Cooked Products

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The aim of this report is the illustration and documentation of important new comprehensions in technology and technique of cooked meat-products. Considering that technology and technique of the various products is quite different, I have chosen an arrangement into 3 classes: Cooked ham, scalded sausages and meat-products produced predominant from precooked materials.

1. Cooked ham

Examinations on the influence upon the slice-connection have consised the following comprehensions: Hot boned meat, cold meat, PSE-meat, and raw material used, do exercise, in this sequence, a decisive influence on the cohesion of slices of cooked ham.
Especially concerning the manufacturing of hot-boned meat the material should be selected by pH-value (30 min p.m.) and only hams with pH-values > 6,3 should be taken. This pH-value is normaly related with an R-value of > 1,05 where the onset of rigor mortis yet not entered (see figure 1). The hot-boned hams must be injected as quick as possible. The limit within which the high WHC can be exploited lies at about 80 min p.m. and can be prolonged at very high pH-values to 105 min p.m. (see figure 2).
Disintegration of the tissue-structure by mechanical treatment as squeezing for example with subsequential immediate injection with normal brine about 10°C - the injection with minus-brine showed no advantage - and direct tumbling at +5°C for at least 6 to 7 h has been favourable. An intermission after tumbling might be advantageous at low tumble-intensities.
Little additives of phosphates (0,05-0,1 %) are able to raise the yield even at prae-rigor-meat (see table 1). When manufacturing hot-boned meat from intact muscles only 50-60 % of the present high WHC is available, because the salt is unable to penetrate fast enough into the myofibrills. That's why additives of phosphate are positive even by hot-boned meat (Reichert et al., in press).
One of the most important factors of influence on the slice cohesion is the composition of the injection brine in connection with the mechanical treatment procedure. A concentration of 2,5 % NaCl, relative to brine-injected ham weight, brings good cohesion when combined with a mechanical treatment procedure involving approximately 100 min at 20 rpm (for a total of 2.000 revolutions). An addition of Na-K-diphosphat resulted in a substantial improvement of slice cohesion. The quality of slice cohesion is closely conneted to the amount of myofibrillary protein which, as a result of salt and phosphat activity, is present in solved state. What is required is a 45 % share of solved myosin and actin (see table 2).

The water binding capacity increases with increased tumbling intensity (up to 8.000 total revolutions), with ambient temperature (0°C to 10°C) and with an atmosphere characterized by oxygen withdrawal (see figure 3). From 2.000 total revolutions onward, slice cohesion showed no further improvement. While the influence of temperature was slight, it was nonetheless significant (recommended levels are between 5°C and 7°C). Vaccum treatment was shown to improve slice cohesion by about 20 %. Long-term heat treatment plus good slice cohesion was a combination attainable in the 65°C to 70°C temperature range only (see figure 4).
Responsible for slice cohesion is not the amount of connective tissue protein which has passed over into solved state during the heat treatment period, but rather its structure and composition and a minimum content level of %-fractions of 60 % (see table 3).
As thermal-treatment the Delta-T-cooking is proposed. The attaining effect of thermal-treatment should correspond to F=20-70 (basic temperature 70°C, z-value 10°C). The cooling down of the hams should exercised slowly by ambient air to a center temperature of 55°C. Subsequently a further cooling in a cooling chamber is necessary (Reichert et al., 1985).

Scalded Sausages

In production of sausages relative to the least cost formulation the determination of bind value constants of different meat materials respectively meat standards was till now issued from the emulsifying capacities and/or emulsion stabilities. Parks et al. postulate new concepts which integrate WHC and the gelation phenomenon. As the most favourable estimation of bind value constants the percental total content of meat protein of the raw material is assigned. As regression equation for Class I = striated, skeletal muscle meats - $y = -1,676 + 1,42264 * x$ total content of meat protein ($r^2 = 94,5$) is assigned (Parks et al., 1985).
Own investigations have shown that the product of protein able to swell and pH-value leads to a significantly better estimation. Protein able to swell PAS = total meat protein - connective tissue protein - globuline - albumine, in which case, in order of simplification the content of globuline and albumine could be neglected in calculation. In any case the pH-value is to be respected. In determination the bind values of 4 different standards of pork meat and 3 different heat treatments a good correlation of a protein able to swell * pH value from r = 0,997 (80°C), r = 0,857 (100°C) and r = 0,794 (110°C) was yielded. In order to investigate the influence of fat tissue, the fat tissue was separated from the standards as far as possible manually and then the fat tissue was separately analysed with standard lean meat with regard to different effects concerning the binding capacity. Hereby it was shown, that the fat tissue analysed has only a very small respectively no influence.

