://doi.org/10.1007/s00003-023-01417-0

Journal of Consumer Protection and Food Safety
Journal für Verbraucherschutz und Lebensmittelsicherheit

SHORT COMMUNICATION

Microbiological investigation on the effect of rinsing of intentionally soiled roe deer carcasses

Birsen Korkmaz[1] · Rafael Hernán Mateus-Vargas[1] · Denny Maaz[1,2] · Felix Reich[1] · Niels Bandick[1] · Monika Lahrssen-Wiederholt[1] · Julia Steinhoff-Wagner[1,3]

Received: 16 November 2022 / Revised: 11 January 2023 / Accepted: 25 January 2023 / Published online: 2 March 2023

Abstract
Reduction of the microbial load of soiled carcasses is essential in the production of game meat. Rinsing with water is a common practice in handling game carcasses to remove any visible contamination. In this study, microbiological investigations were performed on carcasses of roe deer (*Capreolus capreolus*), inoculated with a mixture of gastrointestinal content and then either rinsed (n = 3) or unrinsed (n = 3). Water rinsing may have short-term effects on bacterial contamination related to soiling. However, introducing water into the body cavity may promote bacterial growth during cold storage.

Keywords Game meat · Microbial contamination · Gastrointestinal content · Water washing · Soiled carcasses

1 Introduction

In contrast to livestock meat production, several uncontrollable factors influence the microbiological quality of game meat products at the primary production stage. Disregarding the level of influence of natural conditions, factors such as damage to the abdominal area or an inadequate evisceration technique affect the microbial load (ML) of the muscle surfaces (Branciari et al. 2020; Mirceta et al. 2017). In the field, the presence of soiling is one of the most noticeable indications of the unsuccessful shot or inadequate evisceration practice (Avagnina et al. 2012; Paulsen and Winkelmayer 2004). Nevertheless, carcasses that are visually clean may also contain relevant MLs (Korkmaz et al. 2022a; Paulsen and Schopf 2016; Paulsen et al. 2022). Rinsing with water is one of the most recommended corrective measures to reduce the visible soiling of carcasses as well as the resulting ML (Deutz 2014). As previously discussed for roe deer shot by certified hunters in Germany, rinsing with drinking water at ambient temperature was not always effective, and the corresponding reduction of the ML was not always reproducible (Korkmaz et al. 2022a). The latter is partly due to the fact that the initial ML of surfaces of roe deer's abdominal cavity (belly flap or fillet) was not always visibly associated with soiling. Thus, this incongruence impeded a clear statement on the effectiveness of rinsing on the ML reduction of soiled roe deer carcasses (Korkmaz et al. 2022a). In this study, we aimed to assess the effect of water rinsing on the ML of carcasses directly at harvesting in the field, with a limited set of samples. By experimentally soiling with gastrointestinal content (GIC), we intended to reproduce similar MLs for the rinsed and the unrinsed carcasses. And thus, eliminating this confounder and achieving comparability of ML values prior to treatment at a single hunting day with its particular weather conditions.

2 Results and discussion

Using deliberate contamination of the roe deer body cavities with a freshly prepared mixture of GIC, we intended to standardize the initial microbial conditions of body cavities to better elucidate the impact of rinsing on the ML

Birsen Korkmaz, Rafael Mateus-Vargas have contributed equally to this work.

✉ Birsen Korkmaz
birsen.m.korkmaz@gmail.com

[1] German Federal Institute for Risk Assessment (BfR), Max-Dohrn-Str. 8-10, 10589 Berlin, Germany

[2] Berlin-Brandenburg State Laboratory, Gerhard-Neumann-Straße 2, 15236 Frankfurt (Oder), Germany

[3] School of Life Sciences, Technical University of Munich (TUM), Liesel-Beckmann-Str. 2, 85354 Freising-Weihenstephan, Germany

