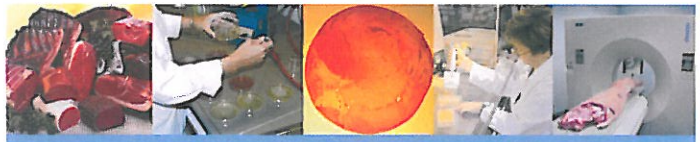
4th International Summer School on Meat Research
MRI – 16-19 September 2014, Kulmbach

MRI Max Rubner-Institut



Technological and sensory Quality of Dry-cured Raw Ham

Developments in self-service packed, sliced goods

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International Competence Center on Meat Quality

MRI

Agenda

Traditional Production of dry-cured Raw Ham
- Definition of Raw Ham
- Processing Technology
- Quality determining Procedures

Raw Ham – Industrial Manufacture
- Processing Technology
- Guaranteeing Shelf-life
- Sensory Traits

Raw Ham – New Technology
- Processing Technology
- Binding Systems
- Quality and Legislative Aspects

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Dry-cured Raw Ham – Definition

Guiding principles for Meat and Meat Products (last update: 8.1.2010)

2.40 „*Dry-cured raw meat products* or Rohpökelware, Rohschinken, Rauchfleisch, Dörrfleisch, süddeutsch auch Speck, Geräuchertes und/oder Geselchtes are raw pieces of meat
- preserved by Curing (i.e. salted with table salt w/wo nitrite and/or nitrate),
- dried, smoked or air-dried,
- showing a consistent colour, typical flavour and a texture, suitable for cutting very thin slices."

2.411 *Dry-cured raw ham* is produced from the hind leg of pigs or parts of it.
- They can be produced from corresponding cuts of other animal species (cattle, reindeer).

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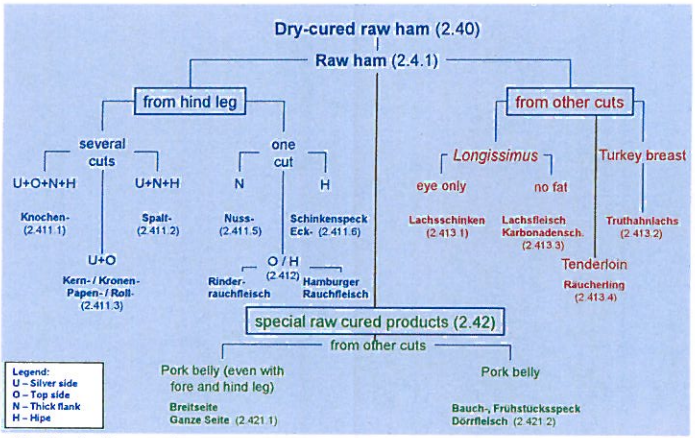

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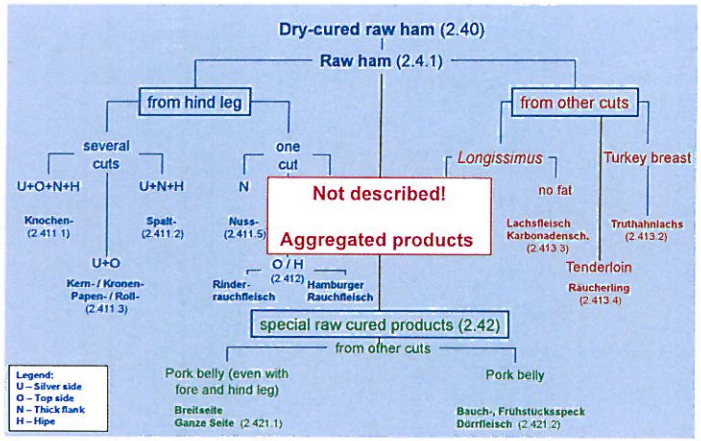