Improving the binding properties

Investigations into the influences exercised by cutter time and temperature - we used constant cutter temperatures from +15°C to -2°C - led to the following results:

Flaked CO_2 used as a coolant. Total deposition, as relates to cutter temperature, process time and heat treatment temperature, is represented in figure 5. During the trials, it became evident that total deposits increased distinctly when cutter temperatures from +10°C to -2°C and cutter work times shorter than those indicated in the exhibits were employed. Charges treated with 80°C heat showed a level of fat deposition from 0,5 to 1,8 % when cutter temperature was +15°C; at 10°C cutter temperature, the comparative values determined were 0,1 to 0,6 %. No deposits were determined for the charges of the +5°C, 0°C and -2°C cutter treatments. With a level of total deposits of 4,1 %, 0°C combined with 28 min process time proved to be the most favourable cutter conditions. The -2°C cutter temperature did not produce any significant reduction in total depositions. Conversely however, when the +5°C cutter temperature was employed, total deposition increased by approximately 1,5 % after 24 min of cutter time already. As was naturally expected, charges receiving a 100°C or 110°C heat treatment also exhibited higher total depositions but in the same relation like the 80°C heat treatment.
Our trials with liquid nitrogen used as a coolant yielded the finding that a constant cutter temperature of 0°C produced the best batch stability. Compared with traditional cutter process methods , the connective tissue free meat protein content level could be reduced by at least 0,3 % (approx. 1,5 % lean meat, minimum). This reduction notwithstanding, total deposits were still distinctly lower than those associated with conventional cutter process technology when heat treatments of either 80°C, 100°C or 110°C were employed over 60 min timeframe (see figures 6-8). These comparisons relate to eight minutes cutter process time(see figure 9). For longer cutter times, up to 20 min for example, further improvements in batch stability could be achieved. In terms of sensory evaluations, batches cutter-processed with the addition of liquid nitrogen as a coolant had more intensive color, while taste and odor differences could not be determined. In the course of several, independently performed trials, it could be clearly demonstrated that the cutter process performed at constantly low temperatures is distinctly more favorable in terms of batch stability than can, by comparison, be said for the conventional cutter process technology without refrigeration. The 5°C to -2°C temperature range proved to produce,within that range, very insignificant differences only. The trend clearly aims at the 0°C mark; -2°C partially produced some icing already. Refrigeration can be effected with both, flaked CO_2 or liquid nitrogen, in which connection mention must absolutely be made of the fact that, when flaked CO_2 is used, evacuation at the end of the cutter process is positively indispensable in order that solved CO_2 gas can be removed. Failling this, pH values reduced by approx. 0.2 unit points and remaining CO_2 gases in solved state would manifest negative effects during heat treatment in the form of bursting of natural casings and/or destruction of the batch material's structure.
What then, are the factors instrumental in improving batch binding ability for material worked in the cutter at constant low temperatures over that of batches manufactured in the cutter under conventional process-technological methods? Following the theory that protein, in solved state, plays a particulary positive role in binding capacity, we can trace several workers' papers which are suggestive of improved protein solubility at lower temperatures. There also seems to be great certainty that the more intensive comminution of lean meat at lower temperatures exercises influence on binding capacity. Due to decreased resilience, lean particles should be less capable of avoiding the action of the cutter knife blades. At any rates, however, the possibility exists to employ longer cutter process time which, as the experiments have shown, enable the processor to achieve clearly improved binding capacity. Investigations into the myosin-related factors influencing gel firmness have shown that the time in which salt is allowed to unfold its activity must be credited with a significant role so that these process-related attributes of salt may be possibly explain some positive effects of presalting (Reichert, 1983) and a longer-term comminuting process at lower temperatures. Also, the temperatures at which the cutter process is run should have an effect on fat binding.

