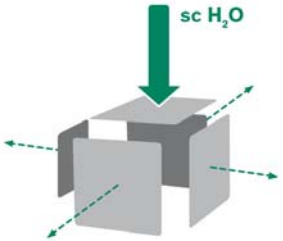
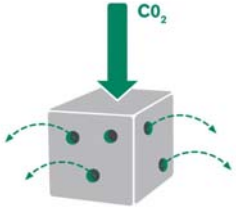
Einfluss von hohem hydrostatischen Druck auf die Struktur von Lebensmitteln

Volker Heinz

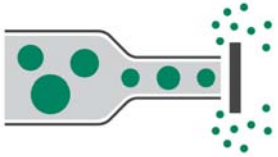
Pressure Processing Principles



Supercritical Water



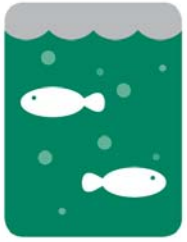
Supercritical CO2



Homogenization

Extrusion

Shock Waves



Blue Biotechnology

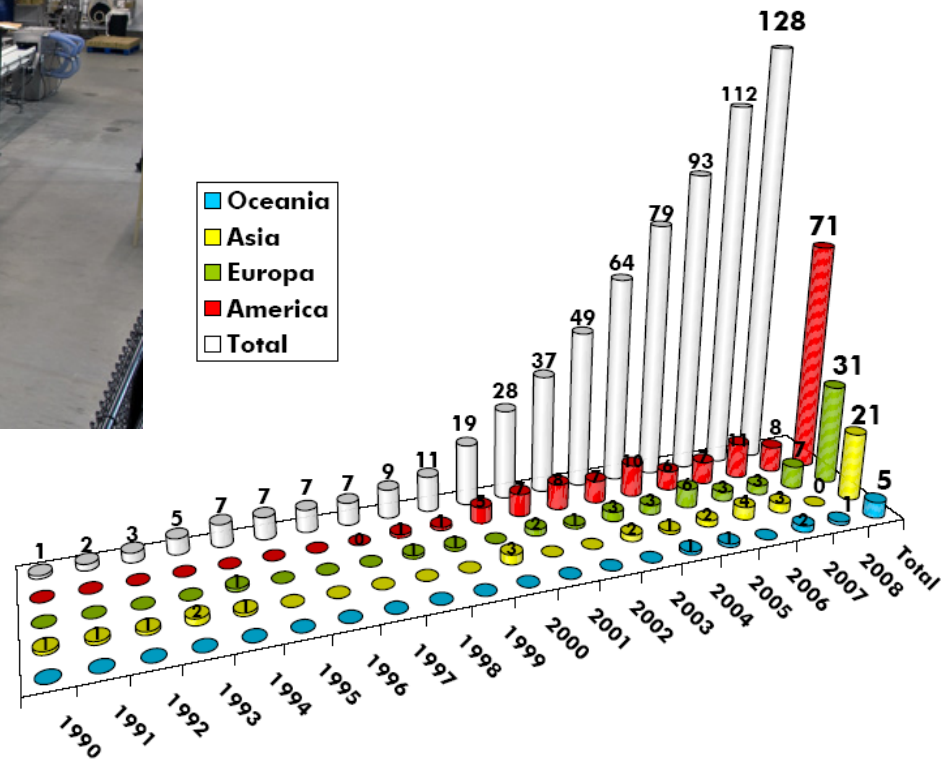
Hydrostatics

Impact of R&D

Table 1.1 Types of R&D (Roussel *et al.*, 1991)

Type of R&D	**Percentage change of success**	**Period till commercial Success**	**Competitive advantage**	**Durability of competitive advantage**
Incremental Line extensions and new applications	40 - 80 %	6 - 24 months	Medium	Short, typically imitable by competitors
Radical New ideas on basis of existing science and new technology	20 - 40 %	2 - 7 years	Strong	Long, often protectable by patents
Fundamental New science as a basis for unknown commercial successes	Difficult to measure	4 - 10 years	Very strong	Long, often protectable by patents

High Pressure
? Incremental - Radical - Fundamental ?



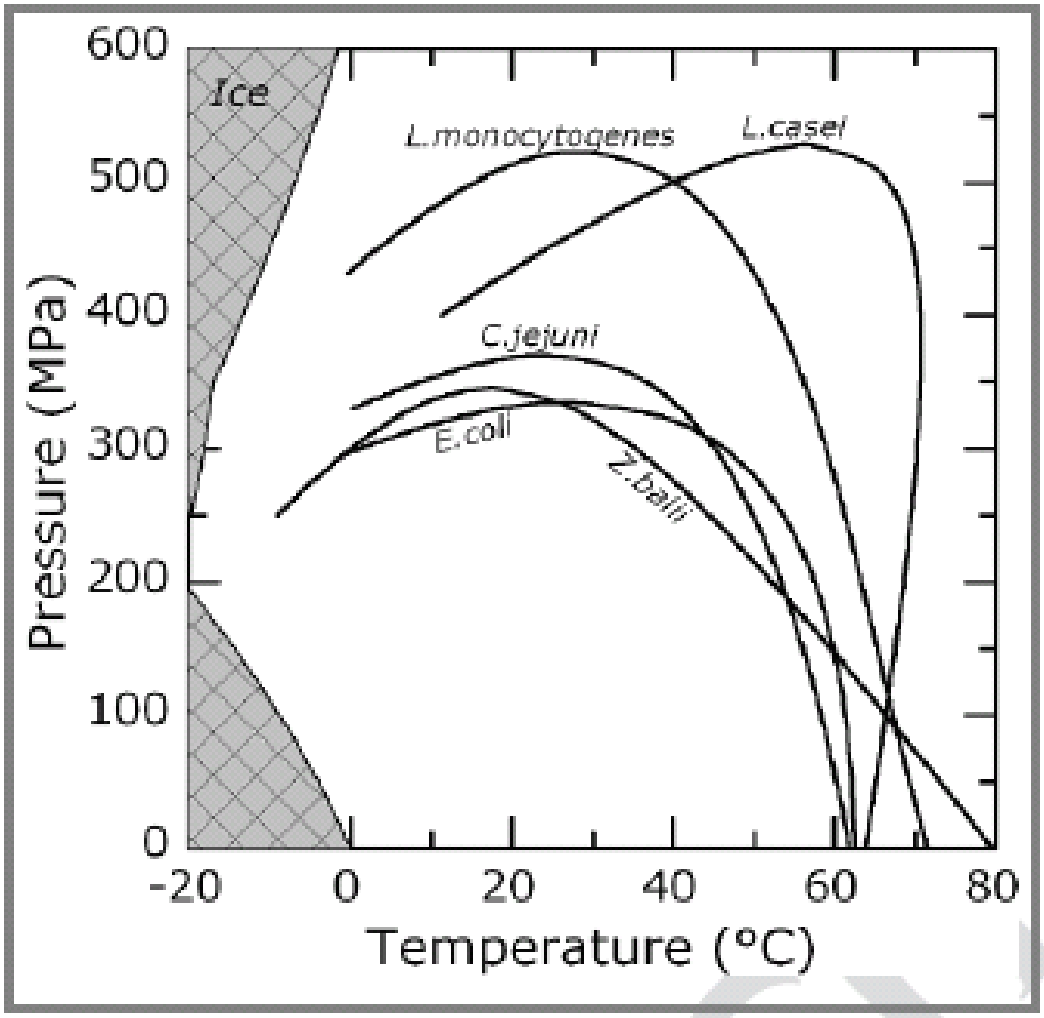


Figure 2. Pressure-temperature isorate diagram for 5 log inactivation of *C. jejuni* [37], *E. coli* and *L. casei* [38], *L. monocytogenes* 74903 [39] and *Z. balii* [41] after 5 min isothermal/isobaric treatment.

Source: Neptune-p-T Archive

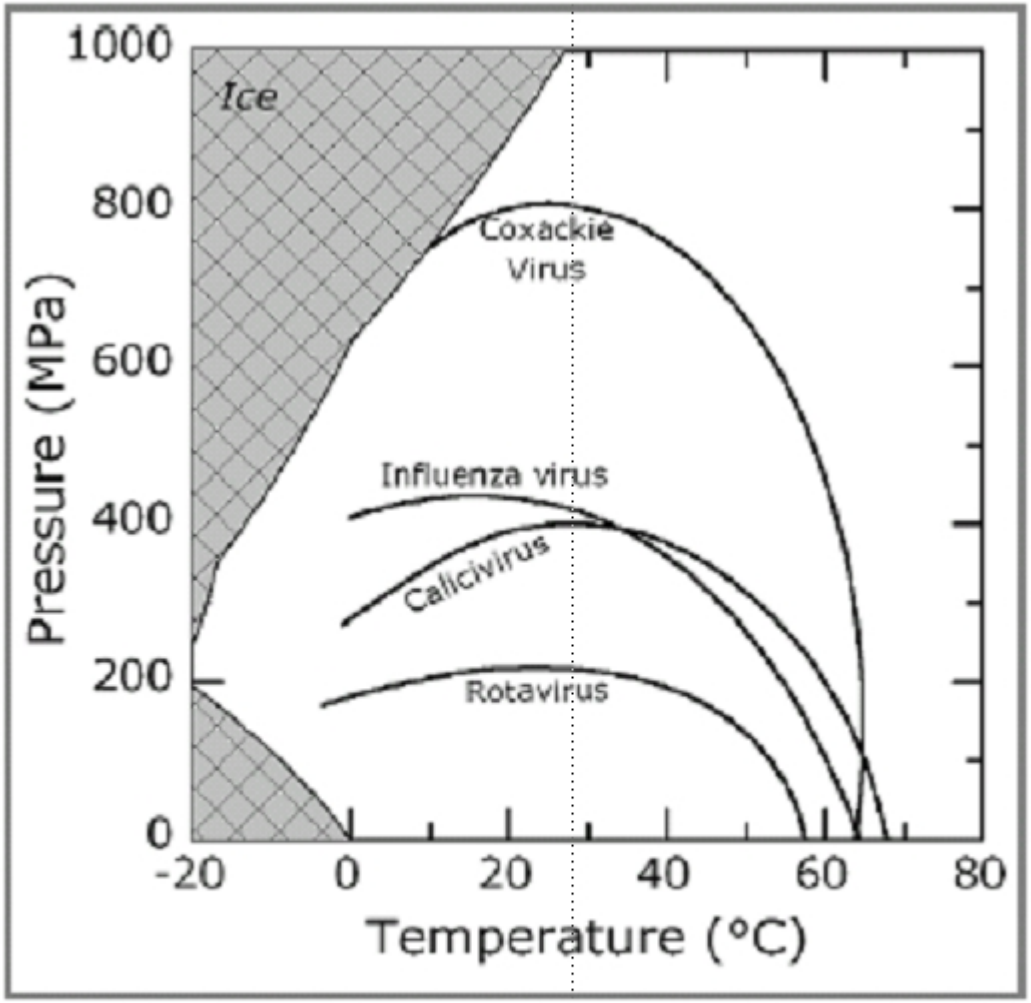


Figure 4. Pressure-temperature isorate diagram for 5 log inactivation of Avian influenza virus (in chicken meat slurry) [42], Feline calici virus (in eagle medium) [45], Coxsackie virus and Rota virus [46] after 1 min isothermal/isobaric treatment.

