64th Reciprocal Meat Conference
21 June 2011, Manhattan, Kansas

MRI
Max Rubner-Institut



German International Competence Center on Meat Quality

Current and Prospective Research and Networking Activities

Ralf Lautenschlaeger

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International Competence Center on Meat Quality

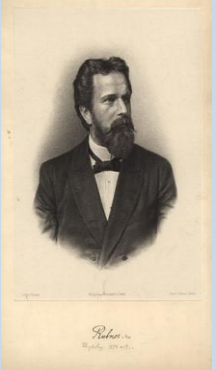
Max Rubner-Institut

Federal Research Institute of Nutrition and Food

President – Prof. Dr. Gerhard Rechkemmer

Main fields of research:

- Nutrition
- Food and bioprocessing technology
- Microbiology and biotechnology
- Safety and quality of food



Max Rubner (1854 – 1932)

- Physician and Physiologist
- Basic work in terms of modern nutritional sciences in Germany

Locations

Departments

- Physiology and Biochemistry of Nutrition, Karlsruhe
- Nutritional Behaviour, Karlsruhe
- Food and Bioprocessing Technology, Karlsruhe
- Safety and Quality of Fruit and Vegetable, Karlsruhe
- Microbiology and Biotechnology, Kiel
- Safety and Quality of Milk and Fish, Kiel
- Safety and Quality of Cereals, Detmold
- Safety and Quality of Meat, Kulmbach
- International Competence Center on Meat Quality, Kulmbach
- Analysis Division, Kulmbach

Safety and Quality of Meat
Research Topics

- Product safety and hygiene
- Sustainable process and product quality
- Carcass grading and value based marketing
- National reference laboratory on poultry meat

Safety and Quality of Meat
Research Topics

Research areas

Standards
of meat production

Technology

Microbiology

Production stages

From the animal
to the meat cut

Slaughtering and
processing

Treatment
of meat products

Research fields

Carcass grading and
marketing standards

Sustainable process
and product quality

Product safety and
hygiene

Grading and Classification of Carcasses

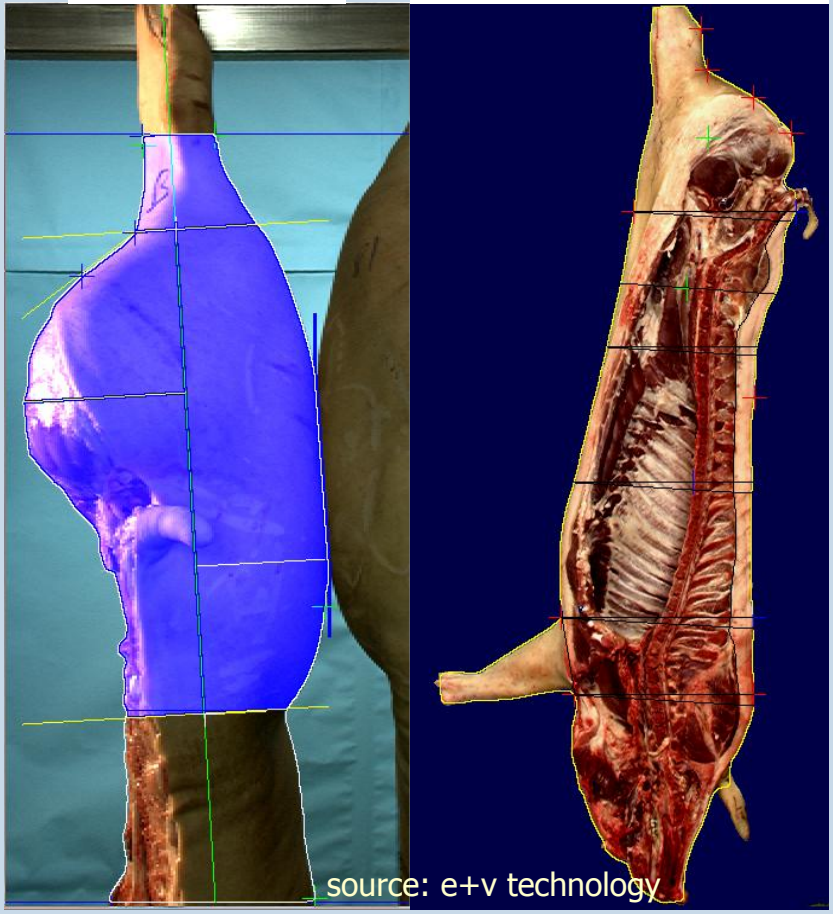
- Developing new methods of measurement
- Admission of grading techniques
- National coordinator in terms of meat grading
- Training of classifiers and supervisors
- Scientific advisory service for new member states

Aims of Instrumental Grading (pork)

- Basis: Lean content in the carcass
- Comparison of prices among EU member states
- Assure fair payment to the producers
- Quick methods and market transparency

Ham volume

Thickness and length measurements



MRI

Computer tomography as reference method for pig carcass classification

M. JUDAS et al.

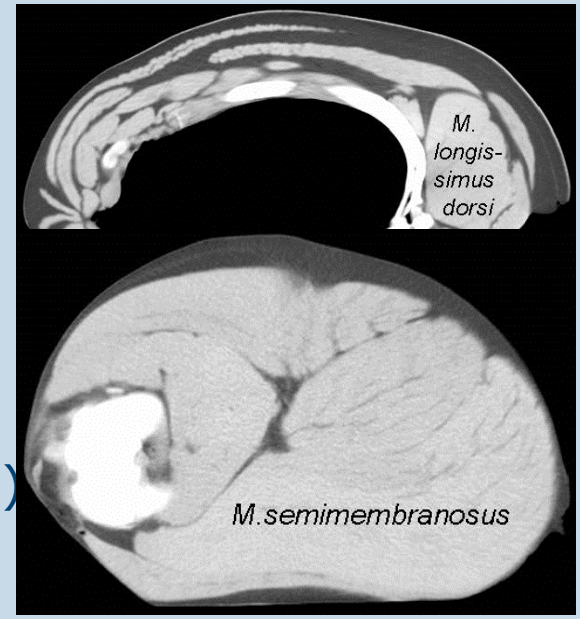
Carcass grading using CT

- Fair market value based on lean meat content
- Different grading methods are applied
- Calibration against reliable reference method
- Manual deboning and tissue dissection serve as measure – labour-intensive and costly