Preserved sausages, like frankfurters

The production of preserved sausages, like frankfurters, again and again leads to difficulties concerning the bursting of the casings. In order to develop calculative methods for heat treatments in relation to the time of bursting from sausages in casings their behaviour of bursting in dependence of time, temperature and presure was examined. For the examination of the bursting behaviour of casings depending on temperature and time (z-value) it is necessary to implement bursting-tests at at least three different temperatures. The experiments have shown, that temperatures of 100°C, 104°C and 108°C (using salt solution) are suitable. A formulation for the calculation of the behaviour of bursting in relation to the heat treatment could be established. The previous determination of some parameters (like water and air content of the sausages) however, is necessary for the application. If this parameters are known, the necessary pressure for the wanted or optimal temperature and time of sterilization can be calculated (see fig. 10) (Reichert in press).
For the determination of the bursting time with a given pressure or the necessary pressure with a given cooking time it has to be ascertained the bursting regression line, for example $y=-0,0534x + 6,334$. For the maximal cooking time without bursting and a given pressure the following equation can be used:

$$\log t = - 0,0534\ T + 6,334 + 2,33 \cdot \log p$$

For a given cooking time the necessary pressure can be calculated with the following equation:

$$\log p = 0,025\ T - 3,07 + 0,519 \cdot \log t$$

T = temperature, t = bursting or cooking time, p = pressure

Cooling rates for meat products

The cooling of four different sausages in different casings (see tab.4-6) in ambient air

(20°C) in comparison with the conventional shower cooling showed the following results:

The negligible slower rates of cooling of heat treated sausages in ambient air didn't result in a higher bacterial count compared with the sausages cooled by shower.The different cooling methods were practised as a center-temperature reached 55°C following normal cooling in refrigerating chambers.

A cooling down in ambient air in relation to the conventional shower cooling arises - relative to the same F-value - three energetic advantages:

- reduction of proceeding-time in the cooking chamber up to 30 % -
- retrenchment of water for showering -
- by the reduction of the heating-time the cooking chamber can be charged in shorter intervals, resulting in a higher output -

Slow cooling of cooked ham resulted in better cohesion. Slow cooling of meat in gelatine resulted in firmer gels that leads to retrenchment of gelatine (see fig. 11)(Reichert and Thumel,1986).

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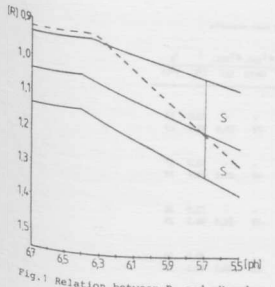


Fig. 1 Relation between R- and pH-values in ham muscles.
~ ~ ~ = values of Kim et al.,1985
s = standard deviations

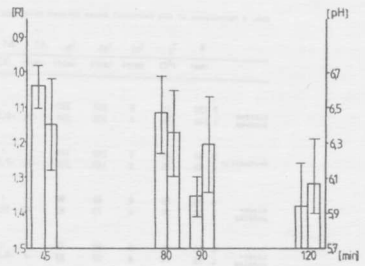


Fig. 2 R- and pH-values in relation to time p.m. in ham muscles.

