UNIVERSITÄT LEIPZIG

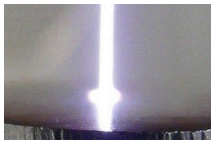
IfLL Institut für Lebensmittelhygiene Leipzig
Gesundes Tier - Gesunder Mensch

Abattoir interventions: novel treatments and non-thermal technologies

RIBMINS WG2/WG3 Virtual Training school, June 21st, 2022

Thiemo Albert, Peggy Braun





AGENDA

1. Introduction
2. Overview of novel/non-thermal technologies
3. Selected technologies and applications
4. Summary and conclusions

AGENDA

1. Introduction
2. Overview of novel/non-thermal technologies
3. Selected technologies and applications
4. Summary and conclusions

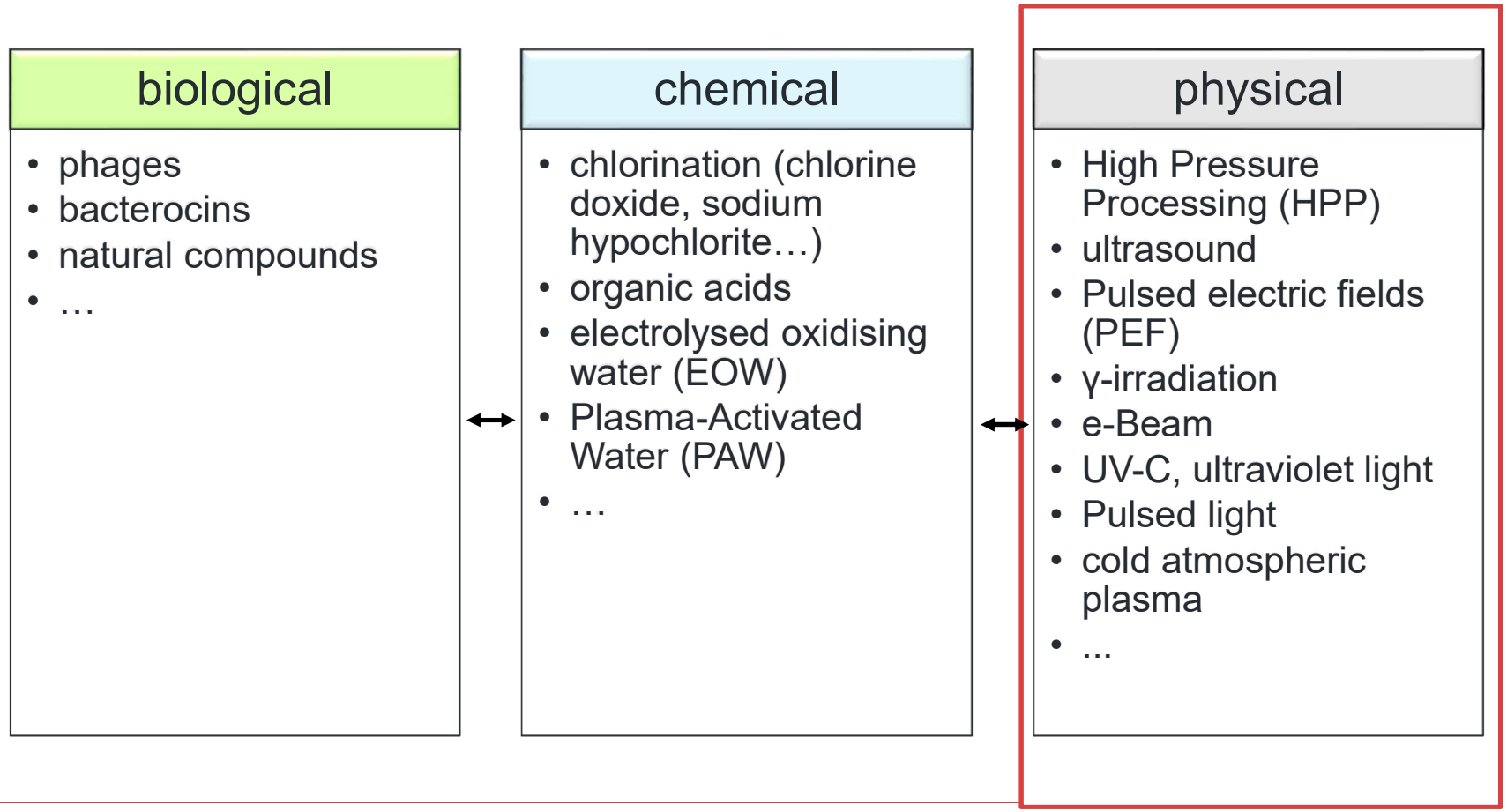
BACKGROUND

- Contamination of poultry, pork or beef carcasses/meat by zoonotic pathogens and spoilage organisms is a challenging problem worldwide.
- Different risk-reduction strategies, mainly at the pre-harvest level, have been applied with varying degrees of success.
- Recent strategies aimed to include the entire processing chain, including transportation, stunning, slaughtering, deboning and further meat processing.
- The impact of non-thermal physical, chemical and biological decontamination technologies has been the subject of many studies.
- Physical methods, which are considered to be fast, mild and residue-free have received more attention and are in the focus of research worldwide.

AGENDA

1. Introduction
2. Overview of novel/non-thermal technologies
3. Selected technologies and applications
4. Summary and conclusions

OVERVIEW OF NOVEL/ NON-THERMAL TECHNOLOGIES



CONSIDERATIONS

- aimed step of the slaughter/processing line
- Possibility of technical implementation