- Computer tomography received admittance as reference method

Reference method for carcass grading – X-ray CT

- Digital X-ray images (high resolution) with different grey scale values:
  - Bones: white
  - Muscles: light gray
  - Adipose tissue: dark gray
- Sharp discrimination between muscle and fat tissue
- CT spiral scans with 150 cross-sections per half-carcass
- Digital image analysis and statistic estimation (Pixel/Voxel)
- Expenditure of time: ~ 15 min. per carcass by CT
  vs. 11 hours by manual dissection



Bones – white; Muscles – grey;
Adipose tissue – dark grey

- Reference trial carried out 2009
- Admission of industrial grading techniques using CT reference (GE Logiq, AutoFOM, CSB-image-meater)
- Update of estimation formulas for pig carcass classification just published

Pork carcass — 2D-Sequence

144 cross-sections à 1 cm from Posterior to Anterior

Quelle: JUDAS 2004

New Technologies and Processing Procedures

Industry robots
Slaughtering and Breaking

High pressure processing
of meat products in combination with thermal treatment

Optimising knives of bowl cutter
shape, cutting edge, number

Raman-Spectrometry
non-invasive analysis of freshness loss

Product Safety, Hygiene, Sustainability of Process and Product quality

Oxygen treatment
bright red colour formation with beef

Functional meat products
healthy processed meat adding nutritional value

Electro-hydraulic shock wave treatment
to improve tenderness of beef cuts

Isolation, Identification and Application of microbes
starter and protective as well as probiotic cultures

Comparative bacteriological study on robot use in industrial pig slaughtering

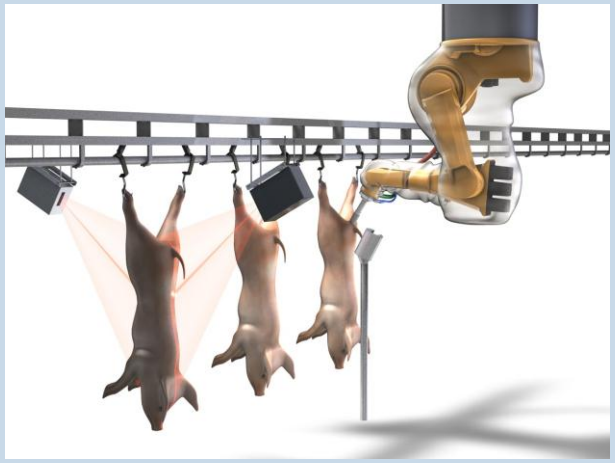
M. MOJE

Using robots in slaughter lines

- Precise measurement with three-dimensional laser system
- Calculation of individual cutting data for each carcass
- Hygiene "suit"– protection against impurities and contami
- Maintenance interval: 2 years of operation

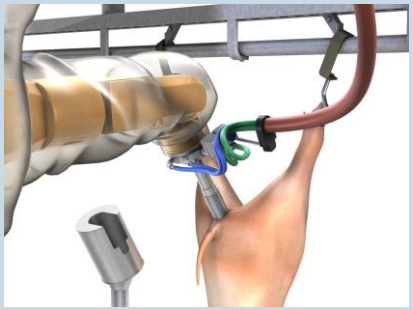
Investigation

- Bacteriological examination at the rectum remover
- 400 carcasses tested
- Manual vs. automated rectum removal / head separation
- Surface total plate counts and *Enterobacteriaceae* counts



Results

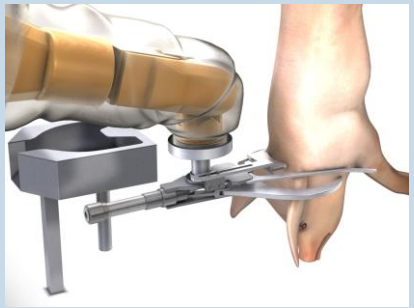
- Rectum removal – slight hygiene advantage for robots
- Median of TPC and *Enterobacteriaceae* with robot slightly lower than after manual removal



Surface TPC on the inner pelvic muscles after rectum removal [cfu/cm^2]

	manual [n = 101]		robot [n = 100]	
	TPC	*Enterobacteriaceae*	TPC	*Enterobacteriaceae*
Min.	5.00×10^1	10	3.00×10^1	10
Median	5.70×10^3	1.70×10^2	1.78×10^3	1.16×10^2
Max.	1.42×10^5	1.63×10^4	3.24×10^4	1.52×10^4

- Head separation – noticeable hygiene advantage for robots
- Median of TPC and *Enterobacteriaceae* count indicate a 1 log reduction compared to manual removal



Surface TPC on deep masseter muscle after head separation [cfu/cm^2]

	manual [n = 101]		robot [n = 100]	
	TPC	*Enterobacteriaceae*	TPC	*Enterobacteriaceae*
Min.	2.20×10^2	10	10	10
Median	2.75×10^3	4.80×10^2	2.75×10^2	1.00×10^1
Max.	3.70×10^5	2.60×10^4	3.50×10^4	1.50×10^3

HPP
of meat products
combined with
thermal treatment

Spore inactivation in cooked sausage – Studies on extending shelf life of canned cooked sausages by high pressure and heat treatment

W.-D. MUELLER (†); Irina DEDERER

Objective

- Complete inactivation of bacterial spores in canned cooked sausages
- Combination of high pressure and heat treatment
- Maintenance of high sensory quality when stored at tropical climates
- Applying two procedures – Heat and High pressure induced spore germination