Table 1 : Parameters influencing cook losses and yield (%) manufacturing ham

T R	pH	s	R	s	Injec %		Cook-l %		yield %		
0	6.25	0.08	1.01	0.04	17.0	3.6	-22.7	0.3	-9.6	2.3	
0	6.03	0.17	1.03	0.02	18.2	0.8	-14.1	0.5	+1.8	0.7	p
0	6.15	0.10	1.05	0.03	14.1	0.7	-20.9	1.6	-9.8	1.9	q
540	6.31	0.06	0.99	0.01	20.4	1.1	-14.9	1.3	+2.4	0.9	
540	6.42	0.31	1.02	0.05	17.5	0.4	- 8.5	1.0	+7.8	2.0	p
540	6.25	0.07	1.04	0.02	18.4	6.8	-16.9	3.5	-1.7	3.2	q
1080	6.13	0.08	1.00	0.02	17.1	2.3	-16.4	0.8	-2.2	1.8	
1080	6.16	0.37	1.06	0.04	18.2	1.3	-12.5	0.8	+3.5	1.0	p
1080	6.16	0.24	1.08	0.04	26.0	1.0	-22.1	2.2	-1.7	3.7	q
1620	6.23	0.16	1.00	0.06	17.4	0.4	-14.9	2.6	-0.6	3.4	
1620	6.22	0.21	1.07	0.04	19.6	0.2	-11.8	1.9	+5.8	2.7	p
1620	6.16	0.38	1.08	0.07	22.1	1.2	-18.0	2.1	+0.1	2.5	q
2160	6.02	0.14	1.08	0.02	20.3	2.6	-18.5	2.1	-3.4	2.4	
2160	6.10	0.16	1.08	0.01	17.3	0.9	-11.4	2.1	+4.0	2.6	p
2160	6.00	0.33	1.08	0.06	24.4	2.5	-17.9	1.4	+2.1	0.9	q
2700	6.15	0.21	1.03	0.04	21.0	0.5	-16.0	2.8	+2.0	3.9	
2700	6.00	0.08	1.09	0.05	21.3	0.5	-14.3	3.0	+3.9	0.4	p
2700	6.16	0.28	1.06	0.04	23.4	2.5	-16.2	2.2	+3.3	0.3	q

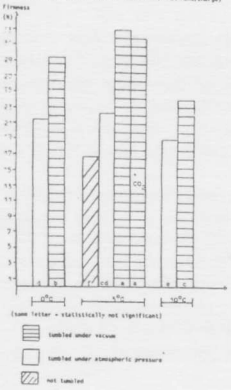
p 0.02 % phosphat in cooked product
q mecanical treatment
T R = total revolutions

Tab. 2 Connection between sodium-, potassium-phosphate - and salt content, binding strength and dissolved myofibrillar protein (n=10)

salt content (%)	content of sodium-, potassium-phosphate (%)	binding strength sensorial (5-point-pattern) not tumbled	tumbled *	instron-measurement not tumbled (N)	tumbled* (N)	% myosin and actin in soluble phase tumbled*
0,14						
1,5	0,5	1,5	2,0	40	46	33
1,5	0,025	2,0	2,0	44	46	31
2,0	0,05	1,8	2,8	46	55	32
2,0	0,05	3,0	3,0	37	51	44
2,5	0,07	2,0	4,8	28	49	51
2,5	0,04	2,2	4,8	43	51	46
2,5	0,05	3,5	5,0	44	44	47
2,5	0,5	3,0	5,0	52	54	
	0	2,0	3,5	54	49	27

*20 rpm, 400 minutes, vakuum, ambient temperature 5°C

Figure 3 Influence of method of treatment and temperature on firmness (like cohesiveness) of cooked hams (n= 20 hams/charge)



Tab. 3 Composition of the soluble connective-tissue-protein-fractions (%) in dependence of heat treatment and extraction-proceedings

Extraction-proceedings	heat temp°C	treatment time (h)	soluble connective-tissue-protein %		
			x̄	σ	s
hotextract	60	1	78.8	21.2	
		3	75.8	24.2	
		4	55.6	44.2	
		6	43.4	46.8	7.8
	70	2	64.1	28.1	7.8
		3	no exact bands		
		5	no exact bands		
	80	1	64.4	35.6	
		2	53.8	46.2	
		3	54.1	45.9	
		4	40.0	33.0	27.0
		6	42.8	29.5	27.6
extraction after quick-cooling	60	1	65.0	35.0	
		2	57.1	42.8	
		3	64.2	57.8	
	70	2	64.3	35.7	
		3	58.3	30.4	11.3
	80	5	64.6	21.2	14.2
		1	55.0	44.2	
		2	58.0	42.0	
		3	55.2	44.8	
		4	no exact bands		
		6	no exact bands		
extraction after cooling	60	1	45.7	54.3	
		3	49.1	50.9	
		4	43.5	56.5	
		6	40.5	59.5	
	70	0.5	64.6	35.4	
		1	54.0	46.0	
		2	50.0	50.0	
		3	61.1	38.4	
		6	58.5	41.5	
	80	0.5	48.0	52.0	
		1	54.2	45.8	
		2	no exact bands		
		3	-	-	-
		6	-	-	-