Raw Ham Manufacture

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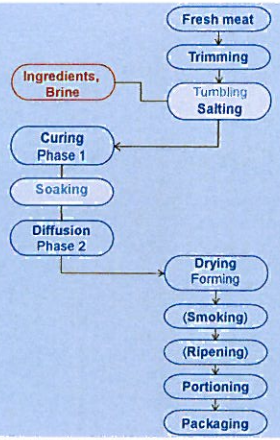
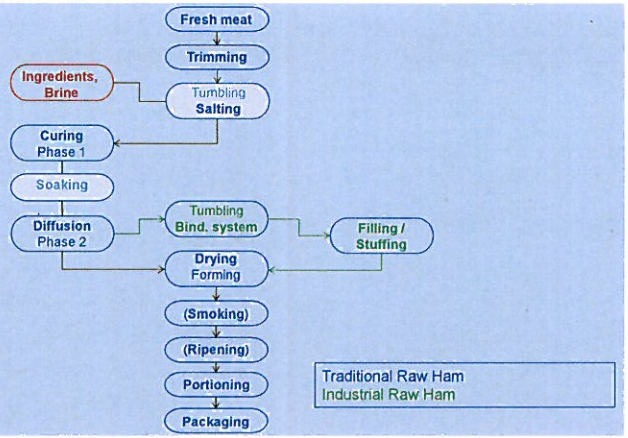


Traditional Raw Ham

Raw Ham Manufacture



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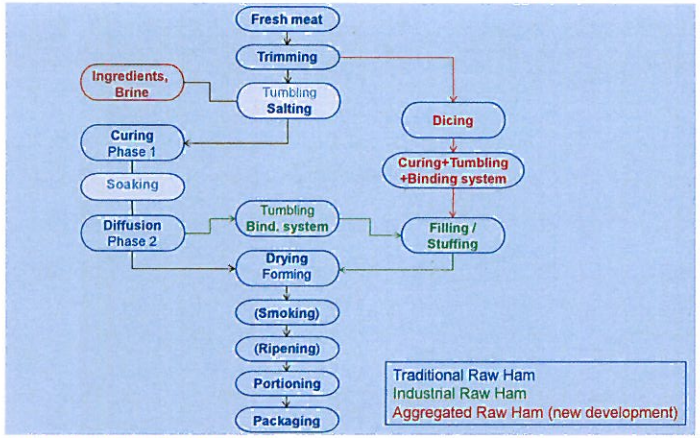


Objectives

Traditional raw ham processing aims in:

- Microbial Stabilisation
  - Table salt
  - Drying
  - Reduction of water activity (a_w value < 0.96)
- Formation of curing colour
  - Nitrite reduction
  - NO + myoglobin → nitrosomyoglobin
  - (Colour stabilisation wo curing salt)
- Flavour formation
  - Decomposition products of nitrite
  - Components of meat (proteins, fats, carbohydrates)
  - Metabolites of meat components (aldehydes, free carbon acids, furans etc.)
  - enzymatically and microbially generated biochemical interactions

Selection of raw material

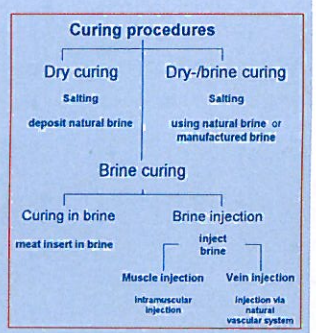
- Slaughter process
  - strict Hygiene
  - minimal microbial contamination
  - very good debleeding (no blood in muscle)
- Treatment
  - quick Chilling to 7 °C in the center
  - accurate cutting/deboning (no slots!)
- pH value
  - < 6.0 for short-term ripened products
  - < 5.8 for long-term ripened products
  - < 5.8 ham from beef (danger of DFD meat)


[STIEBING, 2010]

Curing / Salting

- Salting
  - addition of table salt
  - diffusion and water immobilisation
- Curing
  - addition of nitrite and/or nitrate
  - aim: preservation, curing colour and flavour
  - complex procedure
  - chemical, biochemical, enzymatic reactions

[PRÄNDL et al., 1988]