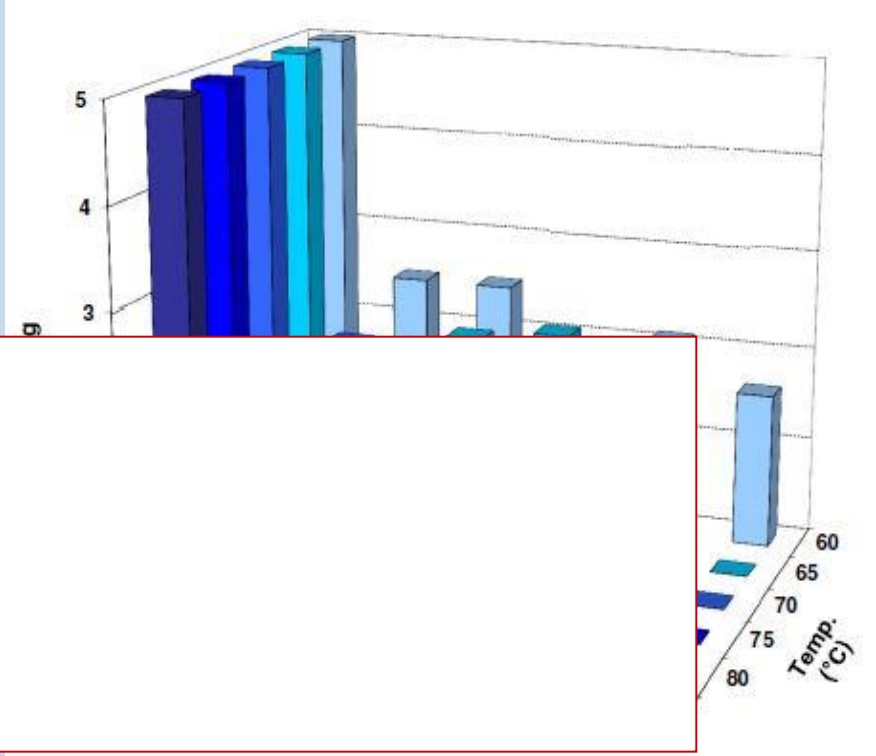
Spores examined

- *Clostridium thermosaccharolyticum* DSM
- *Bacillus stearothermophilus* DSM B171
- *Bacillus subtilis*
- *Clostridium sporogenes*

Results

Simultaneous application of heat and high pressure

- Spores examined at 75 °C
- *Cl. thermosaccharol LB, stearothermoph*



Sensory disadvantages

- Released liquid turned to viscous fluid
- Colour changed from reddish to light pink
- Texture:
  - crumbly at 600 MPa
  - spreadable at 800/900 MPa

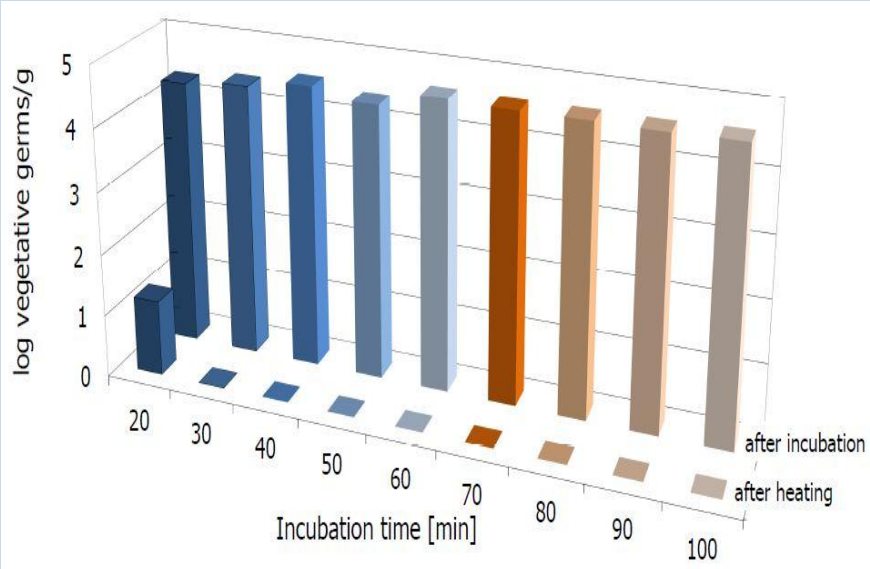
Influence of different pressure intensities and temperatures on inactivation of *Clostridium sporogenes* spores (2 x 4 min)

Heat-induced germination

- vegetative bacteria revealed very high pressure resistance even at 800 MPa

Pressure-induced germination

- most effective at 300 MPa and subsequent pasteurization
- following aspects to consider:
  - Partial germination only until breakdown of dipicolinic acid
  - Complete germination leads to high heat resistance
  - Inactivation of thermophilic spore formers with additional incubation step (at 60 °C for 40 min)



HP-induced germination of *Cl. sporogenes;* spores at 300 MPa, 95 °C for 20 min

Conclusion

- Canned cooked sausages – shelf stable at tropical climates
- Showed high sensory quality
- HPP – an alternative measure for gentle preservation
- Partial or complete inactivation of microorganisms and spores

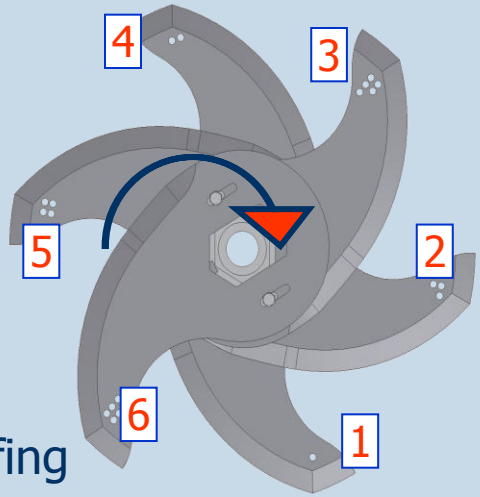
Optimising knives of bowl cutter
shape, cutting edge, number