- HACCP
- target microorganisms and target reduction factors
- legal background, permission, novel food
- adverse effect on fresh meat properties
- Toxic effects
- microbiological resistence
- economic analysis/cost calculation, sustainability
- consumer acceptance, labeling
- …

BACKGROUND

Reception Uploading

Shackling Stunning Bleeding

Scalding Defeathering Evisceration

Carcass Washing

Cooling/Chilling

Portioning/
Further Processing

Packaging

BACKGROUND

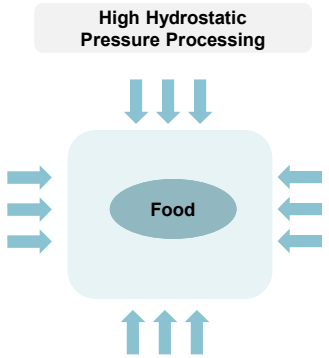
- Reception
- Uploading
- Stunning
- Bleeding
- Dehairing/Removing of skin
- (Scalding)
- (Rinsing)
- Evisceration
- Post-mortem Inspection
- Cooling/Chilling
- Portioning/ Further Processing
- Packaging

AGENDA

1. Introduction
2. Overview of novel/non-thermal technologies
3. Selected technologies and applications
4. Summary and conclusions

HIGH PRESSURE PROCESSING (HPP)

- non-thermal residue-free sterilization and preservation of the whole food
- Le Chatelier s and isostatic principle, 100 - 600 MPa, min, at ambient temperature
- treatment in flexible water-proof vacuum package
- broad antimicrobial effects (Gram-↑, Gram+↓, yeast/moulds↑, spores↓, viruses↑)
- antimicrobial effect depends on pressure and holding time
- no adverse effect on small molecules (e.g. vitamins, flavour compounds)
- effects on macromolecules (proteins, e.g. enzymes)
- possible colour modifications in white and red meat, lipid oxidation (during storage)
- currently used for liquid and high moisture solid products
- already commercialized HPP meat products: sliced cooked ham, precocked meals



