German International Competence Center on Meat Quality
Current and Prospective Research and Networking Activities

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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

Kiel
Hamburg
Detmold
Kulmbach
Karlsruhe
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
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

- 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**

- **Functional meat products**
  - healthy processed meat adding nutritional value

- **Oxygen treatment**
  - bright red colour formation with beef

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

- **Electro-hydraulic shock wave treatment**
  - to improve tenderness of beef cuts
Comparative bacteriological study on robot use in industrial pig slaughtering

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 contamination
- 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/cm²]

<table>
<thead>
<tr>
<th></th>
<th>manual [n = 101]</th>
<th>robot [n = 100]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TPC</td>
<td>Enterobacteriaceae</td>
</tr>
<tr>
<td>Min.</td>
<td>5.00 x 10^1</td>
<td>10</td>
</tr>
<tr>
<td>Median</td>
<td>5.70 x 10^3</td>
<td>1.70 x 10^2</td>
</tr>
<tr>
<td>Max.</td>
<td>1.42 x 10^5</td>
<td>1.63 x 10^4</td>
</tr>
</tbody>
</table>

- **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/cm²]

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<th>robot [n = 100]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>TPC</td>
<td>Enterobacteriaceae</td>
</tr>
<tr>
<td>Min.</td>
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<td>10</td>
</tr>
<tr>
<td>Median</td>
<td>2.75 x 10^3</td>
<td>4.80 x 10^2</td>
</tr>
<tr>
<td>Max.</td>
<td>3.70 x 10^5</td>
<td>2.60 x 10^4</td>
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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*, *B. 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

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)

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

HP-induced germination of *Cl. sporogenes*; incubation at 60 MPa, 37 °C.
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 $\tau = 20, 45$ and $70^\circ$
- Blade bevel $\beta$ – the other important feature
  - $\beta = 14, 27$ and $39^\circ$ respectively
- Effective blade bevel $\beta_1$ – of practical importance
  - $\beta_1 = 10, 20$ and $30^\circ$ 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
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

Instron

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

6% blend from linseed + sunflower seed oil

control
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
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
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

<table>
<thead>
<tr>
<th>Ingredients</th>
<th>Basic recipe</th>
<th>Vegetable recipe</th>
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<tbody>
<tr>
<td></td>
<td>kg</td>
<td>kg</td>
</tr>
<tr>
<td>Pork shoulder</td>
<td>2.4500</td>
<td>2.4500</td>
</tr>
<tr>
<td>Pork back fat</td>
<td>1.2200</td>
<td>0.8100</td>
</tr>
<tr>
<td>Ice</td>
<td>1.2200</td>
<td>0.8100</td>
</tr>
<tr>
<td>Salt (w/wo nitrite)</td>
<td>0.0800</td>
<td>0.0800</td>
</tr>
<tr>
<td>Di-phosphate</td>
<td>0.0100</td>
<td>0.0100</td>
</tr>
<tr>
<td>Spice blend</td>
<td>0.0185</td>
<td>0.0185</td>
</tr>
<tr>
<td>Sodium ascorbate</td>
<td>0.0015</td>
<td>0.0015</td>
</tr>
<tr>
<td>Potato powder</td>
<td>–</td>
<td>0.2000</td>
</tr>
<tr>
<td>Black salsify</td>
<td>–</td>
<td>0.5000</td>
</tr>
<tr>
<td>Celery</td>
<td>–</td>
<td>0.1200</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>5.0</strong></td>
<td><strong>5.0</strong></td>
</tr>
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</table>

### Sensory scores

- **33.6 % points**
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**          | **Staphylococcus**          |
| sakei                       | carnosus                   |
| curvatus                   | xylosus                    |
| plantarum                  | equorum                    |
| pentosus                   |                            |
| paracasei                  |                            |
| **Kocuria**                |                            |
| varians                    |                            |
| **Pediococcus**            | **Streptomyces**           |
| acidilactici               | griseus                    |
| pentosaceus                |                            |
| **Tetragenococcus**        | **Debaryomyces**           |
| halophilus                 | hansenii                   |
| **Leuconostoc**            | **Penicillium**            |
| carnosum                   | nalgiovene                 |
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
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
Thank you for your attention and See you in Kulmbach!