Cutter knives – different slip angles and blade bevels

G.F. HAMMER and S. STOYANOV

- **Subject**

  Design of cutter knives applied with a bowl cutter



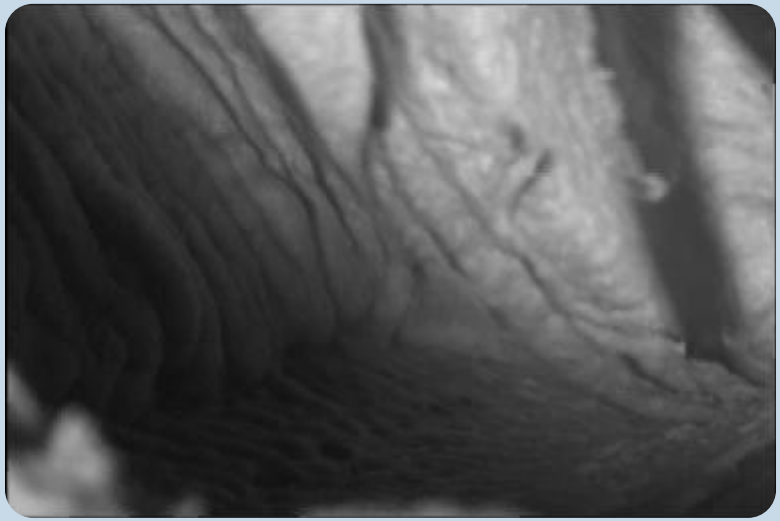
- **Aim**

  Influence of knife design on

  - Dispersion and emulsification of cooked sausage stuffing
  - Duration of chopping
  - Energy consumption

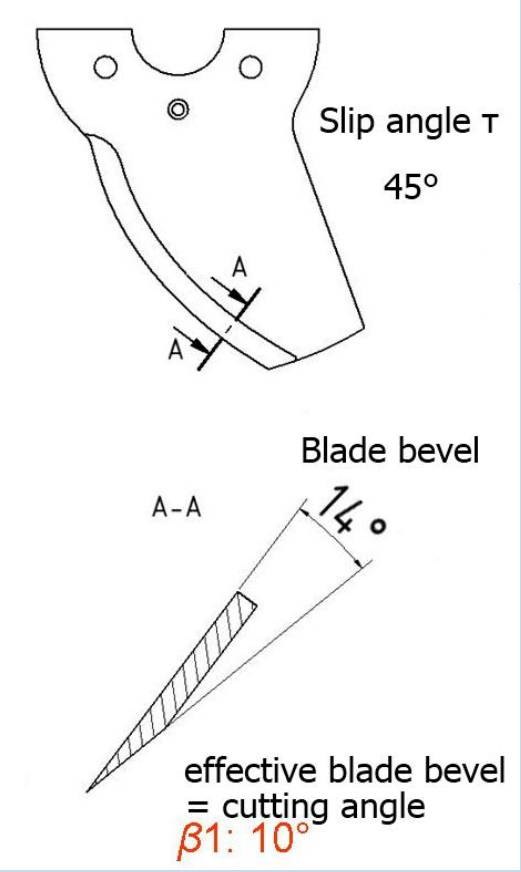
- **Basis**
  - Huge variety of different forms of chopper knives
  - Research results indicate:

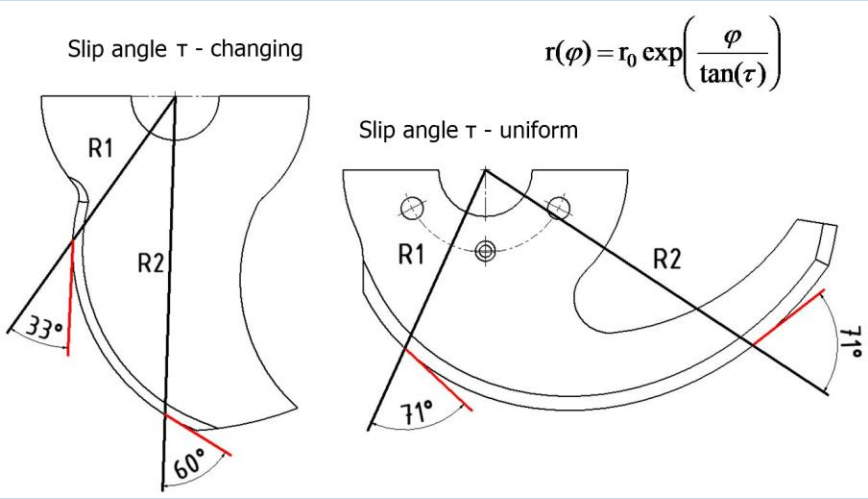
    only 1 out of 3 or 4 knife couples is working



Investigation

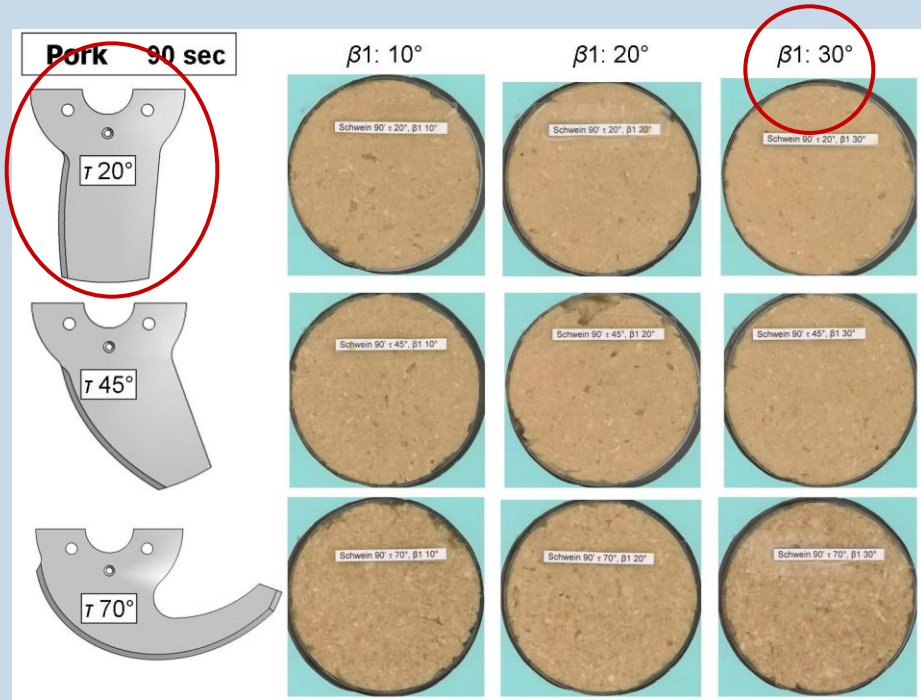
- 3 different forms of cutter knives used
  - slip angles τ = 20, 45 and 70°
- Blade bevel β – the other important feature
  - β = 14, 27 and 39° respectively
- Effective blade bevel β1 – of practical importance
  - β1 = 10, 20 and 30° respectively