APPLICATION OF HPP AT ABATTOIR LEVEL

Reception Uploading

Shackling Stunning Bleeding

Scalding Defeathering Evisceration

Carcass Washing

Cooling/Chilling

Portioning/
Further Processing

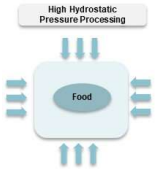
Packaging

Cleaning+Disinfection of equipment

not relevant/reasonable

possible

already applied

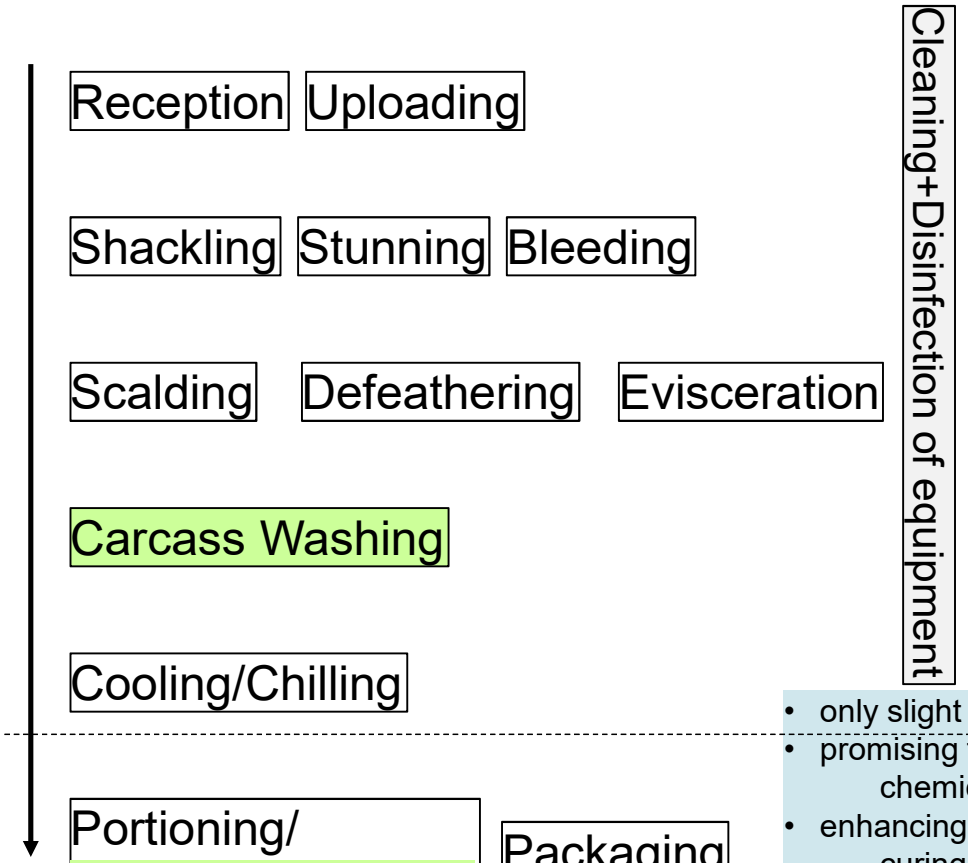


- for certain kinds of packaged meat/meat products
- safety↑
- shelf life↑
- consumer acceptance ↑

ULTRASOUND (US)

- non-thermal approach applying sound waves with higher frequency (>20 kHz) than the normal hearing
- power ultrasound (16-100 kHz)
- high frequency ultrasound (100 kHz- 1 MHz)
- diagnostic ultrasound (1-10 MHz)
- acoustic cavitation (breaking bubbles form hydroxyl ions with antimicrobial properties)
- applications: measuring distances, cleaning, sonography in medical imaging, waste water treatment
- food industry: extraction, cleaning, emulsification, homogenisation, enhancing mass transfer during marination, salting/curing, tenderization)
- no invasive effects, non-polluting form of mechanical energy
- only slight reduction of pathogenic and spoilage organisms in meat (Gram-↑, Gram+↓)
- promising technology combined with other interventions (e.g. combined steam-ultrasound)