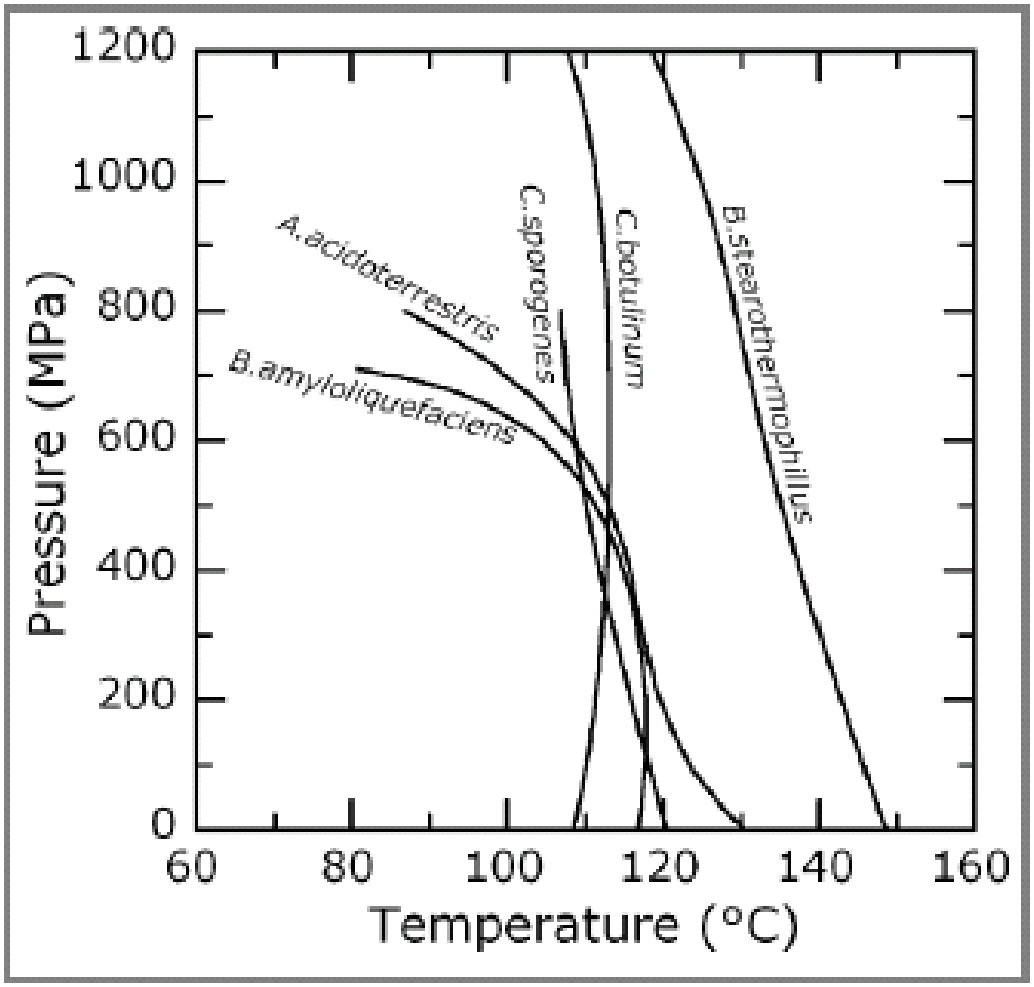
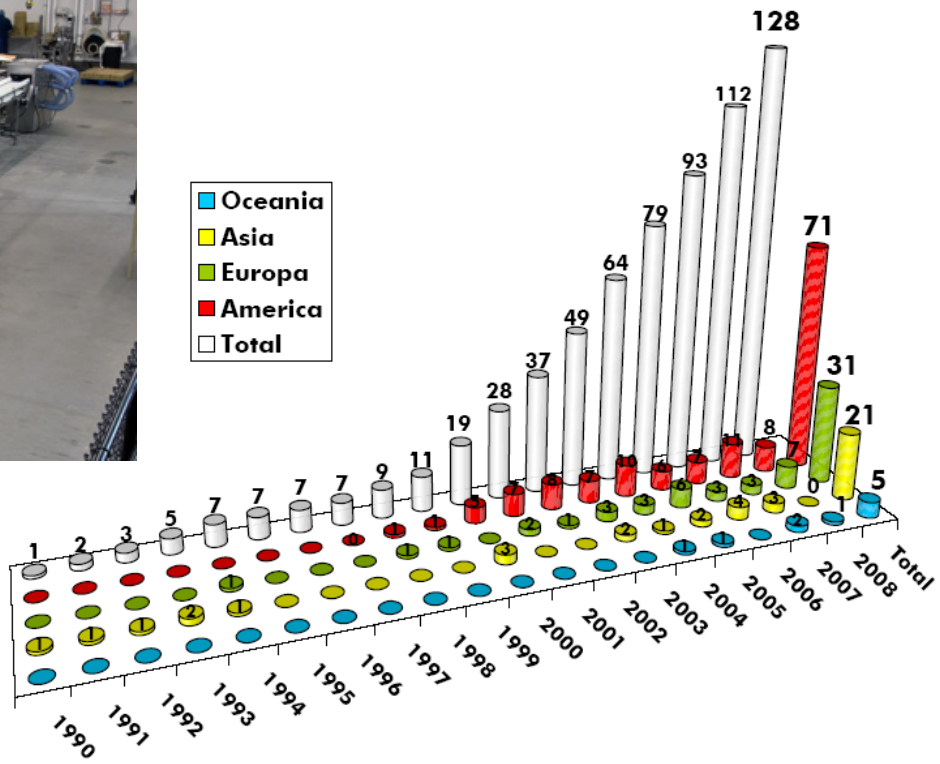


Figure 3. Pressure-temperature isorate diagram for 5 log inactivation of *A. acidoterrestris* [47], *B. amyloliquefaciens* [48], *B. stearothermophilus* [49], *C. botulinum* [50] and *C. sporogenes* [51] after 5 min isothermal/isobaric treatment.

Costs of HPP in Industrial Practice

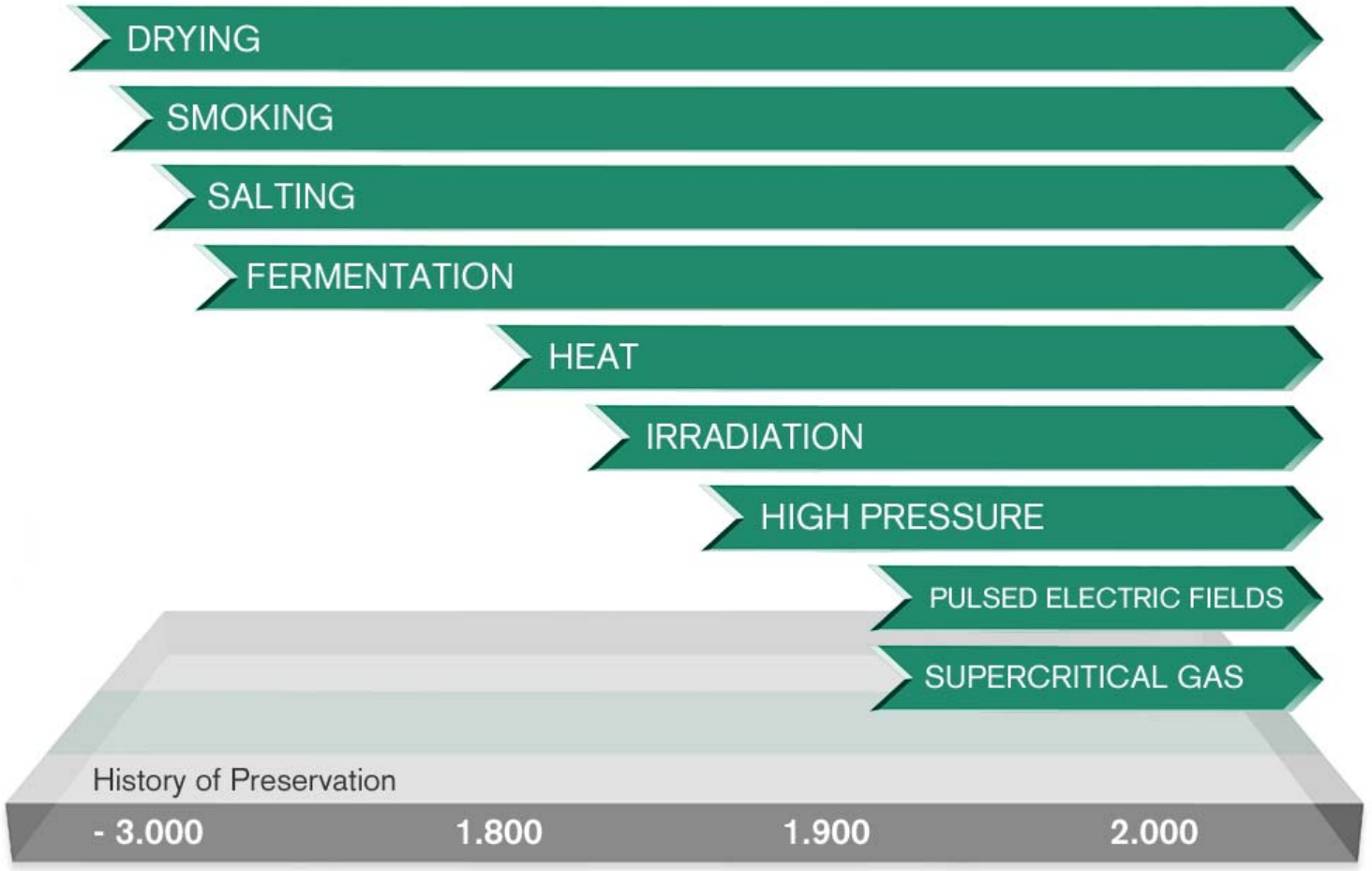


Specific costs **€/t**

Comp	Maintainance	Spare Parts	Energy	Variable	Capital	Total	x1.5 (hot process)
A	160	60	30	250	250	500	750
B	190	55	35	280	280	560	840
C	105	48	35	188	188	376	564
D	125	70	20	215	215	430	645

Data from HPP users

Tradition and New Technologies

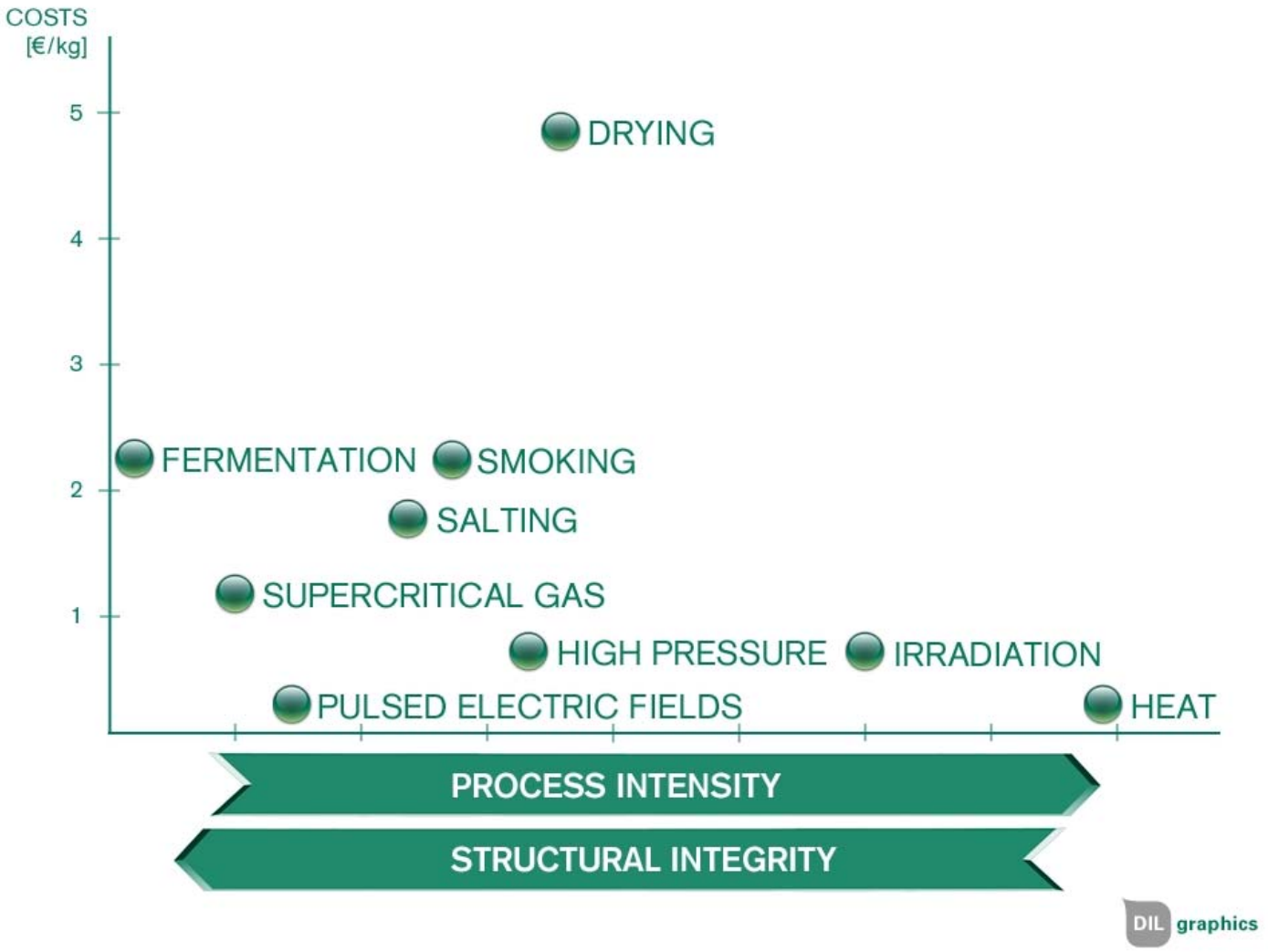


DIL graphics

Preservation – Quality – Costs

	PROCESSING PARAMETERS	PROCESSING INTENSITY	LETALITY	STRUCTURE IMPACT	COST [€/kg]
DRYING	T, t	+	– –	+ +	5
SMOKING	c, T, t	+	+	+ +	2
SALTING	c, t	–	+	+ +	1
FERMENTATION	b, T, t	– – –	+	+	2
HEAT	T,t	+ + +	+ + +	+ + +	0.05
IRRADIATION	∫ w	+ +	+ + +	+ +	0.3
HIGH PRESSURE	p, T, t	+	+ +	+	0.3
PULSED ELECTRIC FIELDS	E, ∫ w	+ +	+ +	+	0.1
SUPERCRITICAL GAS	c, p, T, t	+	+	+	1

Preservation – Quality – Costs



Processes

Our Business

- Fonterra at a Glance
- News
- Innovation and Technology
  - Taking the Lead
  - Products
  - Processes
- Sustainability
- Supplying Fonterra
- Working at Fonterra

Our Products

- Consumer Brands
- Ingredients
- Foodservices
- The Story Of Milk
- Dairy and Nutrition

Search

We are always looking at how we can do things better. Whether it's on the farm or during the manufacturing process, our innovation is what gives us the edge.