Results for emulsion-type stuffing

- Different knives – no differences in product traits and energy consumption
- Slip angle hardly influences traits of batter
- Differences in the ability of comminuting and dispersing the meat raw material
- Knives with righted blade and bigger cutting angle most effective
- Blade bevel influences dispersion of connective tissue within the meat batter



Electro-hydraulic shock wave treatment to improve tenderness of beef cuts

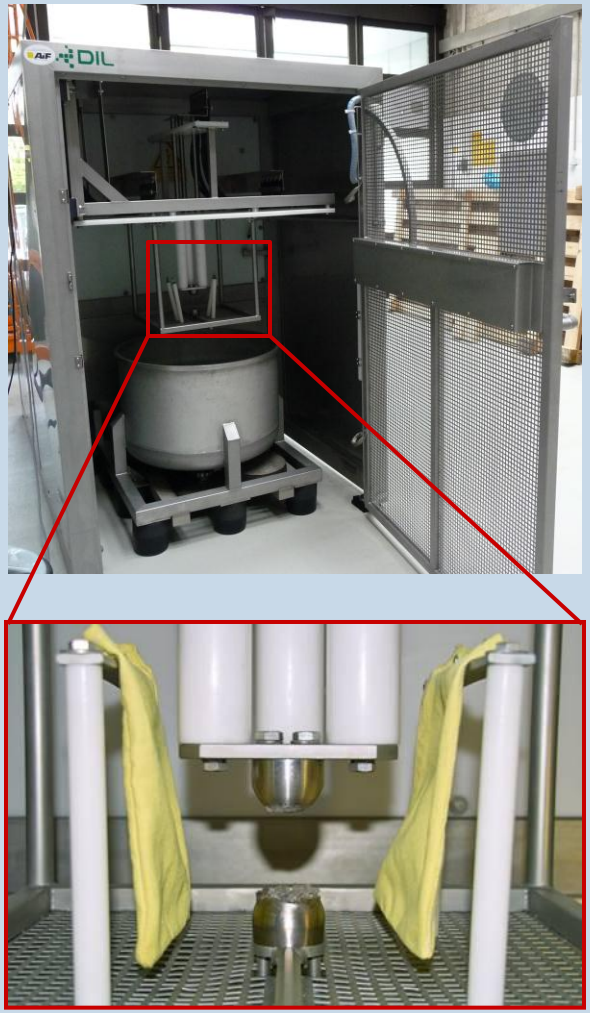
MRI

Tenderization of beef using electro-hydraulic shock waves

S. MÜNCH

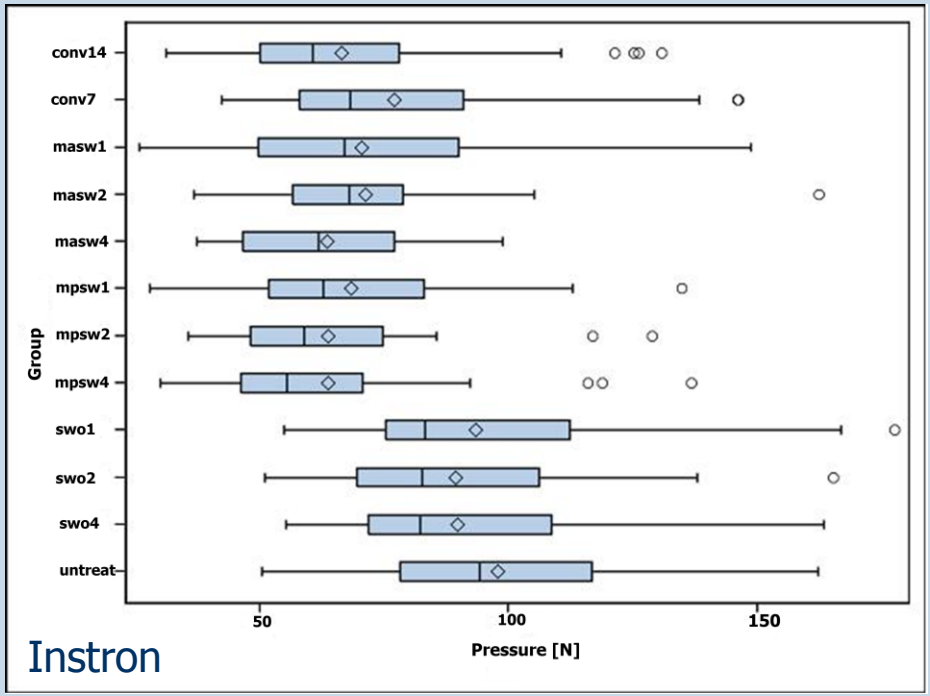
Objective

- Harness shock waves to disintegrate biological tissue
- Generation of plane shock waves to improve homogeneity of treatment
- Accelerate ageing of meat
- Increasing portion of high-quality beef cuts
- Reducing refrigeration capacity and energy costs
- Influence on tenderness, colour, juiciness and flavour



Results

- Improving tenderization required additional maturation – prior to or after shock wave treatment
- Shock wave treatment plus 7-day-maturation similar tenderness as 14 days usual ripening
- Reduction of processing time by 50%
- Increasing no. in shock wave treatments resulted in improved tenderness
- High standard deviations were noticeable
- Further research with higher number of samples required