of game carcasses. Experiments were conducted directly in the hunting ground using freshly shot carcasses under field conditions. Table 1 shows an overview of the basic experimental conditions of each trial. In the context of the practical focus of the experiments, some ambient as well as individual factors could not be controlled, and consequently differed between trials (Table 1). Since ambient temperature, have been described to affect the microbiological quality of game carcasses during the harvesting (Korkmaz et al. 2022b; Paulsen and Winkelmayer 2004; Branciari et al. 2020), the comparing of rinsed and unrinsed carcasses were evaluated separately within each trial. Further influencing factors such as body weight, elapsed time between shot and evisceration of the animals, and the time between the evisceration and the further processing (Korkmaz et al. 2022b; Paulsen and Winkelmayer 2004; Paulsen et al. 2022) are additional challenges for the interpretation of the outcome of the experiments. Despite the low number of carcasses and the different conditions between the hunts for the microbial contamination and development, the subsequent inclusion of further animals for experimental soiling was not undertaken for ethical reasons. The number of animals was also chosen based on results of a previous study, where a higher sample number did not allow further insights on the microbiological effects of rinsing soiled body cavities (Korkmaz et al. 2022a). Nevertheless, we stress that the practical context of this study as well as the use of 2 different muscle surfaces bring valuable results. We obtained baseline data in the field for a basic measure of hygiene that is important for hunters and stakeholders alike. It could be a critical point in the primary production chain of game meat.

In accordance with previous reports (Korkmaz et al. 2022a; Paulsen and Schopf 2016), the ML of visually clean body cavities considerably differed prior to soiling both between and within the trials. The bacteriological load on the surface samples for every trial are presented in Fig. 1. According to an investigation of Paulsen et al. (2022) in 352 hunted roe deer, bacterial counts of clean body cavities can differ considerably between animals even without perforation of structures of the gastrointestinal tract. As expected, sampling before soiling (BS) vs. sampling after soiling (AS) resulted in a general increase of the ML in belly flaps and fillets of soiled carcasses (Fig. 1). The increase in bacterial counts occurred independently from the initial ML and with single exceptions for the *Enterobacteriaceae* and *E. coli*. However, the level of increased ML differed between trials, which may be related to the different bacterial composition of GIC mixtures. In trial 1 and 2, the bacterial load in the mixture ranged from 4.3 to 7.1 $\log_{10}$ CFU/g for the total aerobic colony count (TAC), from 3.7 to 4.4 $\log_{10}$ CFU/g for *Pseudomonas* spp., from 2.5 to 4.2 $\log_{10}$ CFU/g for *Lactobacillus* spp., and from 2.5 to 4.7 $\log_{10}$ CFU/g for *Enterobacteriaceae*. *E. coli* was either below the limit of detection or reached counts of 4.7 $\log_{10}$ CFU/g. Due to technical issues, data of trial 3 was not considered. Although, the proportions of the GIC for preparation of the mixture was comparable between trials, divergence on bacterial content of the mixtures may have occurred due to differences in the microbial content in the segments of the gastrointestinal tract, and may explain the apparent incongruences BS to AS in unrinsed carcasses, especially for both fecal indicators (Fig. 1). The microbial communities may differ between the sections of the gastrointestinal tract as well as between the studied roe deer individuals (Li et al. 2014), which may be influenced by the diet composition in different habitats (König et al. 2020; Liu et al. 2019).

Rinsing soiled belly flap surfaces consistently reduced the TAC as well as the *Pseudomonas* spp. count to a level similar to or lower than the initial ML, as determined by sampling 20 min after rinsing (Fig. 1). However, the effects of rinsing were incongruent between trials for *Lactobacillus* spp., *Enterobacteriaceae*, and *E. coli* on the same surfaces. In contrast to belly flaps and with one exception for *E. coli* (trial 1), the ML on rinsed fillet surfaces remained above the initial bacterial counts, with a maximal difference of 1.40 $\log_{10}$ CFU/cm^2 observed for *Lactobacillus* spp. in trial 1 (Fig. 1). Differences on the effect of rinsing are possibly due to the more irregular surface of fillets compared to belly flaps after field evisceration. The irregular surface may have promoted bacterial attachment and consequently reduced the short-term effects of rinsing (Delaquis and Mccurdy 1990; Dickson 1988).

Regarding the MLs after cold storage, bacterial development during 3 days at + 4 °C did not only differ between rinsed and unrinsed body cavities, but also between meat cuts of single animals. While counts for TAC (trial 1 − 3), *Pseudomonas* spp. (trial 2 and 3), *Lactobacillus* spp. (trial 1 and 3) and *Enterobacteriaceae* (trial 1 and 3) considerably increased on the rinsed belly flap surfaces, slight reductions of the TAC (trial 1 and 2), the counts of *Lactobacillus* spp. (trial 1 and 2) as well as the counts of *E. coli* (trial 1 and 2) were observed for rinsed fillets after the storage (Fig. 1). Interestingly, the ML decreased in 2 of 3 unrinsed body cavities, disregarding the meat cuts after the 3-day cold storage, except for the counts of *Pseudomonas* spp. on fillets. Thus, these results support the hypothesis that residual water may promote bacterial growth on meat surfaces (Sofos 2014).