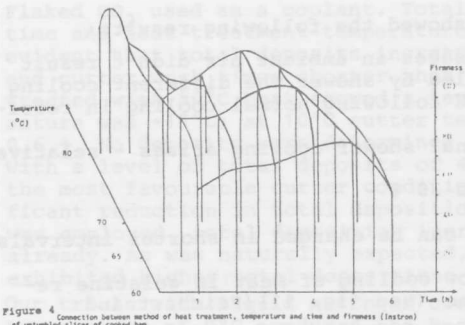


Figure 4 Connection between method of heat treatment, temperature and time and firmness (Instron) of untumbled slices of cooked ham.

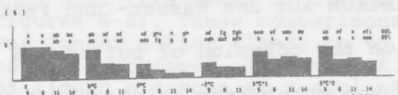


Fig. 6 Total deposits (jelly and fat) in relation to cutter temperature and time. Heat treatment 80°C 60 min. Other dates see fig. 5 and 8.

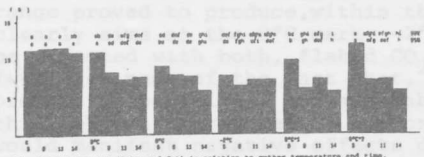


Fig. 7 Total deposits (jelly and fat) in relation to cutter temperature and time. Heat treatment 100°C 60 min. Other dates see fig. 5 and 8

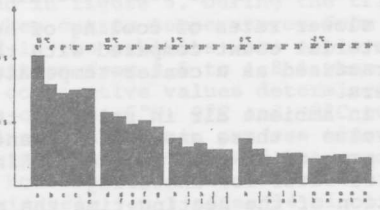


Fig. 5 Total deposits (jelly and fat) in relation to cutter temperature and time. Heat treatment 80°C 60 min (can 73 Ø x 170 mm). Different letters above bars are significantly different (P≤0,05)

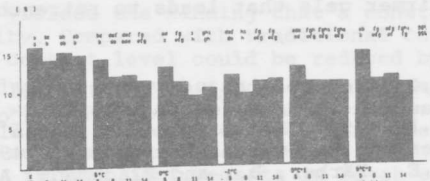


Fig. 8 Total deposits (jelly and fat) in relation to cutter temperature and time. Heat treatment 100°C 60 min. A = conventional cutter process. *1= 0,5 %, *2= 1,0 % lean meat less. Other dates see fig. 5.

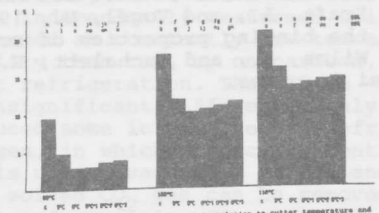


Fig. 9 Total deposits (jelly and fat) in relation to cutter temperature and time. Comparison between conventional, constantly low and lean meat reduced (0,5;1,0;1,5 %) cutter processes. Cutter time 8 min. Other dates see fig. 5.

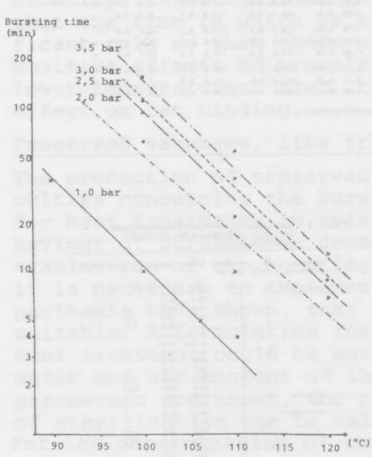


Fig. 10 Regression lines of the bursting-times of sausages in casings in relation to temperature and pressure.