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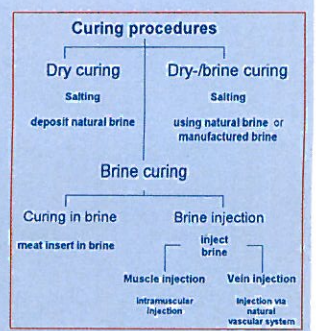
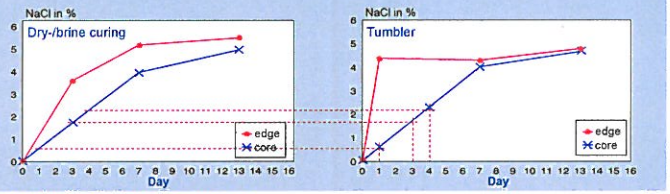
[PRÄNDL et al., 1988]

- Curing temperature
  - 3 °C, max. 5 °C, because diffusion rate hardly dependent on temperature
  - risk of growth of spoilage microorganisms
  - safety criterium: a_w value < 0.96 → salt content ≥ 4.5%



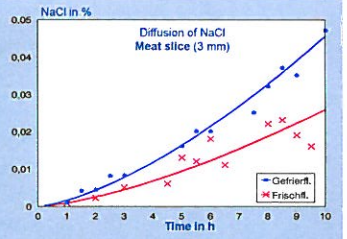
Salt diffusion

- Dependence on curing procedure with **Loin ham**
- Dry-/brine curing
  - slow increase of salt content in surface layer
- Salting using a tumbler
  - immediate input of salt concentration required in surface layer
  - consistent concentration during whole curing period
- Center of the ham
  - no noticeable difference



Salt diffusion

- Dependence on pre-treatment of meat
- Fresh meat
  - slow diffusion
  - strong variance of measured values
- Frozen meat (thawed)
  - accelerated, steady diffusion
  - low variance of measured values
  - decrease of barriers



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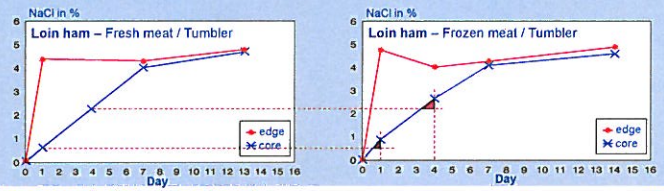


Nitrite *versus* Nitrate

RL 2006/52/EG (5. July 2006, update of RL 95/2/EG,
Annex III, **part C**, Table for E 249, E 250, E 251 and E 252)

E Nr.	Name	Food	Maximum amount added (as $NaNO_2$)	Maximum Residue (as $NaNO_2$)
E 249 E 250	Potassium & sodium nitrite	Processed meat	150 mg/kg	
		Raw ham, brine cured, & similar products		50 mg/kg
		Traditional dry-cured meat products; Dry-cured bacon and similar products		100 mg/kg
		Raw ham, dry-cured, & similar products		50 mg/kg
		Raw ham, dry-/brine cured, & similar products		50 mg/kg
E 251 E 252	Potassium & sodium nitrate	Processed meat without thermal treatment	150 mg/kg	
		Raw ham, brine cured (1.6) and similar products		250 mg/kg (~ 365 mg/kg as KNO_3)
		Raw ham, dry-cured, & similar products		
		Raw ham, dry-/brine cured, & similar products		

Reduction of Nitrate to Nitrite

a) $2\ KNO_3 \xrightarrow{\text{Reduction by Bacteria}} 2\ KNO_2$

b) $2\ KNO_2 \xrightarrow{\text{acidic conditions}} 2\ HNO_2$

c) $2\ HNO_2 \xrightarrow{\text{Anhydration}} H_2O + N_2O_3$

d) $N_2O_3 \xrightarrow{\text{Disproportionation}} NO + NO_2$

e) $2\ NO_2 + H_2O \xrightarrow{\text{Disproportionation}} HNO_2 + HNO_3$

f) $Mb + NO \longrightarrow$ NO-Mb

Nitrate curing

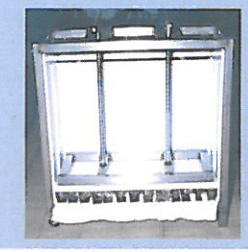
Dry curing, NaCl + 600 ppm potassium nitrate