Manufacturing Innovation

Increasing manufacturing efficiency while driving down operating costs is the challenge for our team of innovators working in Fonterra's Manufacturing business.

High Pressure Processing

Fonterra Ingredients' High Pressure Processing (HPP) innovation team has turned the forceful water pressures normally used as a "blunt" food preservation tool into a high precision instrument for working with dairy products.

Heat Recovery Loop

Our award-winning heat recovery loop project is just one example of the leading role we are taking in our efforts towards operating in ways that are energy-efficient.

Kiwi ingenuity at its best

Our production capabilities and our farmer suppliers' on-farm operations are recognised as being world-leading.

Highly Automated Manufacturing

The development and implementation of innovative technology to achieve cost, time and waste savings across our manufacturing business is a key priority for Fonterra.

Milk Concentration Technology

3,000 fewer tanker movements, significant cost-savings and environmental benefits are the results of the world-first milk concentration technology employed at our Tua Marina site in the South Island of New Zealand.

Our Sustainability

We take sustainability considerations into account in all aspects of our business.

A Glass of Milk

You'd be surprised at how many nutrients are packed into a glass of milk.

Fonterra
Dairy for life

Home > Innovation and Technology > Processes

Processes

View Map

Our Business

- Fonterra at a Glance
- News
- Innovation and Technology
- Taking the Lead

We are always looking at how we can do things better. Whether it's on the farm or during the manufacturing process, our innovation is what gives us the edge.

Manufacturing Innovation

Increasing manufacturing efficiency while driving down operating costs is the challenge for our team of innovators working in Fonterra's Manufacturing business.

High Pressure Processing

High Pressure Processing

Fonterra Ingredients' High Pressure Processing (HPP) innovation team has turned the forceful water pressures normally used as a "blunt" food preservation tool into a high precision instrument for working with dairy products.

- Consumer Brands
- Ingredients
- Foodservices
- The Story Of Milk
- Dairy and Nutrition

Search

Our production capabilities and our farmer suppliers' on-farm operations are recognised as being world-leading.

Highly Automated Manufacturing

The development and implementation of innovative technology to achieve cost, time and waste savings across our manufacturing business is a key priority for Fonterra.

Milk Concentration Technology

3,000 fewer tanker movements, significant cost-savings and environmental benefits are the results of the world-first milk concentration technology employed at our Tua Marina site in the South Island of New Zealand.

A Glass of Milk

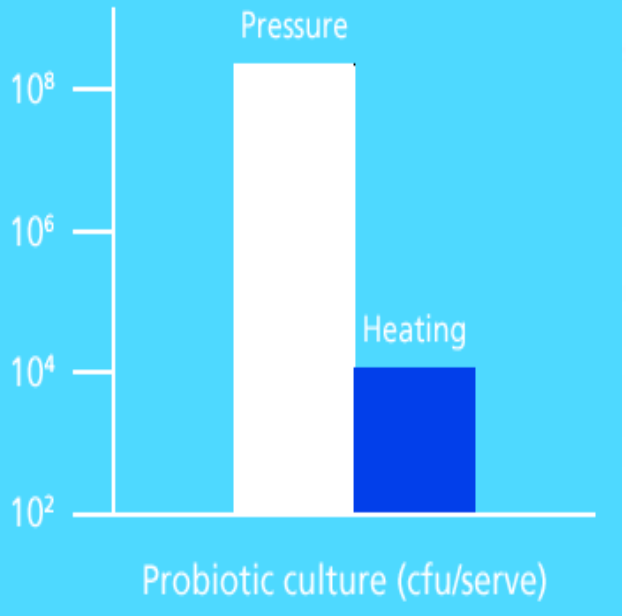
You'd be surprised at how many nutrients are packed into a glass of milk.

Fonterra's technology for probiotic beverages without the need for fermentation

Made possible with patented Fonterra technology

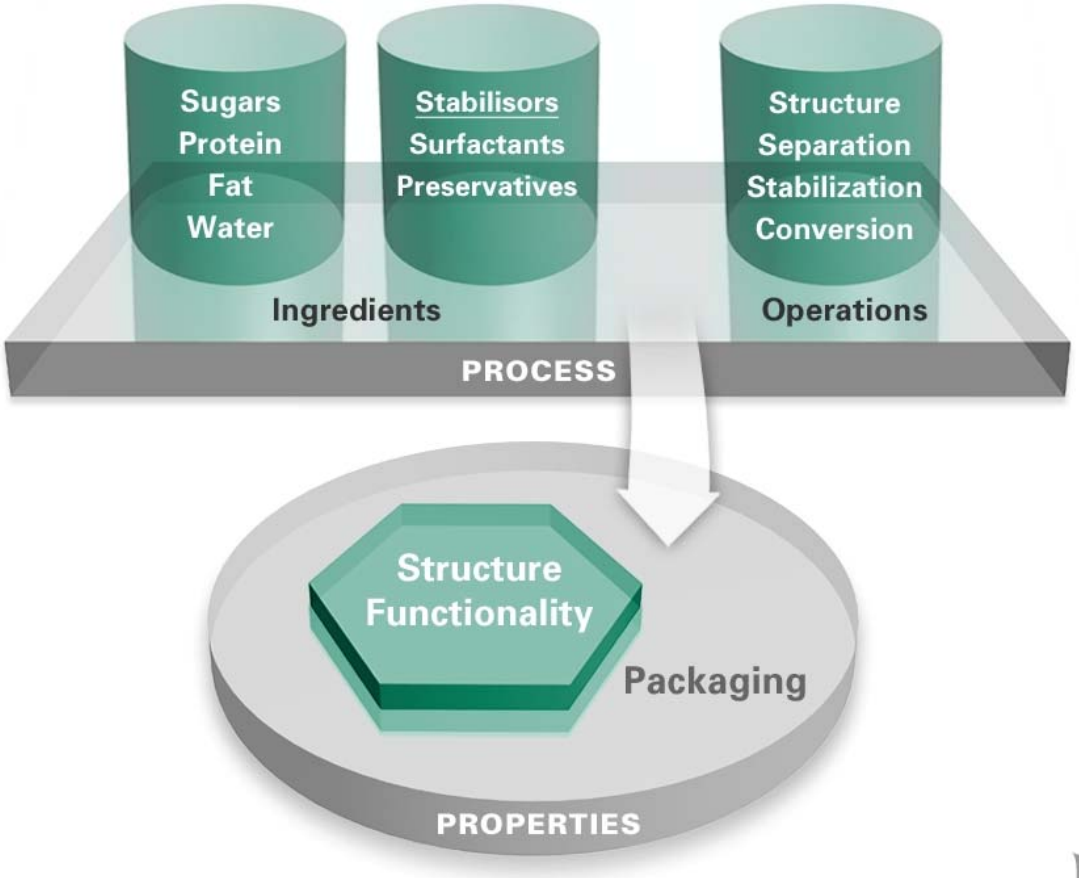
Fonterra has developed a unique manufacturing solution optimised for delivery of its proprietary probiotic strain DR10™. High pressure processing is a completely natural preservation technology that has been used in the food industry for the past 15 years.

Fonterra has utilised high pressure processing to make it possible to produce probiotic beverages without the need for fermentation by selectively eliminating the spoilage microflora while retaining an abundant active probiotic culture. The probiotic culture survival after pressure (5000 bar) and a typical heat treatment (72°C) are compared for a prototype shot format in the diagram on the right.



Fonterra Co-operative Group Limited
PO Box 92032 Auckland

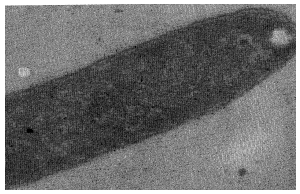
Where UHP can be applied?