Tenderness of groups of *Longissimus* cuts (German Simmental; n = 26; SWT at 36 kV

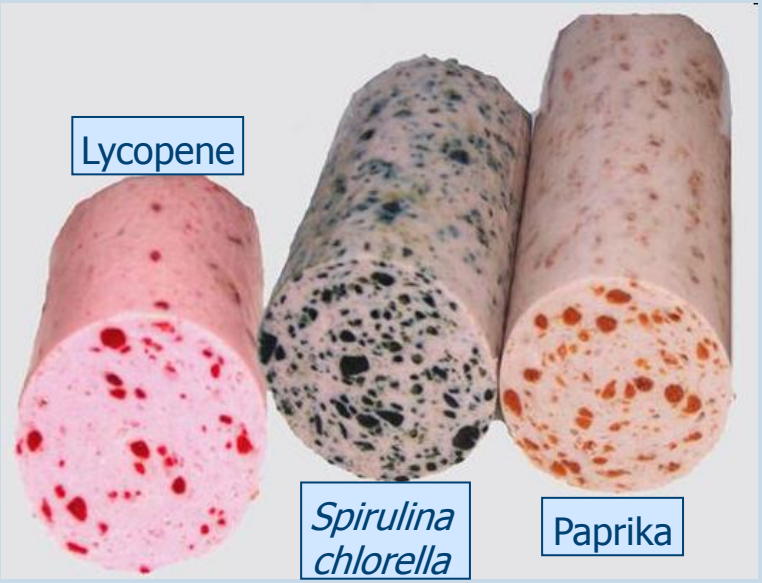
Functional meat products
healthy processed meat
adding nutritional value

Functional food – sausages containing algae, lycopene, omega fatty acids, inulin and paprika

Dr. P. NITSCH

Situation

- Overweight – a #1 public health problem
- Meat products among the critical fat sources
- Produce meat products with reduced energy density
- Limiting factors of fat reduction: technology and sensory
- Supplements usually pose problems – concentration, colouring effects, taste
- Suitable technological techniques are required



Omega fatty acids

- Suitable for attractive cooked sausage product
- 3 to 6% linseed oil can satisfy physiological requirements
- Fulfils sensory expectations of conventional product
- 50 g of such meat product to cover the daily requirement
- Similar situation with rape-seed and sunflower seed/linseed oil mixture

- Also suitable:
  fish oils, ω-3-fatty acid ethyl ester,
  various encapsulated fish oils, perilla oil
- Specific fish oil led to a 2% eicosapentaenoic acid (EPA)
  + docosahexaenoic acid (DHA) content
- Unspecific sensory differences to control sample
- Low TBARS values after production and storage

Results

- Omega fatty acids are an important supplement for functional food
- Ratio of omega-3 to omega-6 compounds is crucial to the physiological effect
- Health-related effect of fish oil containing cooked sausage approved
- Daily intake of 2 g EPA+DHA/100 g sausage
  benefited parameters of fat metabolism, immune system and inflammation
- EPA and DHA supplemented to sausages are of high bioavailability

Inulin

- Inulin suspension considerably reduces fat content
- Suitable for cooked sausage and sausage made from cooked meat raw material
- Sensory status completely corresponding to traditional products
- Sausage made from cooked meat – distinctly upgraded in sensory terms
- Inulin suspension is processed like fat tissue –
  no modification of production procedure required

Results

- Addition of inulin is limited:
  7.5% (cooked sausage)
  20% (finely chopped liver sausage)
- Distinctly fat-reduced meat products
  while retaining specific sensory properties

Inulin suspension

Lycopene

- Lycopene containing gelatin cubes used
- Avoiding coloured smearing at cross section
- No colour transfer to the stuffing
- Sensory corresponds to conventionally formulated cooked sausages
- Highly concentrated lycopene preparation needed for nutritionally effective lycopene ratio
- 50 g sausage would safely cover the daily requirement of 0.01 g lycopene

0% - 0.025% - 0.05% - 0.075% - 0.1%

Intensive colouring effect of added LycoVit 10 CWD to cooked sausage

Investigation and Results

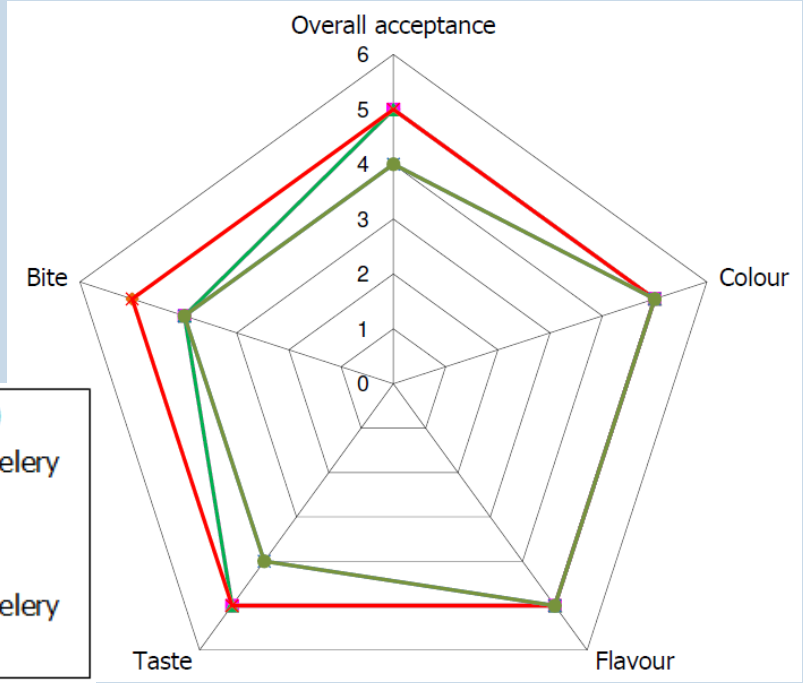
- Fat-reduced cooked sausage using vegetables (Bologna-type; w/wo nitrite curing salt)
- Suitable from technological and sensory point of view: potatoes, black salsify, celery and white cabbage
- Fat reduction by 30% up to 60% easily feasible
- Vegetable portion between 20 and 40%