	Day 16			Day 22			Day 42		
	Diffusion distance in cm								
	0 – 3	3 – 6	6 – 9	0 – 3	3 – 6	6 – 9	0 – 3	3 – 6	6 – 9
Nitrate in ppm	365	46	13	318	54	7	334	158	31
Nitrite in ppm	0	0	0	1.2	0	0	1.8	2.0	0
Curing colour in %	39	19	0	37	27	4	32	35	6
NaCl in %	7.8	1.2	0.4	9.1	1.9	0.6	8.0	4.4	2.2

- Nitrate - total
  - after 42 days – 523 ppm
- Nitrite - total
  - after 16 days – **0** ppm
  - after 42 days – **4** ppm
- Curing colour ratio (55%)
  - after 16 days – 39%
  - after 42 days – 35%

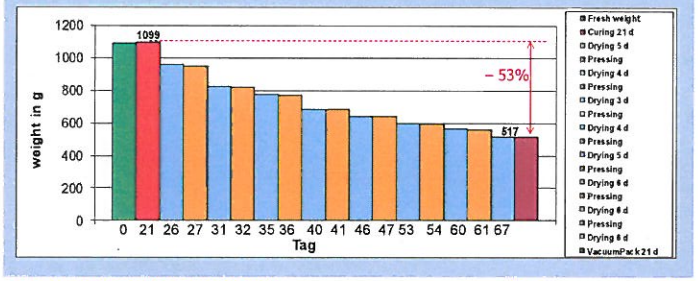
Drying/Pressurisation/Ripening

- Drying
  - Water removal by evaporation
  - Hazard: formation of hard edge → inhibition/stopp of evaporation → weak core
- Pressurisation
  - quick equilibration of water content between core and edge region
  - steady drying process



Drying/Pressurisation/Ripening

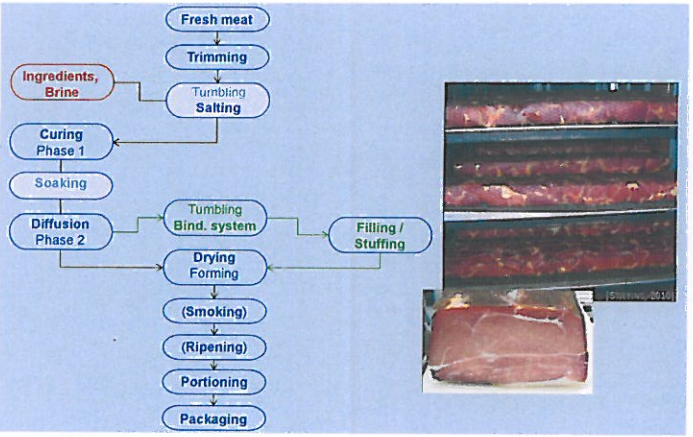
- Example Red deer raw ham from thick flank
  - pH of raw material: 5.8
  - Risk of case hardening
  - PRESSURISATION (in each case 1 day) → steady drying due to equilibration of water content



Degree of drying

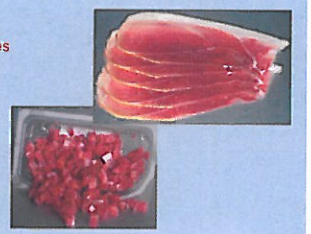
- Water content in raw ham – in the weakest part of the lean portion (LZ 2.414)
  - 65% bone-in ham, Black forrest ham, Hamburger Rauchfleisch, Nagelholz
  - 68% raw ham products usually produced from top and/or silver side
  - 70% special raw ham products from thick flank, hipe and some other cuts
  - 72% raw ham products produced from pork *Longissimus dorsi*
  - –3% for ham products with special accentuation (Delikatess, I a) or labelling such as air-dried or long seasoned