APPLICATION OF ULTRASOUND ABATTOIR LEVEL



not relevant/reasonable

possible

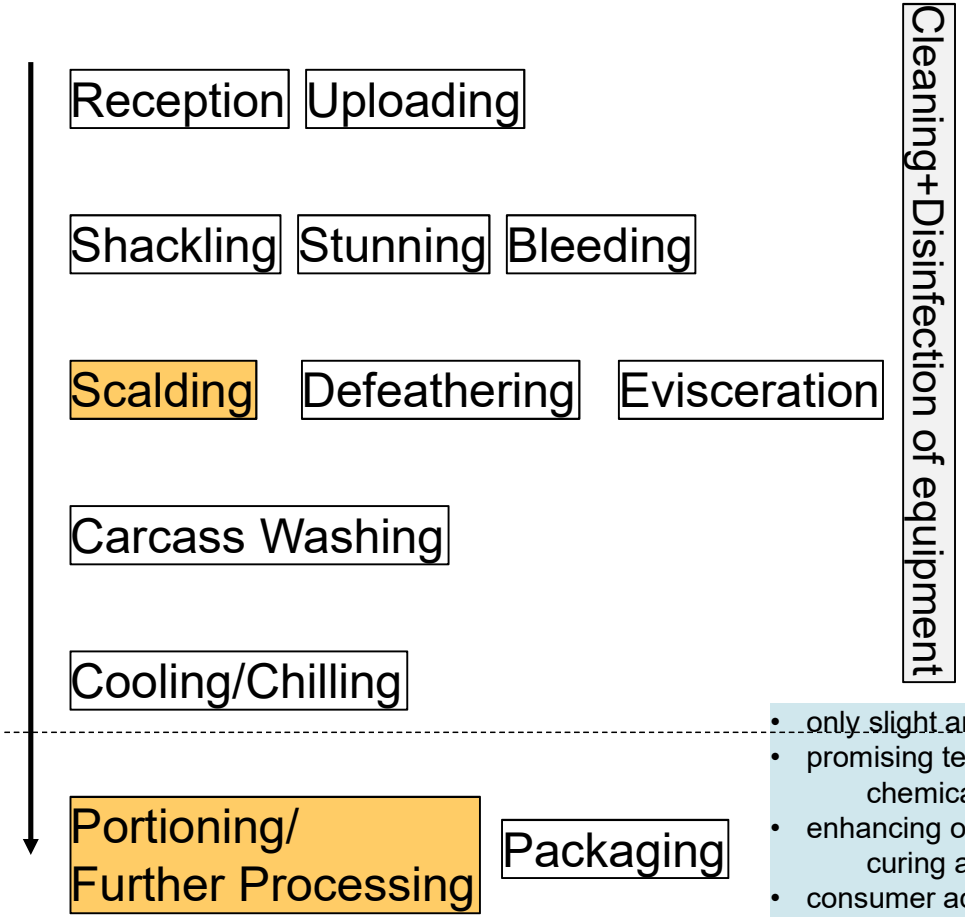
already applied

- only slight antimicrobial effect
- promising technique in combination with other chemical biological treatments
- enhancing of mass transfer processes during curing and pickling of meat
- consumer acceptance ↑

PULSED ELECTRIC FIELDS (PEF)

- use of short high voltage (5-80 kV) pulses for microbial inactivation
- Food is placed between two electrodes and applying an external electric field.
- Movement/accumulation of ions in-/outside the cell; cell polarization
- potential for cell membrane permeabilization
- modifying meat quality (color, texture, water-holding capacity)
- enhancing mass transfer during curing and brining
- limited applications in solid products, weak antimicrobial effects on the surface of meat
- Promising non-thermal technology for treating process waters in poultry processing and for poultry scald

APPLICATION OF PULSED ELECTRIC FIELDS (PEF)



not relevant/reasonable

possible

already applied

- only slight antimicrobial effect
- promising technique in combination with other chemical biological treatments
- enhancing of mass transfer processes during curing and pickling of meat
- consumer acceptance ↑

Y-IRRADIATION AND E-BEAM

- food irratiation has been applied for many decades worldwide
- exposure to electromagnetic energy (γ-ray) or charged particles (e-beam)
- both methods with strong antimicrobial effect (safety↑, shelf life↑)
- inactivation directly by photo-induced single and double-stranded DNA breaks and indirectly by DNA damage induced by radioloysis products
- irradiation efficiency is dependend on species, food composition and temperature
- application: (raw) meat products
- irratiated meat and meat products are already commecially avaiable in different countries (e.g. France, Belgium, Netherlands, China)
- both technologies cause sensory changes (lipid and protein oxidation