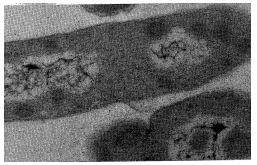
DIL graphics

HP Effect

microbes



Inactivation

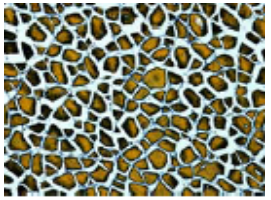


starch

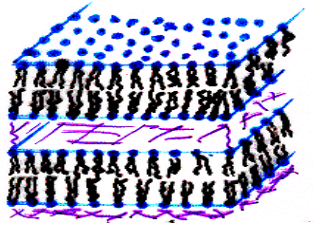
Swelling

tissue

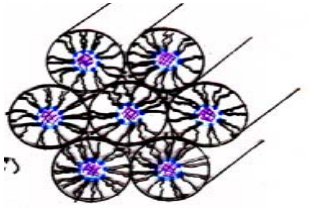
Disintegration



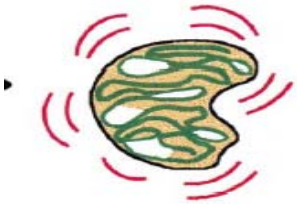
lipids



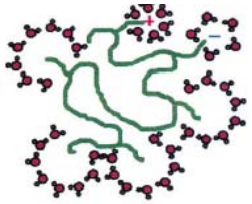
Transition



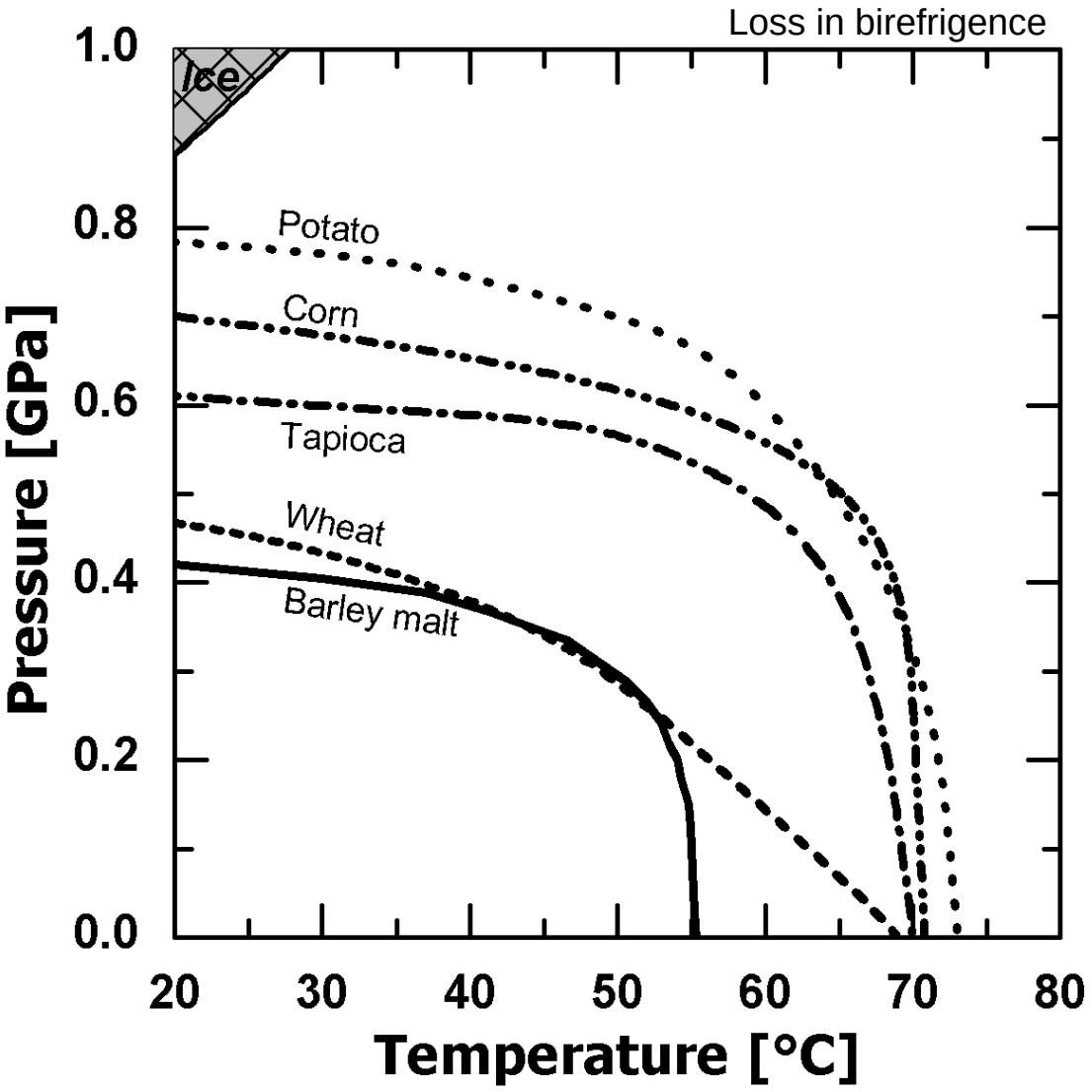
proteins



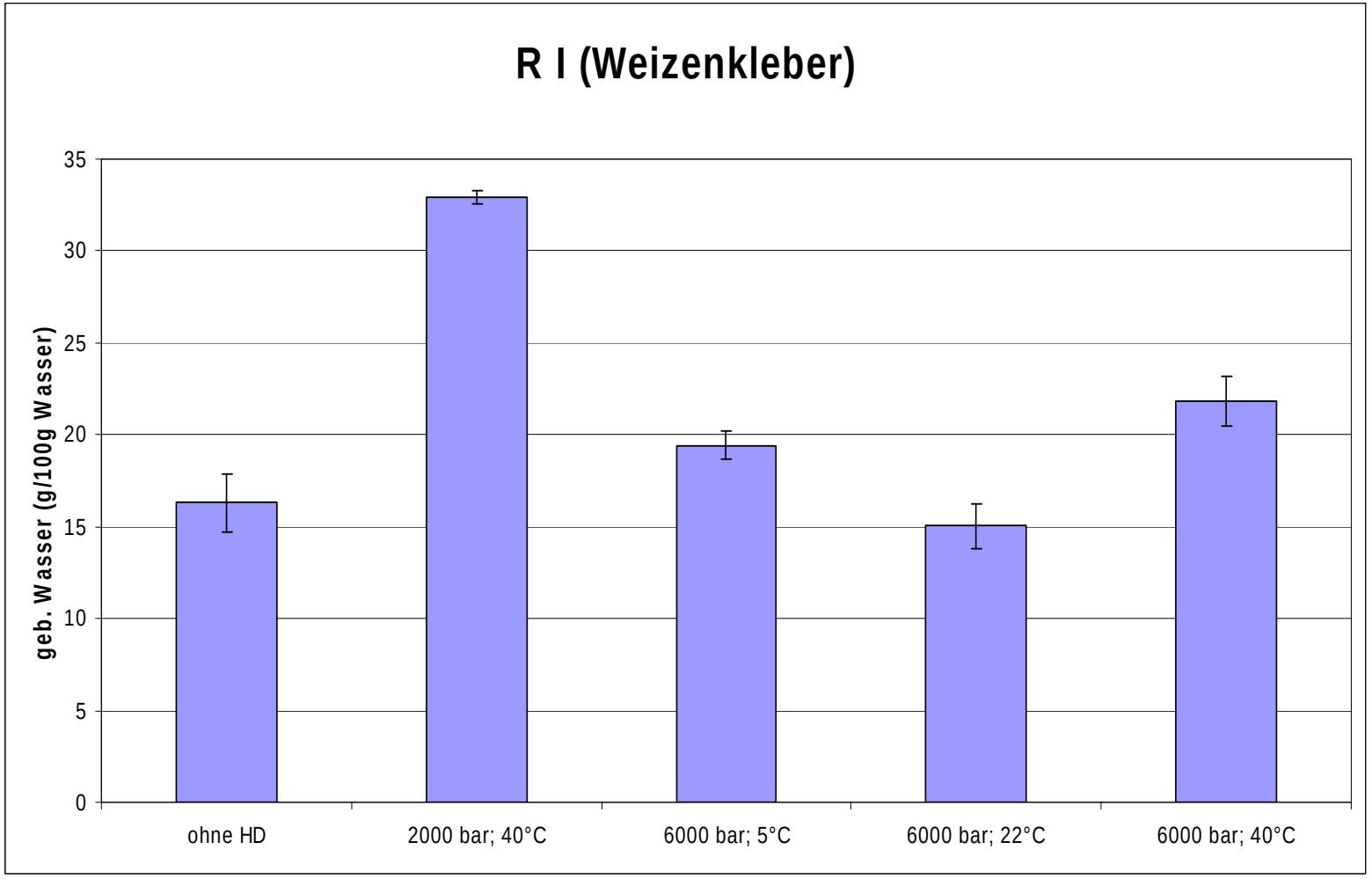
Unfolding

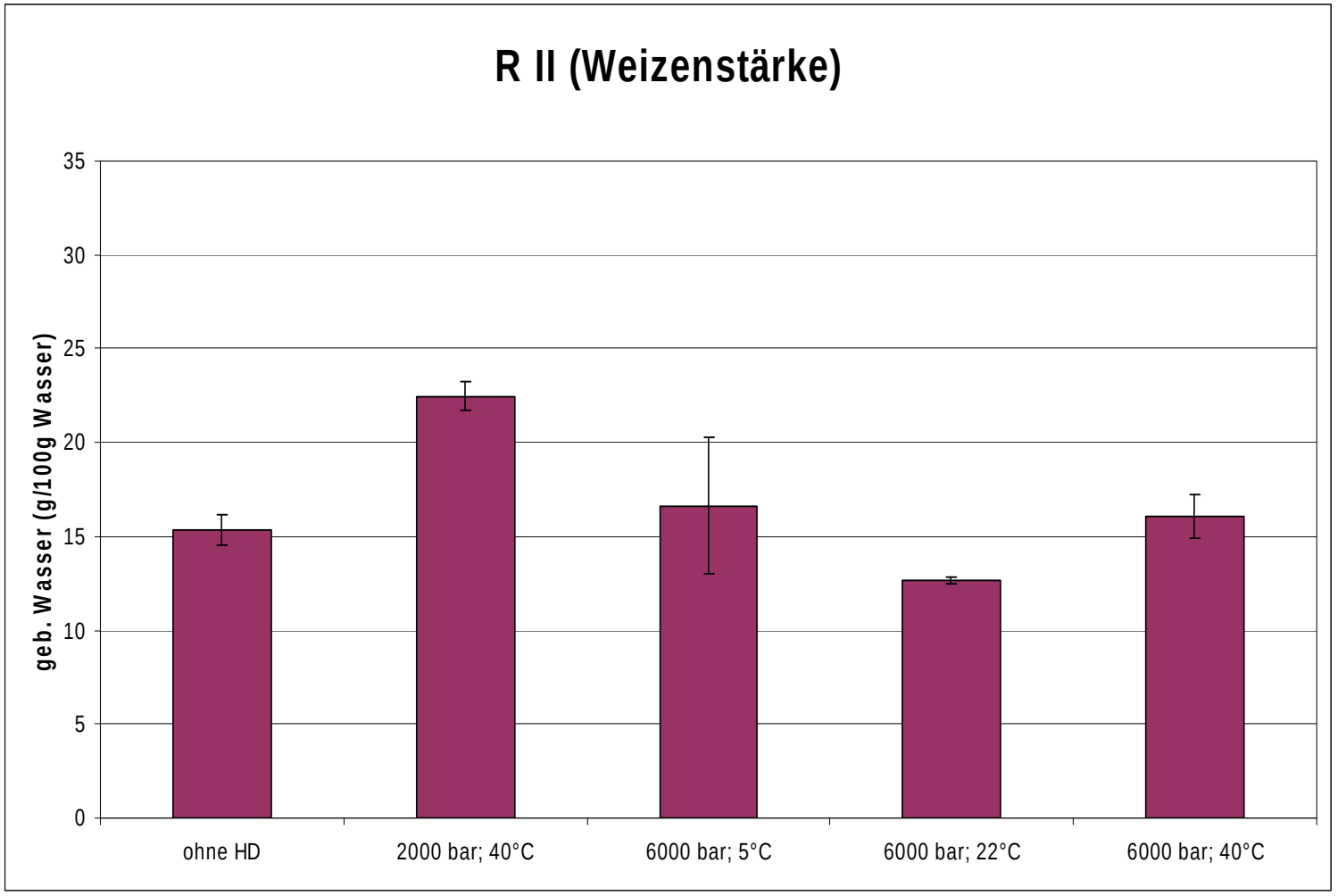


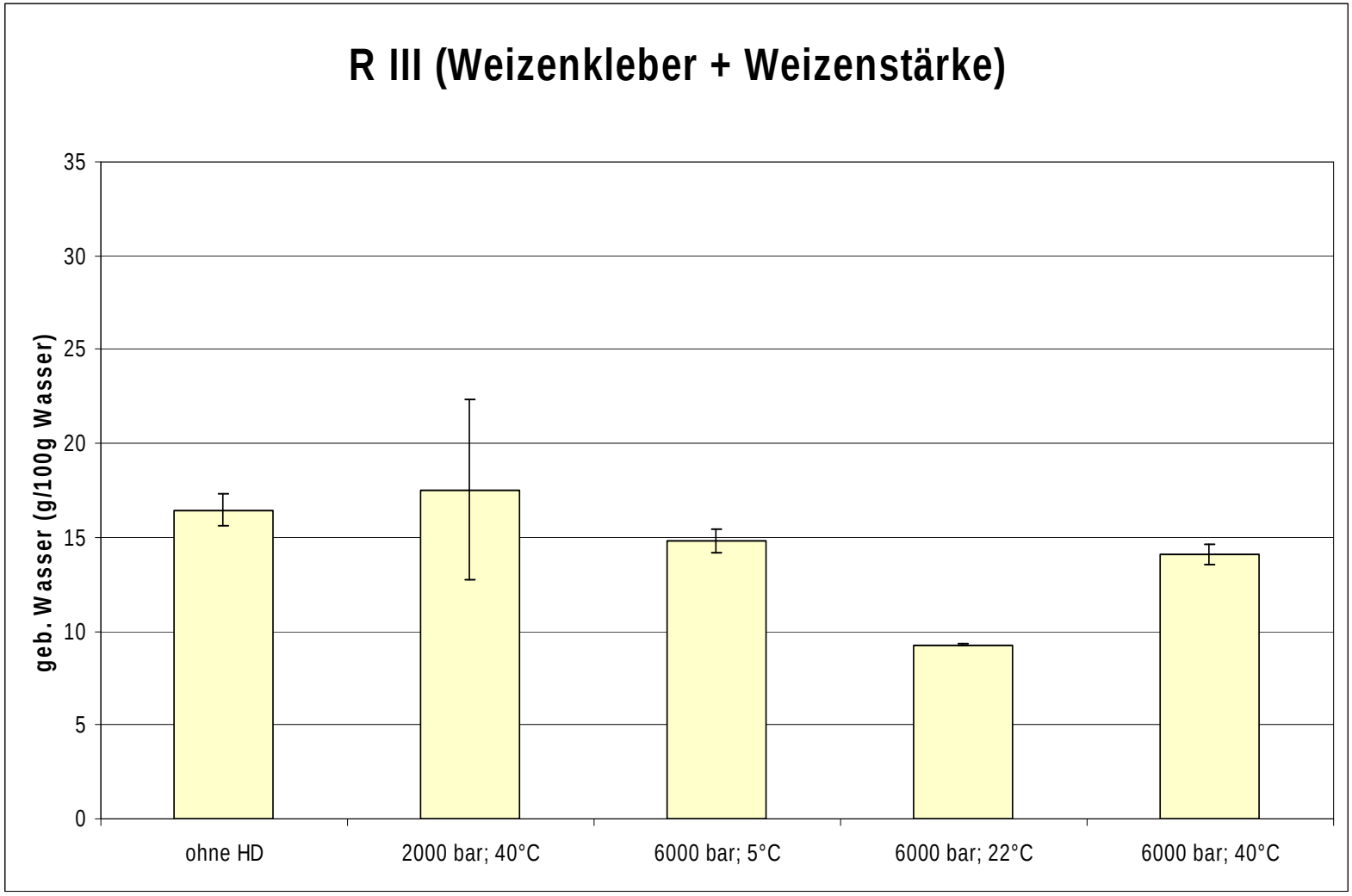
Starch

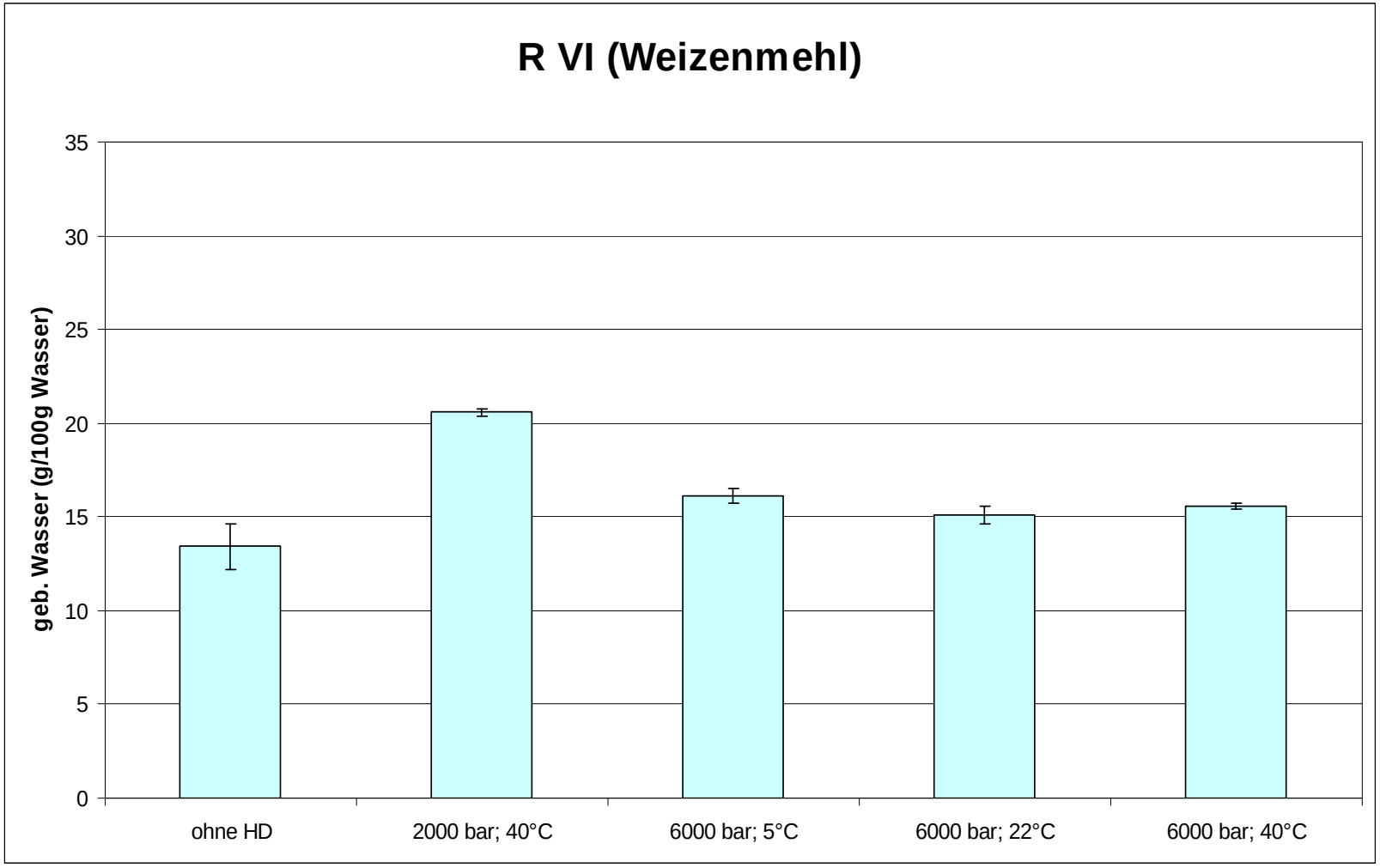


Buckow et al., 2007


R I (Weizenkleber)
geb. Wasser (g/100g Wasser)
35
30
25
20
15
10
5
0
ohne HD
2000 bar; 40°C
6000 bar; 5°C
6000 bar; 22°C
6000 bar; 40°C