Tab. 4 Comparison of the technical dates between water- and air-cooling of meat products

	Ø (mm)	T_1 (°C)	t_{h1} (min)	t_{h2} (min)	t_h (min)	Δt (min)	Δt (%)	t_c (min)	$t_{tot.}$ (min)	$\Delta t_{tot.}$ (min)	$\Delta t_{tot.}$ (%)	T (°C)	T_o (°C)
Scalded sausage	D 120	75	8	222	230	-	-	58	288	-	-	70,0	13
	L 120	75	8	208	216	-14	-6,1	106	216	-72	-25,0	69,0	13
Mortadella	D 95	75	8	140	148	-	-	35	183	-	-	70,0	17
	L 95	75	8	129	137	-11	-7,4	68	137	-46	-25,1	68,7	17
Black-pudding	D 80	75	8	82	90	-	-	23	113	-	-	70,0	26
	L 80	75	8	73	81	-9	-10,0	55	81	-32	-28,3	66,3	26
Liver-pudding	D 65	75	8	64	72	-	-	21	99	-	-	70,0	18
	L 65	75	8	57	65	-7	-9,7	43	65	-28	-30,1	68,1	18

Tab. 5 Comparison of the technological dates between water- and air-cooling of meat products

	Ø (mm)	F_h (min)	F_c (min)	F (min)	F_h/F_c (%)	f_h (min)	f_c (min)	j_h (%)	j_c (%)	T_1-T (°C)
Scalded sausage	D 120	40,8	35,2	76,0	1,2	168	220	1,8	1,2	5,0
	L 120	27,4	48,6	76,0	0,6	168	365	1,8	1,5	6,0
Mortadella	D 95	25,7	21,5	47,2	1,2	107,5	142	1,7	1,3	5,0
	L 95	15,1	32,1	47,2	0,5	107,5	300	1,7	1,3	6,3
Black-pudding	D 80	17,7	13,3	31,0	1,3	68,5	92	1,6	1,3	5,0
	L 80	8,3	22,7	31,0	0,4	68,5	252	1,6	1,2	6,7
Liver-pudding	D 65	13,2	8,8	22,0	1,5	51,5	64	1,5	1,5	5,0
	L 65	6,8	15,2	22,0	0,4	51,5	208	1,5	1,2	6,9

Tab. 6 Comparison of the energy-and water-costs of meat products in casings by shower and air-cooling

Product	Scalded sausage		Mortadella		Black-pudding		Liver-pudding	
Diameter Ø (mm)	120		95		80		65	
Cooling-condition	S	A	S	A	S	A	S	A
Product quantity per rank (kg)	1158	1158	919	919	800	800	765	765
Kcal/rank	60.021	59.183	44.214	43.433	32.162	31.300	35.005	34.250
kWh	69,8	68,8	51,4	50,5	37,4	36,4	40,7	39,8
kWh/100 kg	6,03	5,94	5,59	5,50	4,68	4,55	5,32	5,20
DM/100 kg	0,452	0,446	0,419	0,413	0,351	0,341	0,399	0,390
Water consumption per rank (m^3)	0,493	-	0,293	-	0,196	-	0,179	-
m^3/100 kg	0,043	-	0,032	-	0,025	-	0,023	-
DM/100 kg m^3 = DM 2,5	0,108	-	0,079	-	0,063	-	0,058	-
Total costs DM/100 kg	0,560	0,446	0,499	0,413	0,414	0,341	0,457	0,390
%	-	-20,4	-	-17,2	-	-17,6	-	-14,7

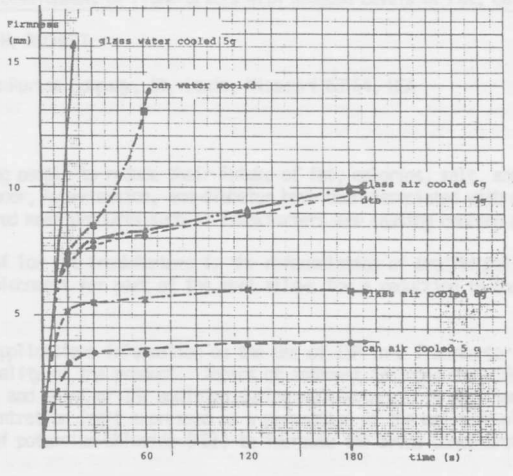


Fig.11 Gel-stability of aspic jelly in dependence of cooling rate measured over the penetration depth of a stamp in relation to time.
can= 99 Ø · 63 mm