APPLICATION Y-IRRADIATION AND E-BEAM

Reception
Uploading
Shackling
Stunning
Bleeding
Scalding
Defeathering
Evisceration
Carcass Washing
Cooling/Chilling
Portioning/ Further Processing
Packaging

Cleaning+Disinfection of equipment

not relevant/reasonable

possible

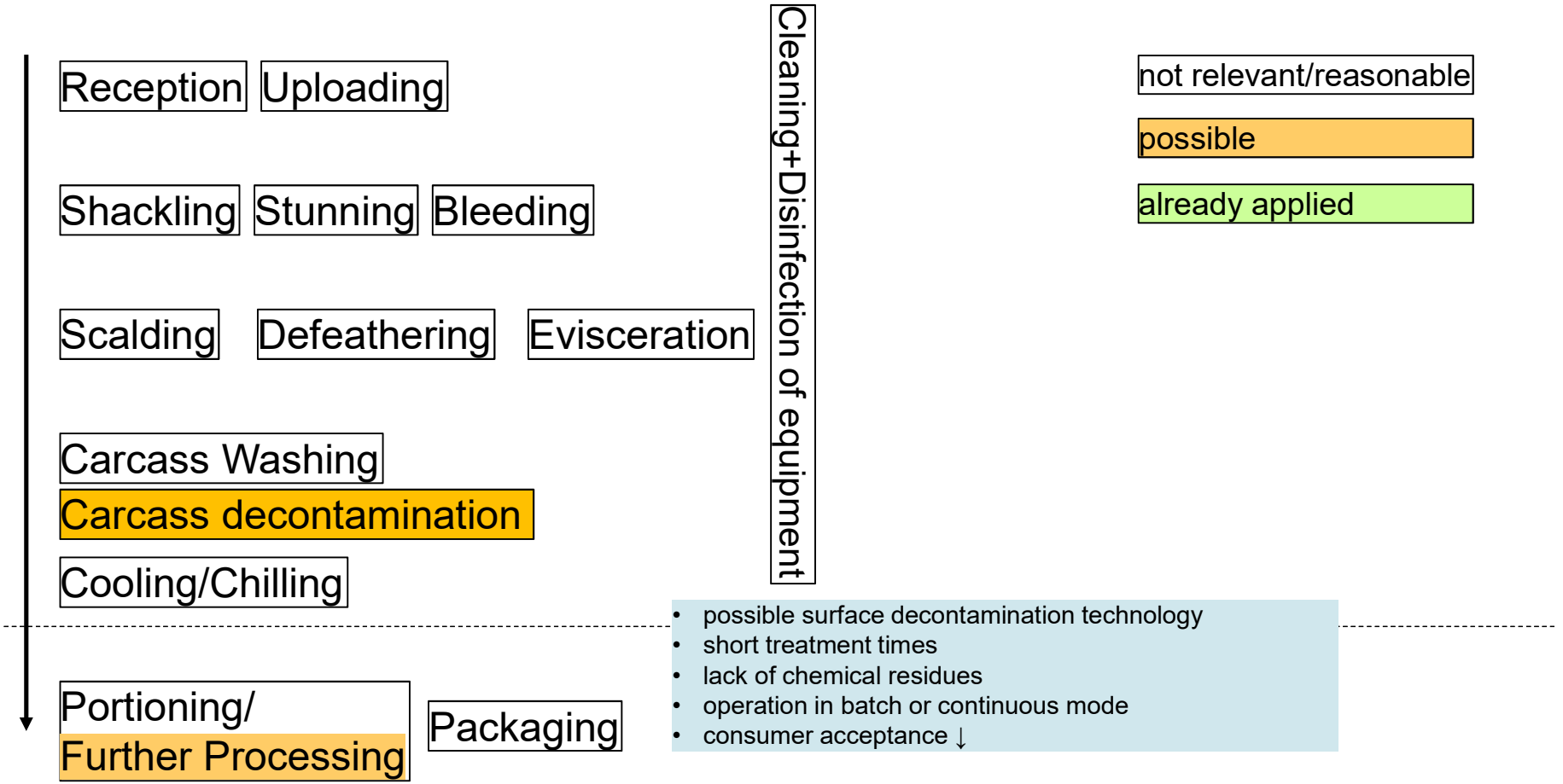
already applied

- strong antimicrobial affect
- treatment of frozen and prepackaged meat/meat products possible
- consumer acceptance ↓