R II (Weizenstärke)
geb. Wasser (g/100g Wasser)
35
30
25
20
15
10
5
0
ohne HD
2000 bar; 40°C
6000 bar; 5°C
6000 bar; 22°C
6000 bar; 40°C


R III (Weizenkleber + Weizenstärke)
geb. Wasser (g/100g Wasser)
35
30
25
20
15
10
5
0
ohne HD
2000 bar; 40°C
6000 bar; 5°C
6000 bar; 22°C
6000 bar; 40°C


R VI (Weizenmehl)
geb. Wasser (g/100g Wasser)
35
30
25
20
15
10
5
0
ohne HD
2000 bar; 40°C
6000 bar; 5°C
6000 bar; 22°C
6000 bar; 40°C

HPP-Einfluss auf Getreidemahlprodukte

Die rheologischen Eigenschaften von dispersen Systemen werden u.a. von dem Anteil an kontinuierlicher flüssiger Phase bestimmt, der für das Fließen zur Verfügung steht. Im Falle von Teig ist das das frei verfügbare Wasser.

Durch HPP ist es möglich, das Verhältnis zwischen freiem und gebundenem Wasser (Anteil an Wasser das über Wasserstoffbrücken oder elektrostatische Bindungen an funktionelle Gruppen von Makromolekülen angelagert ist) zugunsten des gebundenen Anteils zu verschieben.

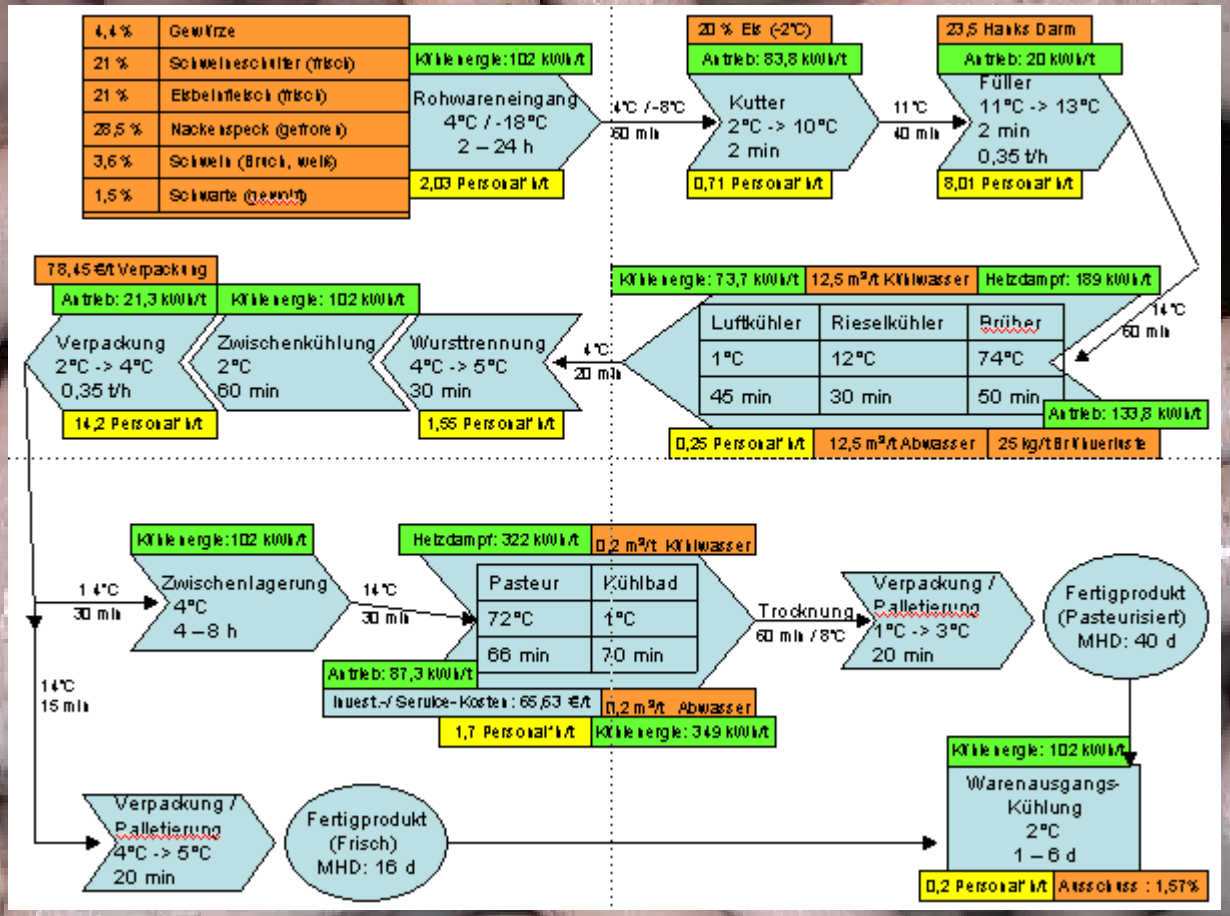
Folgende Effekte sind damit verbunden:

- **bei gleichen rheologischen Eigenschaften der Teige kann mehr Wasser verarbeitet werden**
- **der Backverlust wird vermindert**
- **die Krumenfestigkeit wird vermindert**
- **die alterungsbedingte Verfestigung der Backwaren verzögert sich, da die Retrogradation von einem höheren Niveau des Anteils an gebundenem Wasser startet**