Raw ham – Industry products



Raw ham – Industry products

- Requirements
  - high efficiency during slicing process
  - proper aggregation of cuts and slices
  - high product safety (big surface area)
- Technology
  - aggregation of small individual hams
  - using tumbler for salting and binding system
  - forming with casings or containers
  - aggregation by means of binding system
  - application of additional preservation procedures
  - slicing, dicing, packaging (MAP)
- Product traits
  - offered as slices or dices
  - mild salty taste
  - relatively high water activity
  - often long shelf life
  - mostly cold storage demanded
  - can be produced from poultry meat



Additional preservation procedures

Aim: Stabilisation against microbial spoilage using

- refrigeration
- additives
- high hydrostatic pressure
- starter and protective cultures

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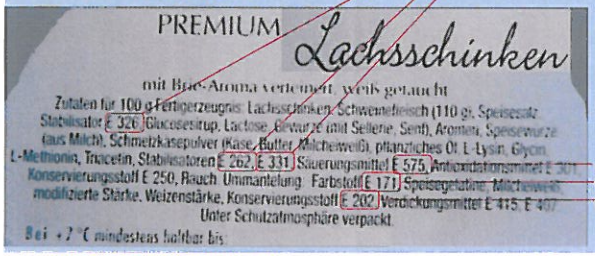

Additional preservation procedures

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Sensitivity of microorganisms against HPT

- Gram-positive bacteria more resistant than Gram-negative
- cocci more resistant than rods
- bacteria in logarithmic growth phase more sensitive
- bacterial spores very resistant to pressure

Additional preservation procedures

Aim: Stabilisation against microbial spoilage using

- refrigeration
- additives
- high hydrostatic pressure
- starter and protective cultures

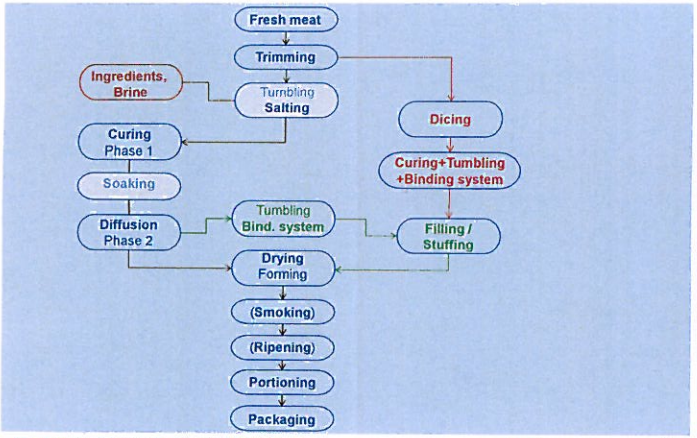
Process temperature during HPT

−18 °C 20 °C

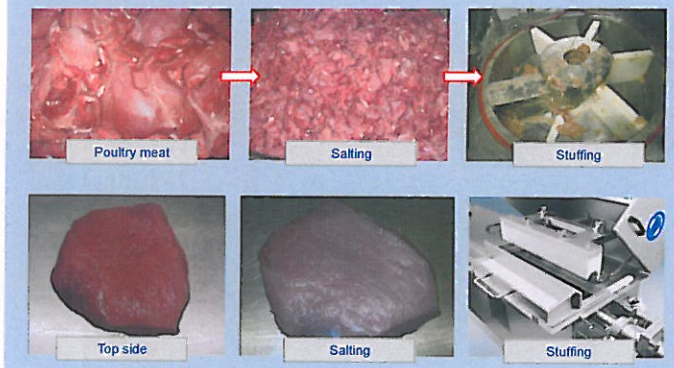
adiabatic temperature increase at 800 MPa = 24 K

+6 °C 44 °C

New raw ham products, formed/agglomerated



Manufacture of formed products



[STIEBING, 2010]