PULSED LIGHT

- Pulsed light (PL), Pulsed UV-light (PUV), Intense pulsed light (IPL), High-intensity pulsed light (HIPL)
- rapid and gentle decontamination technology
- very short (µs) high power pulses from xenon lamp generate broad-spectrum light
- manifold multiplied energy incoropration as compared to continous application of UV-light
- antimicrobial impact by photo-chemical effects
- inactivation of different pathogens on meat surfaces, impact on bacterial spores
- antimicrobial effect is dependend on species, surface type and composition, energy input
- possible adverse effect on sensorical properties (colour and odour changes)

APPLICATION OF PULSED LIGHT

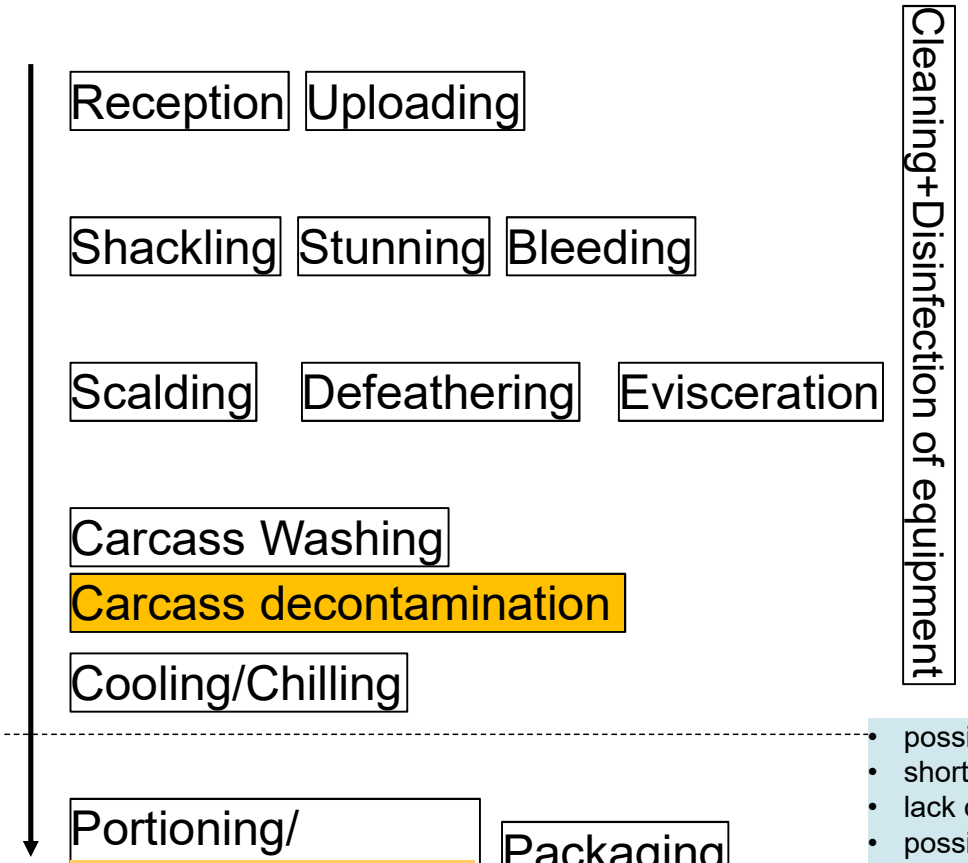


- possible surface decontamination technology
- short treatment times
- lack of chemical residues
- operation in batch or continuous mode
- consumer acceptance ↓