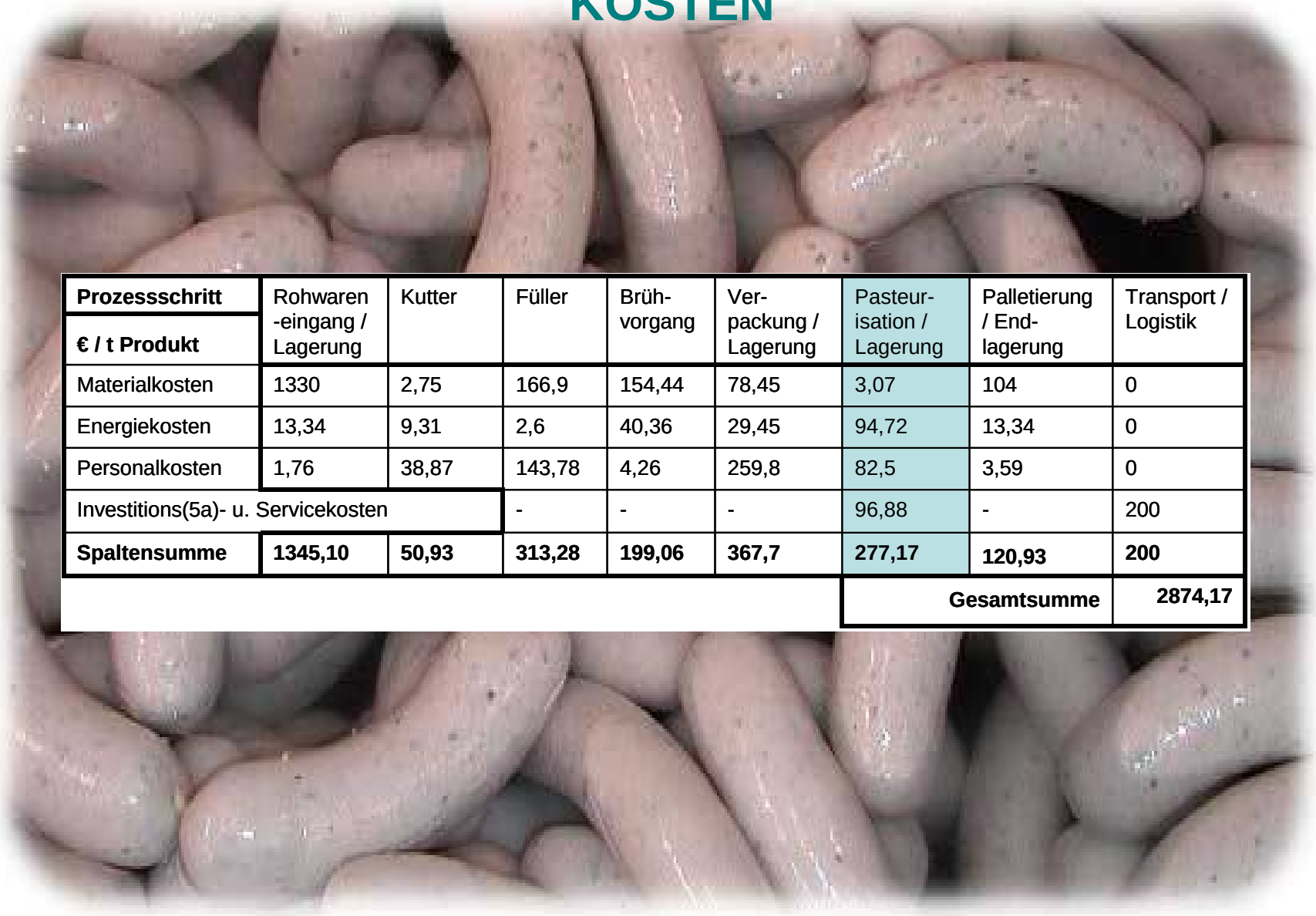
Innovation

22. Februar 1857 erfunden durch Bierwirt SEPP MOSER

Tradition

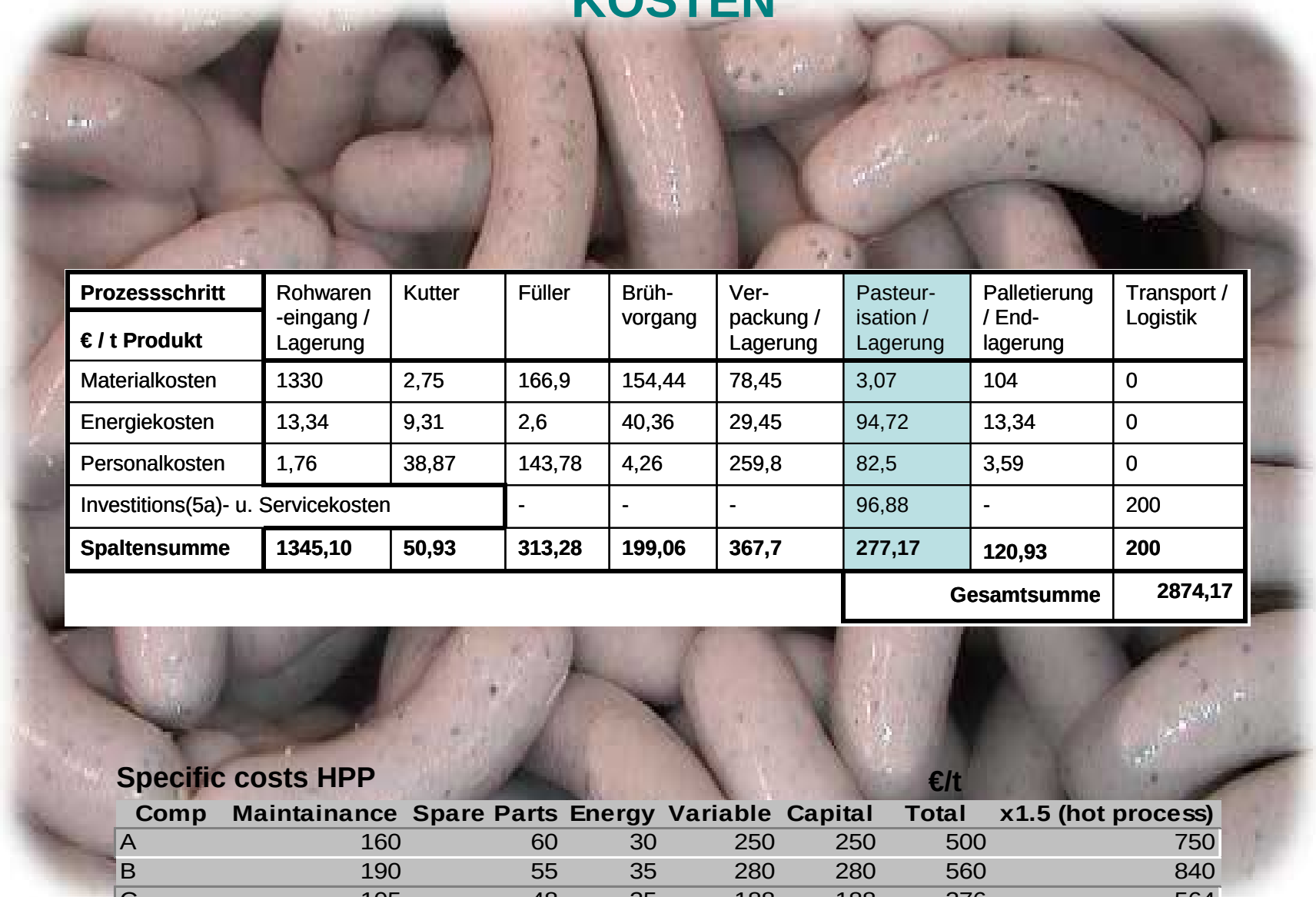

4,4 % Gewürze
21 % Schweineschulter (frisch)
21 % Eisbeinfleisch (frisch)
28,5 % Nackenspeck (gefroren)
3,6 % Schwein (Bruch, weiß)
1,5 % Schwarte (gewolft)
Kühlenergie: 102 kWh/t
Rohwareneingang
4°C / -18°C
2 – 24 h
2,03 Personal' h/t
4°C / -8°C
60 min
20 % Eis (-2°C)
Antrieb: 83,8 kWh/t
Kutter
2°C -> 10°C
2 min
0,71 Personal' h/t
11°C
40 min
23,5 Hanks Darm
Antrieb: 20 kWh/t
Füller
11°C -> 13°C
2 min
0,35 t/h
8,01 Personal' h/t
78,45 €/t Verpackung
Antrieb: 21,3 kWh/t
Kühlenergie: 102 kWh/t
Verpackung
2°C -> 4°C
0,35 t/h
14,2 Personal' h/t
Zwischenkühlung
2°C
60 min
Wursttrennung
4°C -> 5°C
30 min
1,55 Personal' h/t
4°C
20 min
Kühlenergie: 73,7 kWh/t
12,5 m³/t Kühlwasser
Heizdampf: 189 kWh/t
Luftkühler | Rieselkühler | Brüher
1°C | 12°C | 74°C
45 min | 30 min | 50 min
Antrieb: 133,8 kWh/t
0,25 Personal' h/t
12,5 m³/t Abwasser
25 kg/t BSB Fracht
14°C
60 min
Kühlenergie: 102 kWh/t
14°C
30 min
Zwischenlagerung
4°C
4 – 8 h
14°C
30 min
Heizdampf: 322 kWh/t
0,2 m³/t Kühlwasser
Pasteur | Kühlbad
72°C | 1°C
66 min | 70 min
Antrieb: 87,3 kWh/t
Invest.-/ Service-Kosten: 65,63 €/t
1,7 Personal' h/t
0,2 m³/t Abwasser
Kühlenergie: 349 kWh/t
Trocknung
60 min / 8°C
Verpackung / Palletierung
1°C -> 3°C
20 min
Fertigprodukt (Pasteurisiert)
MHD: 40 d
14°C
15 min
Verpackung / Palletierung
4°C -> 5°C
20 min
Fertigprodukt (Frisch)
MHD: 16 d
Kühlenergie: 102 kWh/t
Warenausgangs-Kühlung
2°C
1 – 6 d
0,2 Personal' h/t
Ausschuss : 1,57%

KOSTEN



Prozessschritt **€ / t Produkt**	Rohwaren -eingang / Lagerung	Kutter	Füller	Brüh-vorgang	Ver-packung / Lagerung	Pasteur-isation / Lagerung	Palletierung / End-lagerung	Transport / Logistik
Materialkosten	1330	2,75	166,9	154,44	78,45	3,07	104	0
Energiekosten	13,34	9,31	2,6	40,36	29,45	94,72	13,34	0
Personalkosten	1,76	38,87	143,78	4,26	259,8	82,5	3,59	0
Investitions(5a)- u. Servicekosten			-	-	-	96,88	-	200
Spaltensumme	**1345,10**	**50,93**	**313,28**	**199,06**	**367,7**	**277,17**	**120,93**	**200**
							Gesamtsumme	**2874,17**

KOSTEN

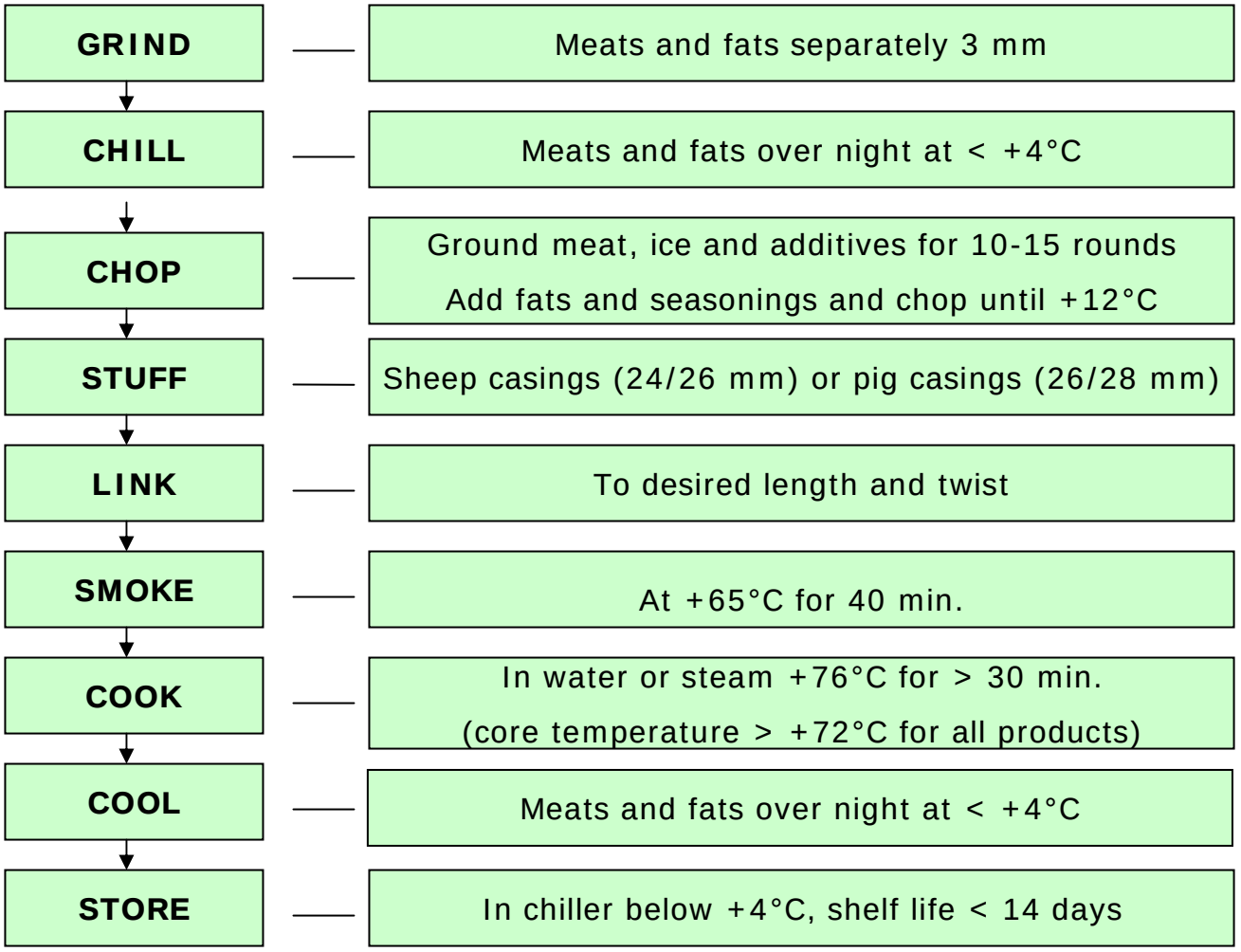


Prozessschritt € / t Produkt	Rohwaren -eingang / Lagerung	Kutter	Füller	Brüh-vorgang	Ver-packung / Lagerung	Pasteur-isation / Lagerung	Palletierung / End-lagerung	Transport / Logistik
Materialkosten	1330	2,75	166,9	154,44	78,45	3,07	104	0
Energiekosten	13,34	9,31	2,6	40,36	29,45	94,72	13,34	0
Personalkosten	1,76	38,87	143,78	4,26	259,8	82,5	3,59	0
Investitions(5a)- u. Servicekosten			-	-	-	96,88	-	200
Spaltensumme	**1345,10**	**50,93**	**313,28**	**199,06**	**367,7**	**277,17**	**120,93**	**200**
							Gesamtsumme	**2874,17**

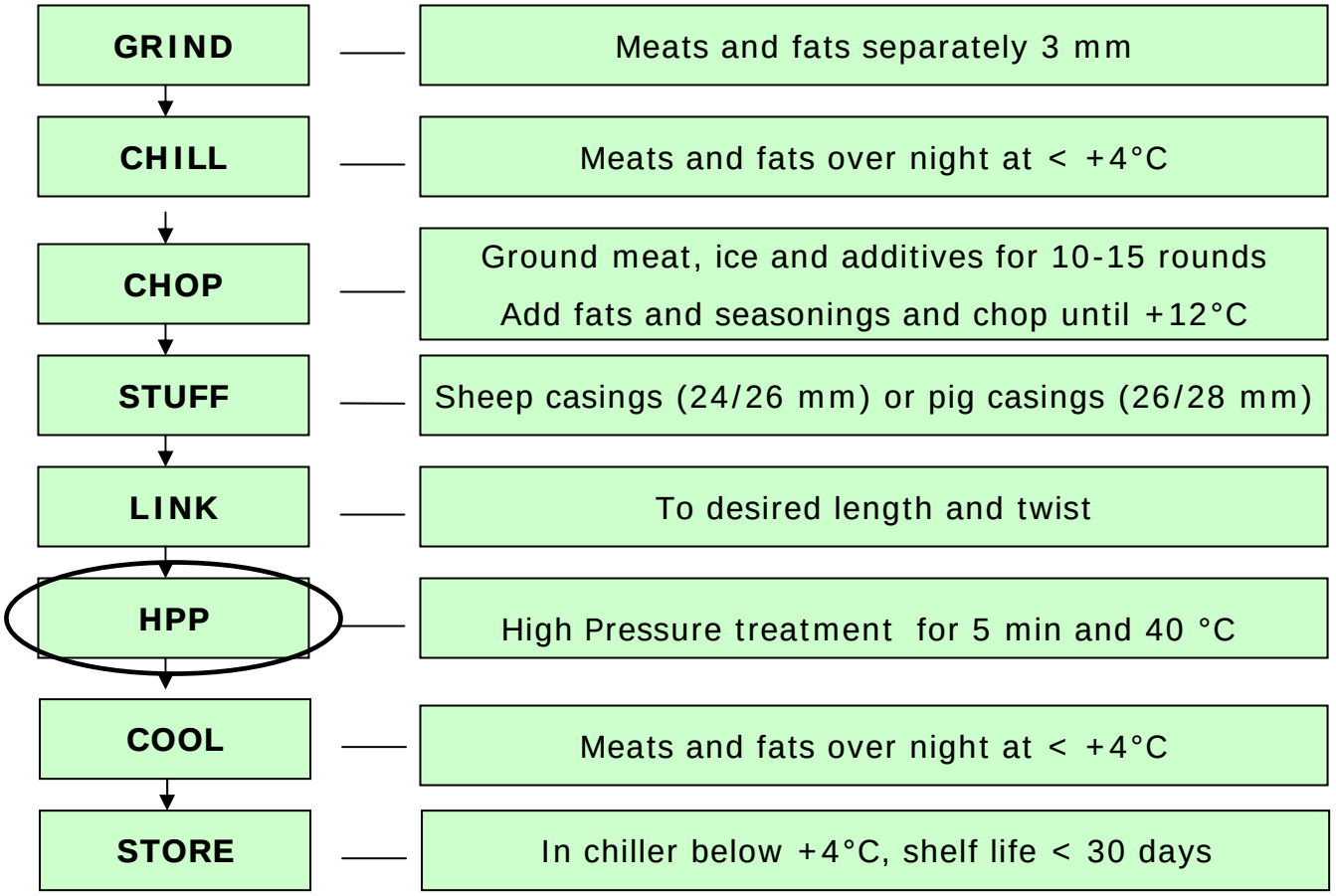
Specific costs HPP **€/t**

Comp	Maintainance	Spare Parts	Energy	Variable	Capital	Total	x1.5 (hot process)
A	160	60	30	250	250	500	750
B	190	55	35	280	280	560	840
C	105	48	35	188	188	376	564
D	125	70	20	215	215	430	645