Recipe

Ingredients	Basic recipe		Vegetable recipe	
	kg	%	kg	%
Pork shoulder	2.4500	49.00	2.4500	49.00
Pork back fat	1.2200	24.40	0.8100	16.20
Ice	1.2200	24.40	0.8100	16.20
Salt (w/wo nitrite)	0.0800	1.60	0.0800	1.60
Di-phosphate	0.0100	0.20	0.0100	0.20
Spice blend	0.0185	0.37	0.0185	0.37
Sodium ascorbate	0.0015	0.03	0.0015	0.03
Potato powder	–	–	0.2000	4.00
Black salsify	–	–	0.5000	10.00
Celery	–	–	0.1200	2.40
Total	**5.0**	**100.0**	**5.0**	**100.0**

–33.6 % points

Sensory scores



MRI

Application of starter and protective cultures to meat products

L. KRÖCKEL

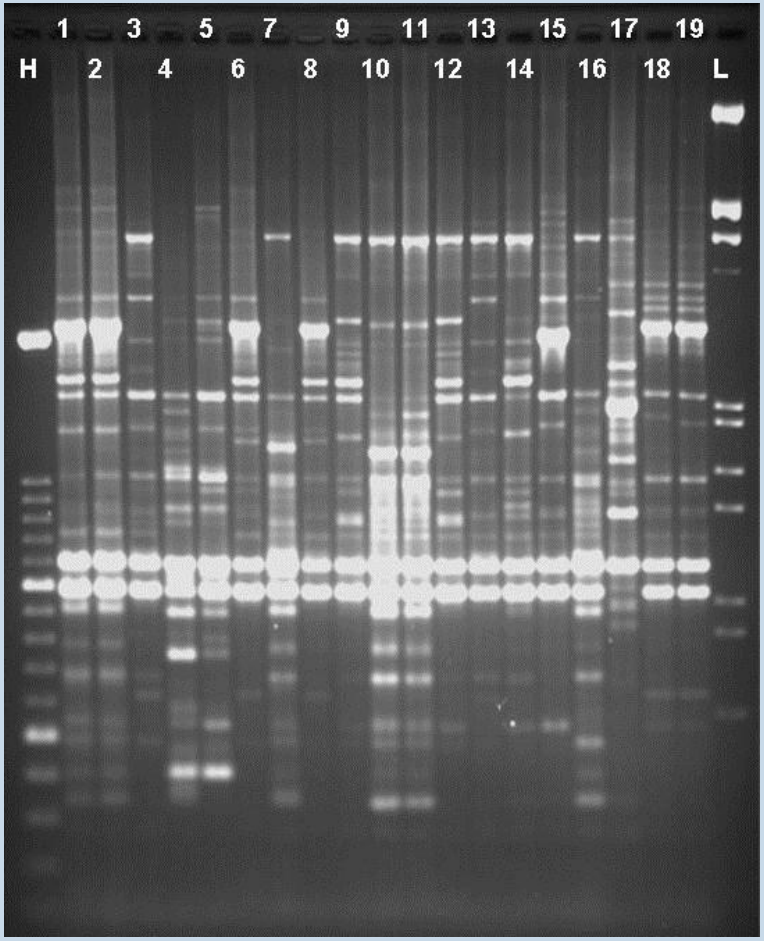
Situation

- Advantages in life sciences and biotechnology need utilisation of microbiological-genetical resources
- MRI Kulmbach, for more than 30 years determines, collects and registers meat-associated bacteria
- Potential starter and protective microbes for meat products
- 1000 isolates registered with MGRDEU database (Microbial Genetic Resources in Germany; www.genres.de/mgrdeu)
- Collection – useful basis for screening tests regarding meat-associated LAB and Staphylococci

Starter and protective cultures for dry-fermented raw sausage and raw ham	
Lactobacillus *sakei* *curvatus* *plantarum* *pentosus* *paracasei*	***Staphylococcus*** *carnosus* *xylosus* *equorum* ***Kocuria*** *varians*
Pediococcus *acidilactici* *pentosaceus*	***Streptomyces*** *griseus*
Tetragenococcus *halophilus*	***Debaryomyces*** *hansenii*
Leuconostoc *carnosum*	***Penicillium*** *nalgiovense*

Application

- Kulmbach-collection provides
  - Resource for future product developments
  - Well characterised bacteriocine forming species
  - Basic research work with bacteriocines Sakacin A and P (*Lb. sakei* subsp.)
  - Bacteriocine Sakacin Q was found (*Lb. sakei* strains Lb674 and LTH673)
- Identification of new strains:
  - *Lactobacillus versmoldensis* (halophile, prevalent in many foods)
- Protective cultures
  - Investigation of genetical bio-diversity of LAB
  - Alternative to chemical preservatives
  - Improvement of sensory product quality
  - Application to pre-packed fresh meat

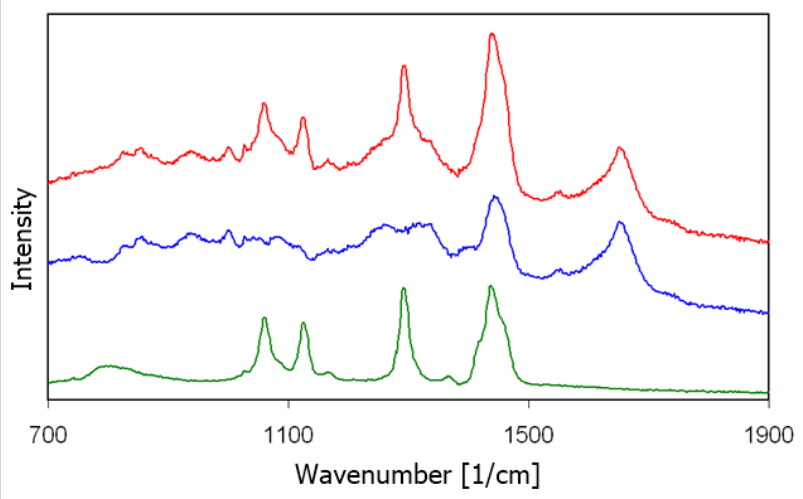


Variety of *Lb. sakei* subsp. *carnosus* isolates – genomic finger print by means of BOX-PCR