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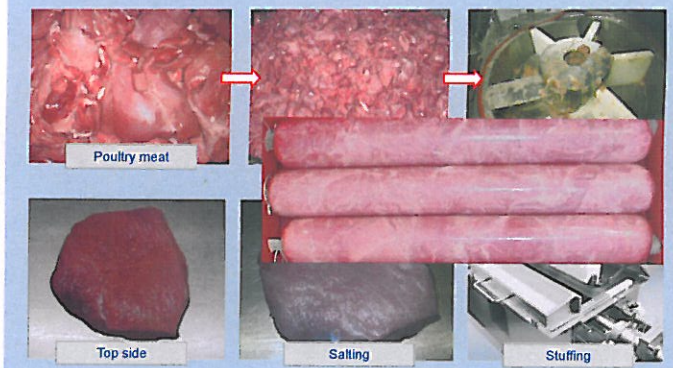
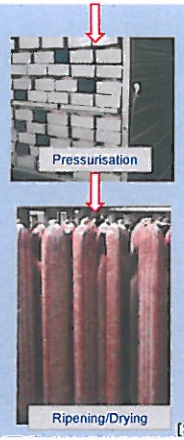


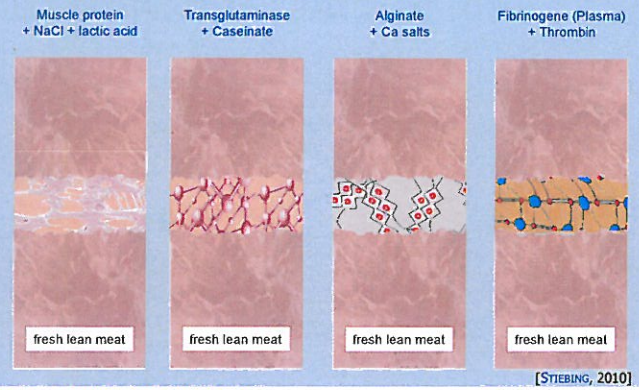
[STIEBING, 2010]

… further procedure



[Stiebing, 2010]

Binding systems

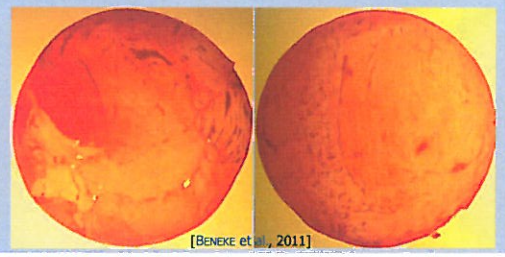


[Stiebing, 2010]

Formed raw ham products – Examination

Sensoriy assessment using a light box:

- formed products may be identified
- adhesive area visible (porous structure)
- fibres are sometimes not noticeable



[Beneke et al., 2011]

Formed raw ham products

Critical aspects

- Product labelling
  - fraud of consumers
  - identification limited
  - best way: control after filling
  - declaration "type of raw ham"
- Binding systems
  - enzymes
  - hydrocolloids
  - detectability limited

Positive aspects

- sustainable production
  - processing of high quality lean meat trimmings (with red meat)
- high product safety
  - tumble process intensivies salting
  - quick dissemination of salt within small pieces of meat
  - proper decrease of water activity
- nutritive aspects
  - low-fat products are common
  - sliced raw ham can also be produced from poultry

Formed raw ham products

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Labelling!

Positive aspects

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- nutritive aspects
  - low-fat products are common
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Conclusion

- Dry-cured raw ham: detailed description in German guidelines for meat and meat products
- Quality criteria: shelf stable wo cooling, consistent colour, typical flavour, firm texture
- Raw material: refrigerated, hygienic meat with pH value < 5.8
- Curing process: temperature 3 °C until a_w value < 0.96 is reached (or salt content of 4.5%)
- Nitrate: not recommended at 3 °C (bacterial reduction of Nitrite)
- Salting with Tumbler: maximum and controlled deposition of salt in surface layer of meat
- Frozen meat (thawed): in favour of diffusion process of salts and of drying process
- Mechanical pressurisation: no case hardening and drying edge, quick drying, forming

- Industry product from small hams: Binding systems required, no declaration/labelling
- Application of anti-microbial additives
- High pressure treatment is used sometimes
- Innovative, formed raw ham products: Binding systems needed
  Labelling as "Ham" not permitted
  Update of German Guidelines necessary