Processing


GRIND
Meats and fats separately 3 mm
CHILL
Meats and fats over night at < +4°C
CHOP
Ground meat, ice and additives for 10-15 rounds
Add fats and seasonings and chop until +12°C
STUFF
Sheep casings (24/26 mm) or pig casings (26/28 mm)
LINK
To desired length and twist
SMOKE
At +65°C for 40 min.
COOK
In water or steam +76°C for > 30 min.
(core temperature > +72°C for all products)
COOL
Meats and fats over night at < +4°C
STORE
In chiller below +4°C, shelf life < 14 days

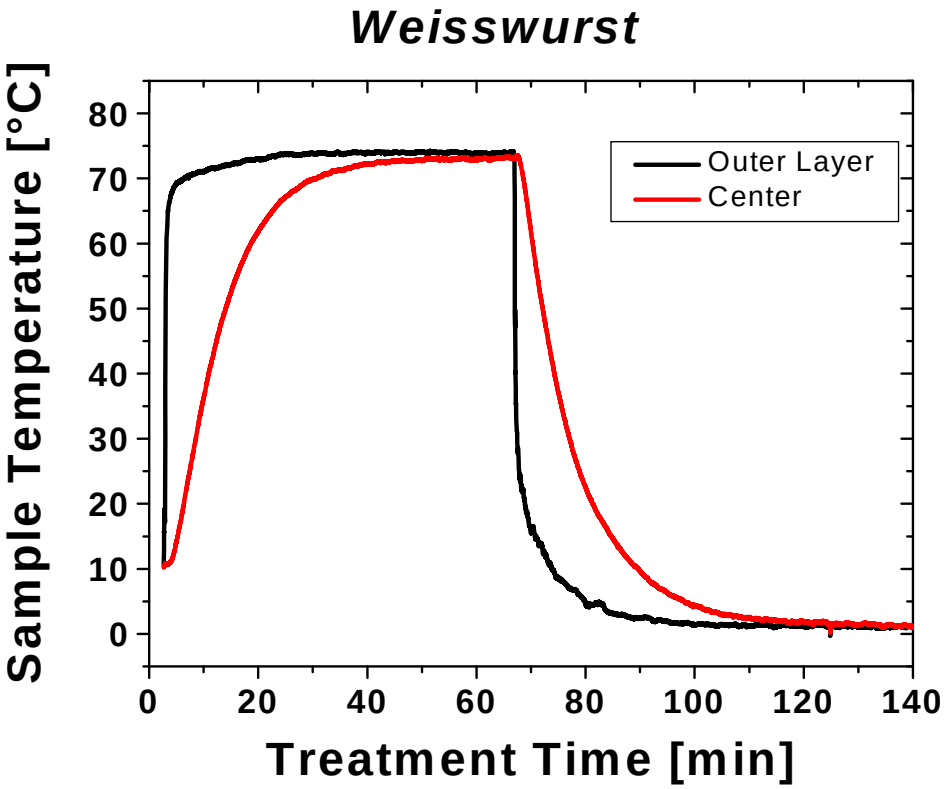
PROCESSING using HP-treatment



Possible advantages of the HP-treatment

- extended shelf life of the raw- denaturated sausages
- cold preservation and structure formation (due to the high pressure protein denaturation) in one step
- better water holding capacity of sausages
- developing a new products with different structure and sensory properties

Temperature-Time Profile



HEAT: 60 min **HPP: 6 min**

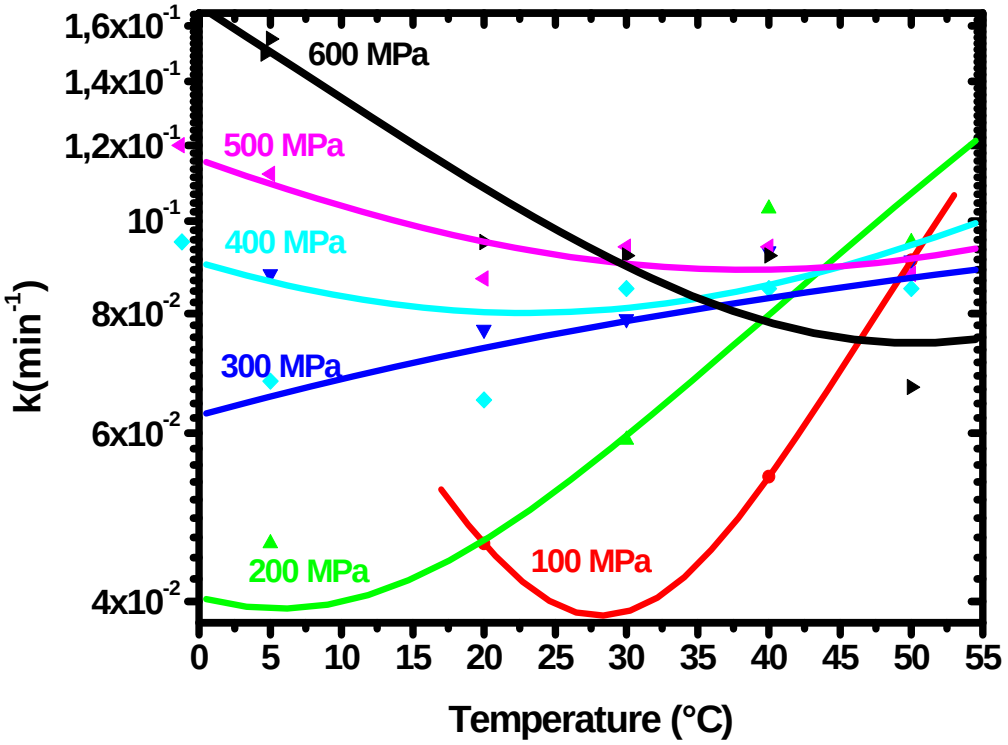
Solubilization of protein and network building

1. Mechanical cutting/chopping/comminuting of the muscle tissue resulting in the release and extraction of muscle proteins out of the muscle cells.

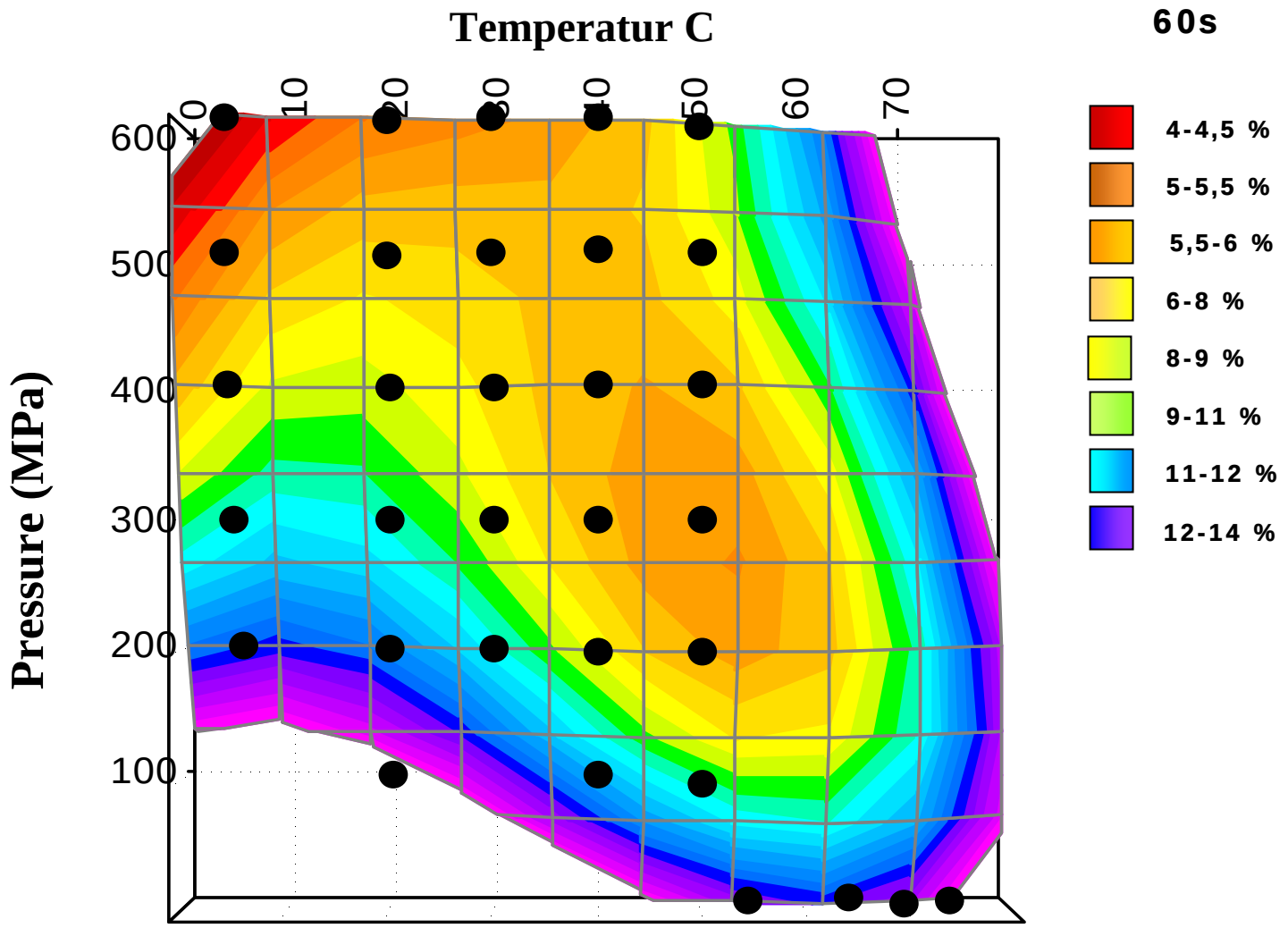
2. Solution of part of the released previously solid muscle proteins in the water/salt mix added.

3. Enhancement of the transition of solid muscle proteins to the gelatinous or liquid phase in the presence of phosphates or other suitable substances such as citrates.

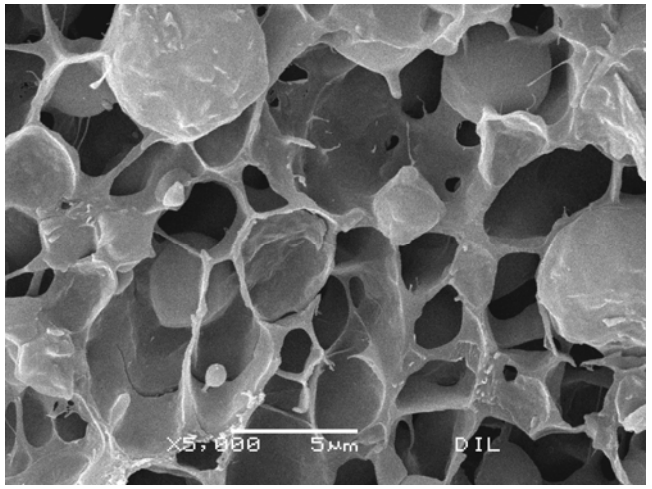
Pressure and Temperature dependence on water immobilization rate