Raman-Spectrometry
non-invasive analysis
of freshness loss

Research project "Fresh scan"

- Optical measurement of packed product status – non-invasive, non-contact, quick
- Resulting and measured Raman-shift – characteristic "Finger print" for a material
- Follow-up of biochemical/physical changes in meat in dependence on time
- Advantages of Raman spectrometry:
  using visible light
  no sensitivity to water
- "Finger print" in terms of protein and fat
  – Raman suitable for product identification
- Portable Raman measuring head available



Raman spectra – packed meat (red), packaging material (green), meat (blue)

International Competence Center on Meat Quality

Targets

- Meat quality ⇨ traits, methods, basics (physiology, analytics)
- Networking with stakeholders (producers, industry, consumers, NGO)
- Risk assessment and risk strategies over the entire supply chain
- Acquisition of research and cooperation projects
- Knowledge transfer to national and international partners in the meat sector
- Organization of meetings, workshops and the "Kulmbach Summer School"

International Competence Center on Meat Quality

Research projects scheduled

- Sustainability management systems over entire value chain of meat (11 partners)

  Objective: - Definition and analysis of indicators of sustainability
  - Regarding consumer behaviour
  - Based on "quality" in the sense of the Rio process (economy, ecology, sociology)

- Quality of pre-packed meat under modified atmosphere (7 partners)

  Objective: - Deeper knowledge of the effect of high oxygen atmosphere
  - Quality assurance of MAP packed meat – hygiene, substantial equivalence, contaminants

- Raman spectrometry for online determination of content and composition of intramuscular fat in beef and pork (4 partners)

  Objective: - Development of a non-invasive, portable online device for use under industrial processing conditions

Research projects scheduled

- Exsanguination status in slaughter pigs - Development of an automated monitoring system (3 partners)

  Objective: - Automated measuring of individual level of blood removal of slaughter pigs
  - Prevention of insufficient killing process
  - Improvement of animal welfare

- Boar fattening and impacts on meat quality and slaughter value (3 partners)

  Objective: - Based on refusal and prohibition of castration without anaesthetic
  - Comparison of carcass value of boars, sows and castrates
  - Processing of boar meat and sensory acceptance of final products
  - Measures to reduce boar taint
  - Quick analytical method for online assessment of boar taint

- Binding systems for restructured raw, dry-fermented meat products

  Objective: - Technological suitability and analysis of different binding systems used for processing restructured raw ham
  - Based on latest developments in pre-packed sliced raw ham products

Research projects running

- Packaging hot-boned beef and pork (*M. longissimus dorsi*)

  Objective: - packaging of high-value cuts into tight-fitting tubular film
  - no vacuum, reduction of rigor shortening
  - inactivation of microbes by dip moulding in hot water
  - testing suitability for subsequent MA packaging

- Dry- and wet-aged beef

  Objective: - dry ageing w/wo moulds at high humidity combined with high air flow rate
  - wet ageing under vacuum w/wo starter cultures
  - comparison with regard to sensory traits (tenderness/flavour)

- Captive bolt stunning with cattle

  Objective: - 3 stunners with different bolt lengths and power of impact
  - alternative for "pithing" (not allowed since BSE)
  - preventing excitations of slaughtered ruminants
  - improving safety at work and meat quality

Tuesday, 18 October 211

10:00 – 10:30 am

Address of welcome
Prof. Dr. Gerhard Rechkemmer, President of MRI

Presentation of the Max Rubner-Institut

Ageing of Meat
10:30–11:00 am: Postmortem biochemical processes in meat
Schwägele, Fredi, MRI

11:00–11:30 am: Most common tenderising treatments to meat
Moje, Matthias, MRI

11:30–12:00 am: Conditioning vers
carcasses
Troeger, Klaus, MRI

12:00–1:00 pm: Demonstra
shortening etc.

1:00–2:00 pm: Lunch

2:00–2:30 pm: Latest trends i
versus wet aged beef
Lautenschläger, Ralf, MRI

2:30–3:00 pm: Beef maturation u
Kröckel, Lothar, MRI

3:00–3:30 pm: An alternative pack
hot-boned meat
Münch, Siegfried, MRI

3:30–4:30 pm: Demonstration of age
treatments

4:30–5:00 pm: Coffee break

5:00–5:40 pm: Beef maturing under vacuum – microbiological and hygienic risks
Gareis, Manfred, MRI

5:45 pm: End of sessions

6:30 pm: Welcome Reception

Wednesday, 19 October 2011

Pre-packaging of case-ready meat

8:30–9:15 am: Meat packaging and shelf life – Russian experience
Gorbatov, Stanislav, VNIIMP, Moscow

9:15–10:00 am: Skin packaging – a suitable alternative compared to MAP
Métais, Pascal, Sealed Air – Cryovac Food S

10:00–10:30 a

7:00 pm: Get together in a characteristic Franconian tavern

Thursday, 20 October 2011

9:00–9:45 am: Advantages of short distance supply
Hösl, Johann and Kerstin Kunz, real SB-Warenhaus GmbH

10:00–12:30 am

Visit of a g operation in a retail store

nological requirements in

ases Division, Netherlands

and sustainability regarding

GmbH & Co. KG

lopments and

ing different gases
materials

Friday, 21 October 2011

8:00–8:45 pm: Packaging material and MAP suitable for application of new technologies (HPP)
Tobias Richter, Multivac Sepp Haggenmüller GmbH & Co. KG

9:00–12:00 am:

MRI meat pilot plant – Demonstrations of practical importance

High hydrostatic pressure application to fresh meat – sensory effects (rancidity, colour loss, changes in texture, coagulation)

Appearance of meat pressurised under oxygen atmosphere

Thank you for your attention

and

See you in Kulmbach!