Table 1 Description of natural experimental conditions for inoculated and rinsed (n = 3) or unrinsed (n = 3) roe deer carcasses at each trial

Trial no	Carcass no	Sex	Body weight (kg[a])	Time (min[b])	Water volume (ml[c])	Temperature (°C)					pH			
						Ambient	Pelvis[d]		Back[e]		Pelvis[d]		Back[e]	
							At hunting day	After cold storage	At hunting day	After cold storage	At hunting day	After cold storage	At hunting day	After cold storage
1	1[f]	Male	11	145	1680	11	33	7	28	6	6.7	6.4	5.8	6.2
	2	Female	18	180	–		27	4	28	4	5.5	5.8	5.5	6.0
2	3	Female	9	75	1840	0	20	3	19	2	5.7	5.7	5.5	5.6
	4	Male	13	150	–		14	4	10	2	5.5	5.7	5.5	5.9
3	5	Male	14	240	7200	6	34	5	29	5	5.6	5.8	5.7	5.7
	6	Female	12	45	–		19	5	19	5	5.8	6.1	5.7	6.0

[a]After evisceration of the carcass

[b]Elapsed between killing and evisceration

[c]Used for rinsing the carcass

[d]Temperature or pH measured in the muscle close to the pelvis

[e]Temperature or pH measured in the muscle between the 13th and 14th spinous process of the thoracic spine

[f]Eviscerated without opening the pelvis, all other carcasses were eviscerated with opening pelvis