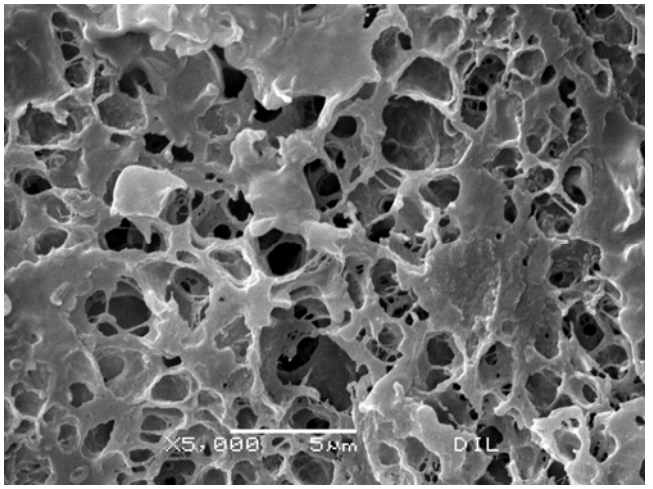
p-T diagram of water immobilization



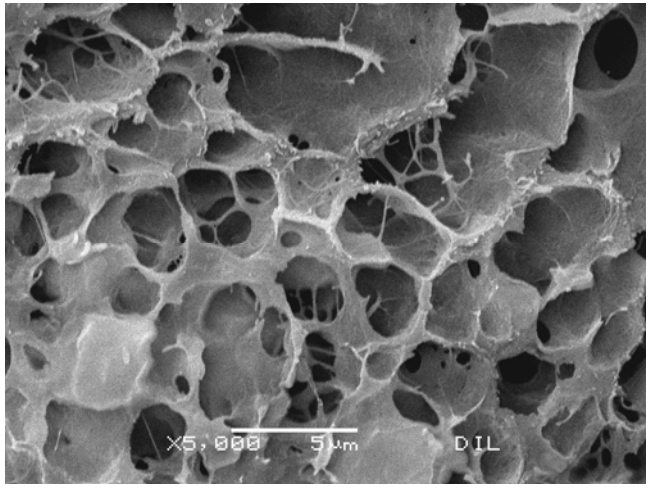
BRÜHWURST



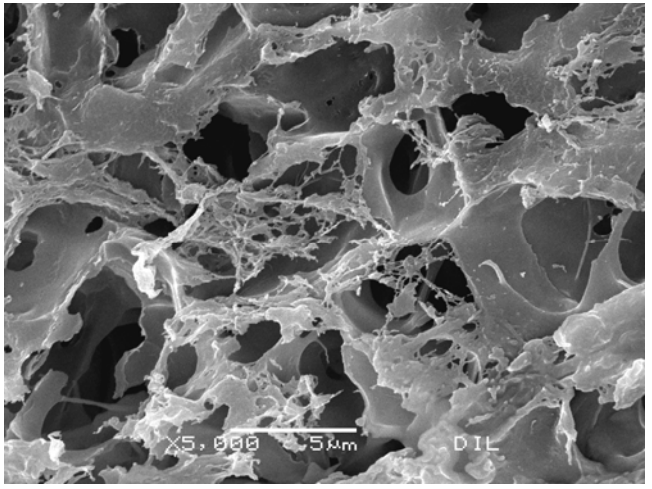
Brät, unbehandelt



Brät, thermisch denaturiert 76°C, 30 min



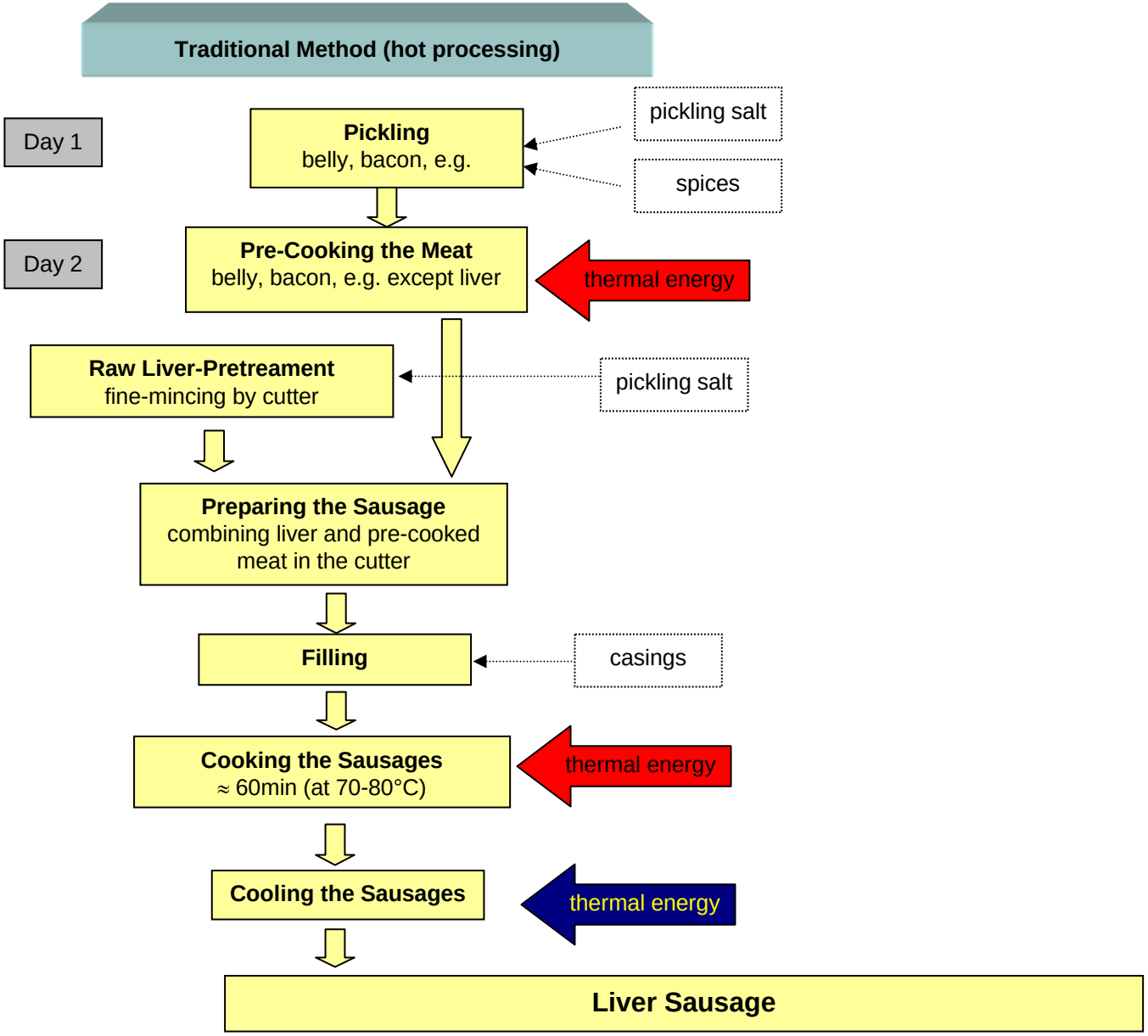
Brät (30°C), 600 MPa, 3 min; 71,43 MPa/s



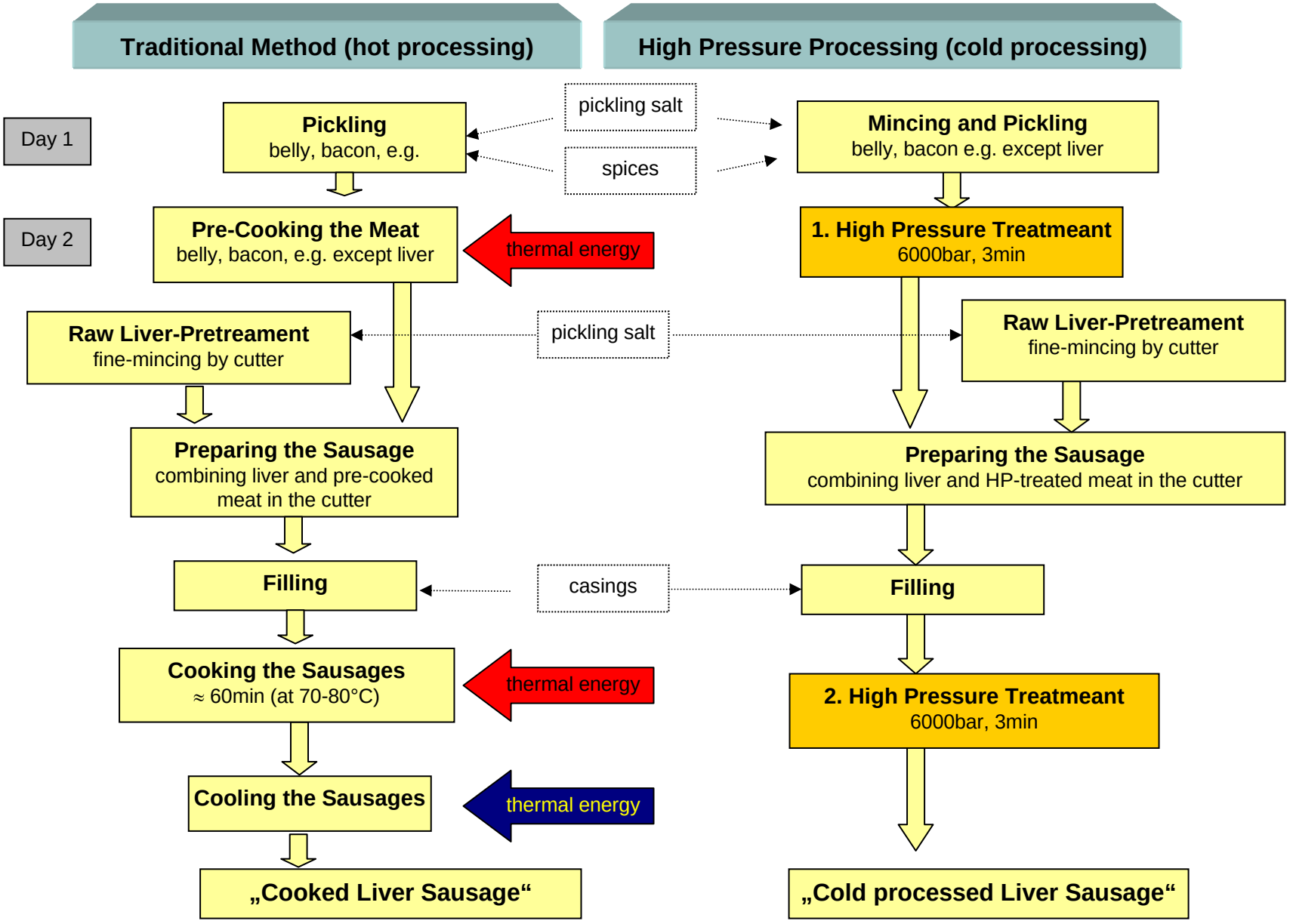
Brät (30°C), 600 MPa, 3 min; 1,43 MPa/s

KOCHWURST

Production of Liver Sausage



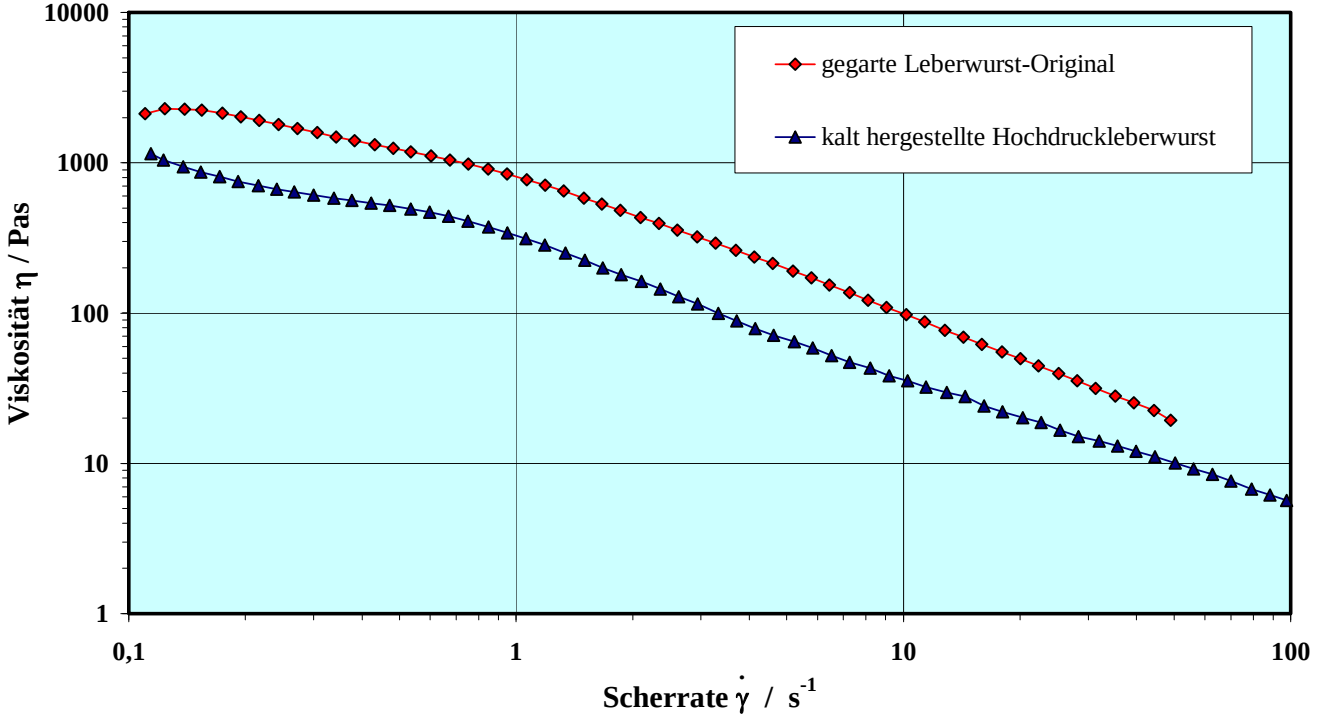
Production of Liver Sausage



Merkmale der über Hochdruck hergestellten Leberwurst im Vergleich zur traditionell gekochten Leberwurst:

- intensiverer Geschmack
- feinere Struktur
- verbesserte Streichfähigkeit

Vergleich der Viskositätsfunktionen



Zusammenfassung

1. **Die Kosten von HPP liegen zwischen 30 und 50 Cent/kg**

2. **HPP als Prozessergänzung wird derzeit nur in wenigen Fällen aus ´Safety´ Gründen angewendet**

3. **HPP als Prozessalternative zur Strukturbildung (+ Safety + Haltbarkeitsverlängerung) hat ein wesentlich größeres Potential**

4. **Mit FEI-Unterstützung (16007N: HPP und Getreidemahlprodukte; 15884: Stosswellen zur Rindfleischreifung) werden derartige Möglichkeiten untersucht**