APPLICATION OF ULTRAVIOLET (UV-C) LIGHT

- UV light – electromagnetic radiation with wavelenght from 10 – 400 nm
- UV-C (200 – 280 nm) with antimicrobial effects targeting nucleic acids generating pyrimidine dimers (suspending vital cellular functions)
- current legal applications: e.g. treatment of water, fruit, vegetables, stored hard cheese, shell eggs
- antimicrobial effect restricted to surfaces
- limited antibacterial effect on meat and skin surfaces of slaugthered animals (matrix/shield-effect, topography, bacterial multilayer overloading/overlapping)
- UV-C light can form off-flavors by lipid peroxidation, “sunburnt flavor“

APPLICATION OF UV-C LIGHT



not relevant/reasonable

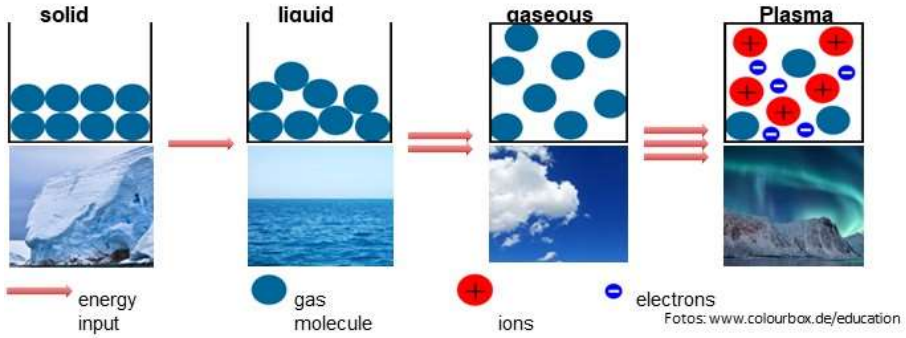
possible

already applied

- possible surface decontamination technology
- short treatment times
- lack of chemical residues
- possible adverse effects on sensorical properties
- operation in batch or continuous mode
- consumer acceptance ↓

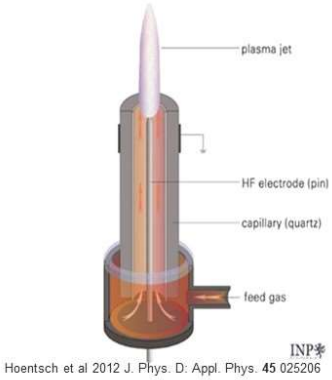
PLASMA-BASED TECHNOLOGIES

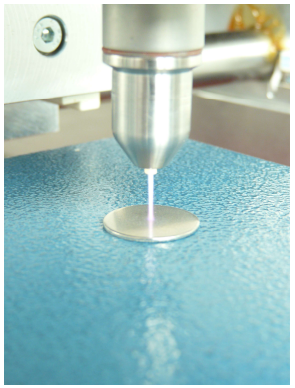
- „Fourth state of matter“
- quasi-neutral ionized gas composed of ions, free electrons, atoms, molecules
- egneration mostly by electric or electromagnetic energy
- classified in thermal and non-thermal plasma (e.g. cold atmospheric plasma)
- antibacterial effects resulsting from reactice oxygen or nitrogen species, charged particles, electric field, UV…
- applications: sterilisation/decontamination (packaging, food,tools), coatings, s