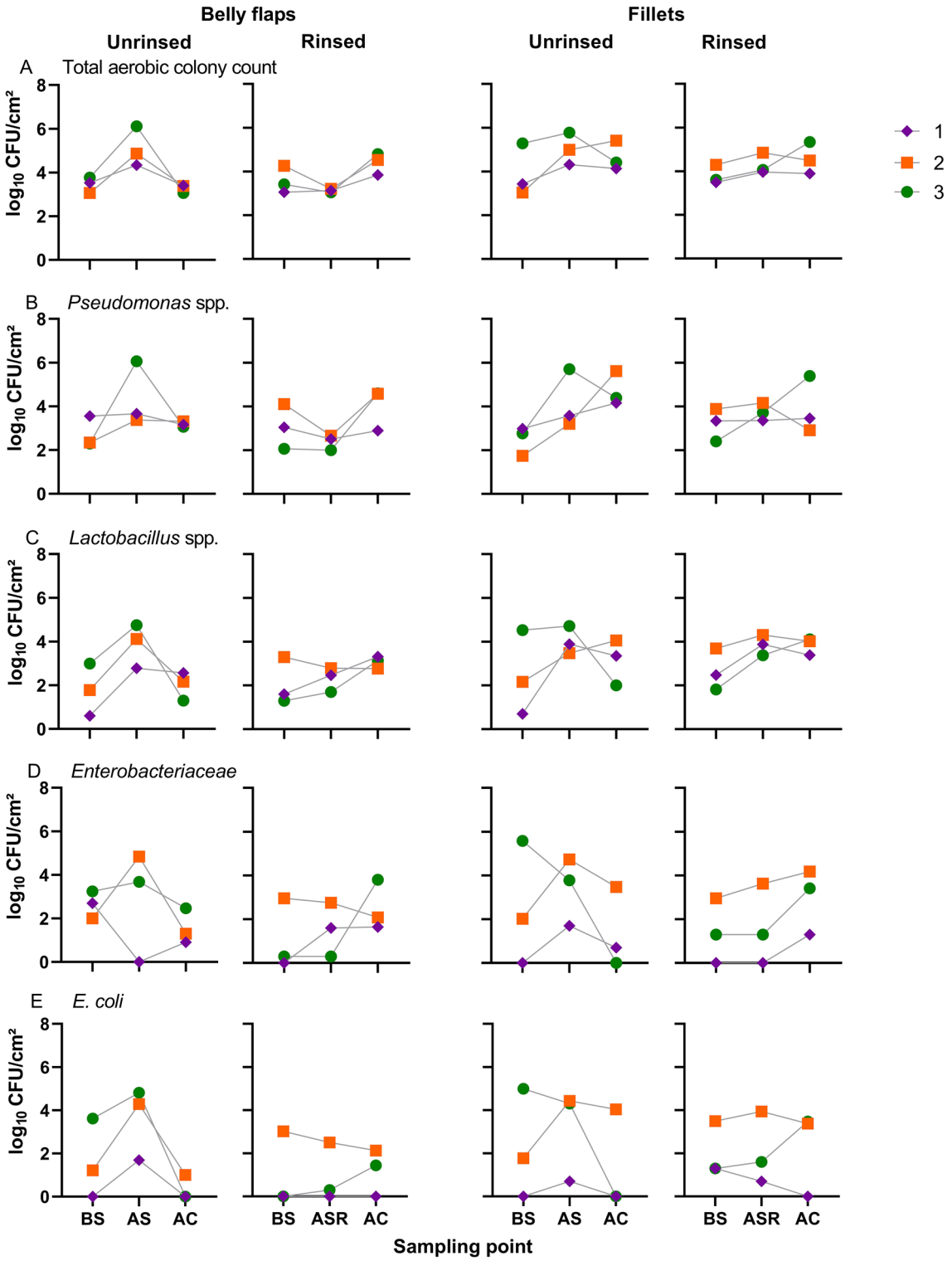

Fig. 1 Bacterial counts determined on rinsed and unrinsed meat surface of roe deer body cavities that were intentionally soiled with GIC mixture in 3 different experimental trials (1 – 3). Total aerobic colony count (**A**), *Pseudomonas* spp. (**B**), *Lactobacillus* spp. (**C**), *Enterobacteriaceae* (**D**), *E. coli* (**E**). Sampling was performed before soiling (BS), after soiling (AS) or after soiling and rinsing (ASR), and after cold storage for 3 days at + 4 °C (AC). The values are presented for individual carcasses; values below the limit of detection are given as 0

3 Conclusions

In conclusion, the microbiological investigation after this experimental approach showed that rinsing of soiled roe deer body cavities may acutely reduce the bacterial load directly caused by fresh soiling under field conditions. However, rinsing with water may further facilitate the growth of remaining bacteria during cold storage. Further experimental studies are required to better understand the effects of rinsing on the shelf life of game meat under different storage temperatures. Based on this and previous observations (Korkmaz et al. 2022a) as well as considering ethical issues, soiling complete body cavities should be avoided in future studies, since the practice compromises the hygienic quality of the whole carcass and the obtained information is limited. Instead, similar to previous studies that examined the effect of washing meat from slaughtered animals (Castillo et al. 1998), future studies should rather use meat cuts of game carcasses including muscles with different surface characteristics and perform them under controlled laboratory conditions. Because there, potential influencing factors such as bacterial contamination load, rinsing regime or temperature can be modulated. This may also permit i.e. the examination of hot water rinsing, which was reported to reduce bacterial counts on livestock carcasses (Bosilevac et al. 2006). Overall, regardless of whether a carcass is visually clean or whether rinsing successfully removed visual soiling, all game products should be cooked to a core temperature of 70 °C for at least 2 min prior consumption.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s00003-023-01417-0.

Acknowledgements The authors sincerely thank the German Institute for Federal Real Estate (BImA), the German Federal Forest Service, the hunting districts of the state forest of Brandenburg, and each individual hunter for their significant support in obtaining the roe deer carcasses for this project. Furthermore, the authors would like to sincerely thank Jorge Numata for proofreading this paper.

Funding Open Access funding enabled and organized by Projekt DEAL. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. This study was funded by the core budget of the German Federal Institute for Risk Assessment (BfR-SiN-1322-702).

Declarations

Conflict of interest The authors declare that they have no conflict of interest.