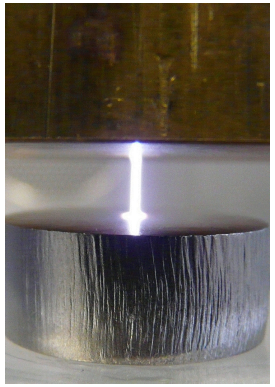


- direct application

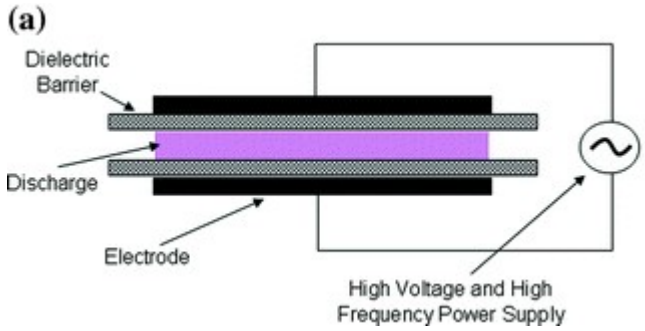
plasma jets







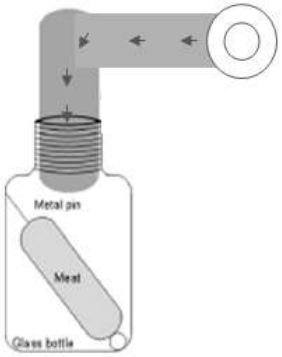
DBD Plasma



Quelle: Subedi et al., 2017

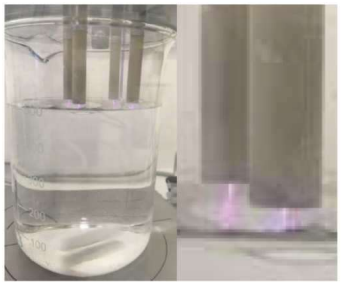
- indirect application

Plasma-activated gas



Fröhling et al., 2012 Innovative Food Science and Emerging Technologies 16 (2012)

Plasma-activated water



APPLICATION OF PLASMA-BASED TECHNOLOGIES

Reception
Uploading

Shackling
Stunning
Bleeding

Scalding
Defeathering
Evisceration

Carcass Washing
Carcass decontamination
Cooling/Chilling

Portioning/
Further Processing
Packaging

Cleaning+Disinfection of equipment

not relevant/reasonable

possible

already applied

- possible surface decontamination technology
- possible treatment of prepackaged meat
- short treatment times
- lack of chemical residues
- possible adverse effects on sensorical properties
- operation in batch or continuous mode
- consumer acceptance ↓

AGENDA

1. Introduction
2. Overview of novel/non-thermal technologies
3. Selected technologies and applications
4. Summary and conclusions

SUMMARY

already applied +potential application

technology	scalding	carcass deconta-mination	deboning	meat processing	prepack-aged meat/meat products	cleaning and disinfection of equipment
HPP	-	-	-	-	+	-
ultrasound	+	-	-	+	+	-
PEF	+		-	+	+	-
y-irradiation	-	-	+	+	+	-
e-beam	-	-	+	+	+	-
UV-C	-	+ (poultry)	+	-		+
Pulsed light	-	+ (poultry)	+	-	+	+
Plasma	-	-	+	-	+ (DBD, plasma gas)	+ (PAW)

CONCLUSIONS

- Physical non-thermal (novel treatments) have the potential to be used at certain steps at the abattoir and at further processing steps in addition to common hygienic measures.

- It is evident that significant bacterial reductions are achieved with gamma-ray, electron beam irradiation and high pressure processing, followed by pulsed light, UV-C and cold plasma, with ultrasound and PEF alone proving the least effective.

- As a limitation, it must be noted that sensory deviations may occur and the legal approvals may have to be applied for.

- However, the aim of future research should be more focused on the combined use of different technologies to further increase the inactivation effects by keeping meat quality at the same time.

FURTHER INFORMATIONS

Albert, T., Braun, P.G., Saffaf, J., Wiacek, C.
Physical methods for the decontamination of meat surfaces.
Current Clinical Microbiology Reports (2021) 8:9-20.
https:/doi.org/10.1007/s40588-021-00156-w

Barroug, S., Chaple, S., Bourke, P.
Combination of natural compounds with novel non-thermal technologies for poultry products: A review.
Frontiers in Nutrition (2021) 8.
doi: 10.3389/fnut.2021.628723

UNIVERSITÄT
LEIPZIG

THANK YOU FOR YOUR ATTENTION!

Thiemo Albert
Institute of food hygiene

An den Tierkliniken 1, 04103 Leipzig
T +49 341 97-217 F +49 341 97-249

albert@vetmed.uni-leipzig.de
www.lebensmittelhygiene.vetmed.uni-leipzig.de