References

Avagnina A, Nucera D, Grassi MA, Ferroglio E, Dalmasso A, Civera T (2012) The microbiological conditions of carcasses from large game animals in Italy. Meat Sci 91(3):266–271. https://doi.org/10.1016/j.meatsci.2012.01.025

Bosilevac JM, Nou X, Barkocy-Gallagher GA, Arthur TM, Koohmaraie M (2006) Treatments using hot water instead of lactic acid reduce levels of aerobic bacteria and enterobacteriaceae and reduce the prevalence of escherichia coli O157:H7 on Preevisceration beef carcasses. J Food Prot 69(8):1808–1813. https://doi.org/10.4315/0362-028X-69.8.1808

Branciari R, Onofri A, Cambiotti F, Ranucci D (2020) Effects of animal, climatic, hunting and handling conditions on the hygienic characteristics of hunted roe doer (*Caprelous capreolus* L.). Foods 9(8):1076. https://doi.org/10.3390/foods9081076

Castillo A, Lucia LM, Goodson KJ, Savell JW, Acuff GR (1998) Comparison of water wash, trimming, and combined hot water and lactic acid treatments for reducing bacteria of fecal origin on beef carcasses. J Food Prot 61(7):823–828. https://doi.org/10.4315/0362-028X-61.7.823

Delaquis PJ, Mccurdy AR (1990) Colonization of beef muscle surfaces by *Pseudomonas fluorescens* and *Pseudomonas fragi*. J Food Sci 55(4):898–902. https://doi.org/10.1111/j.1365-2621.1990.tb01560.x

Deutz A (2014) Game meat hygiene under Alpine conditions. In: Paulsen P (ed) Trends in game meat hygiene, From forest to fork. Wagening Academix Publishers, pp 213–222

Dickson JS (1988) Reduction of bacteria attached to meat surfaces by washing with selected compounds. J Food Prot 51(11):869–873. https://doi.org/10.4315/0362-028X-51.11.869

König A, Hudler M, Dahl SA, Bolduan C, Brugger D, Windisch WM (2020) Response of roe deer (*Capreolus capreolus*) to seasonal and local changes in dietary energy content and quality. Anim Prod Sci 60:1315–1325. https://doi.org/10.1071/AN19375

Korkmaz B, Maaz D, Reich F, Gremse C, Haase A, Mateus-Vargas RH, Mader A, Rottenberger I, Schafft HA, Bandick N, Nöckler K, Alter T, Lahrssen-Wiederholt M, Steinhoff-Wagner J (2022b) Cause and effect analysis between influencing factors related to environmental conditions, hunting and handling practices and the initial microbial load of game carcasses. Foods 11(22):3726. https://doi.org/10.3390/foods11223726

Korkmaz B, Reich F, Alter T, Steinhoff-Wagner J, Maaz D, Gremse C, Haase A, Mader A, Schafft HA, Bandick N, Nöckler K, Lahrssen-Wiederholt M (2022a) Microbial load of rinsed and unrinsed body cavities of roe deer (*Capreolus capreolus*) on the killing day and after cold storage: a preliminary investigation. Food Control. https://doi.org/10.1016/j.foodcont.2022b.109141

Li Z, Zhang Z, Xu C, Zhao J, Liu H, Fan Z, Li G (2014) Bacteria and methanogens differ along the gastrointestinal tract of chinese roe deer (*Capreolus pygargus*). PLoS ONE 9(12):e114513. https://doi.org/10.1371/journal.pone.0114513

Liu J, Liang X, Liu Y (2019) Comparison of the gut microbiota composition between captive and wild roe deer. bioRxiv. https://doi.org/10.1101/831222

Mirceta J, Petrovic J, Malesevic M, Blagojevic B, Antic D (2017) Assessment of microbial carcass contamination of hunted

wild boars. Eur J Wildl Res 63(2):37. https://doi.org/10.1007/s10344-017-1096-3

Paulsen P, Schopf E (2016) Wildbrethygiene bei Rehen - Lage der Schusswunden bei Rehen, Bewertung von Verschmutzungen und mikrobielle Belastung der Brust- und Bauchhöhle. Rundschau für Fleischhygiene und Lebensmittelüberwachung 68:431–433

Paulsen P, Winkelmayer R (2004) Seasonal variation in the microbial contamination of game carcasses in an Austrian hunting area. Eur J Wildl Res 50(3):157–159. https://doi.org/10.1007/s10344-004-0054-z

Paulsen P, Smulders F, Kukleci E, Tichy A (2022) Bacterial surface counts and visually assessed cleanliness of carcasses from hunted roe deer (*Capreolus capreolus*). Wiener Tierärztliche Monatsschrift Vet Med Austria. https://doi.org/10.5680/wtm000003

Sofos JN (2014) Chapter 6—meat and meat products. In: Motarjemi Y, Lelieveld H (eds) Food safety management. Academic Press, pp 119–162. https://doi.org/10.1016/B978-0-12-381504-0.00006-8