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Thermisation
for cheese milk or before milk cold storage

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Outline of presentation

1. Definition of thermisation, legal aspects
2. Thermisation for cheese milk
   a. Hurdle concept for cheese making
   b. Raw milk quality
   c. Heating conditions
   d. Comparison with pasteurization
3. Thermisation before milk storage
4. Conclusions

Definition of thermisation

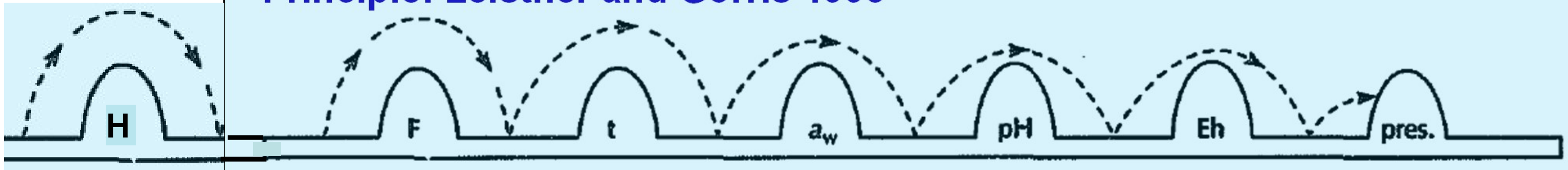
- **Codex Alimentarius (2009**): Code of hygienic practice for milk and milk products:
  - Thermization: The application to milk of a heat treatment of a **lower intensity than pasteurisation that aims at reducing the number of microorganisms**. A general reduction of log 3–4 can be expected. Microorganisms surviving will be heat-stressed and become more vulnerable to subsequent microbiological control measures
- **Swiss confederation**:
  - Labelling “Cheese made from thermised milk” if: Milk heated for at least 15 s at a temperature above 40°C and lower than 72°C and if the alkaline phosphatase test reaction is positive*
- **Encyclopaedia of dairy sciences:**
  - A range of sub-pasteurisation heat treatments of milk (Deeth, 2022).

** Labelling is voluntary; Regulation of the Swiss confederation on foodstuff of animal origin 817.022.108*

Thermisation for cheese milk

Technological hurdles secure food safety of semi-hard cheeses

Principle: Leistner and Gorris 1995



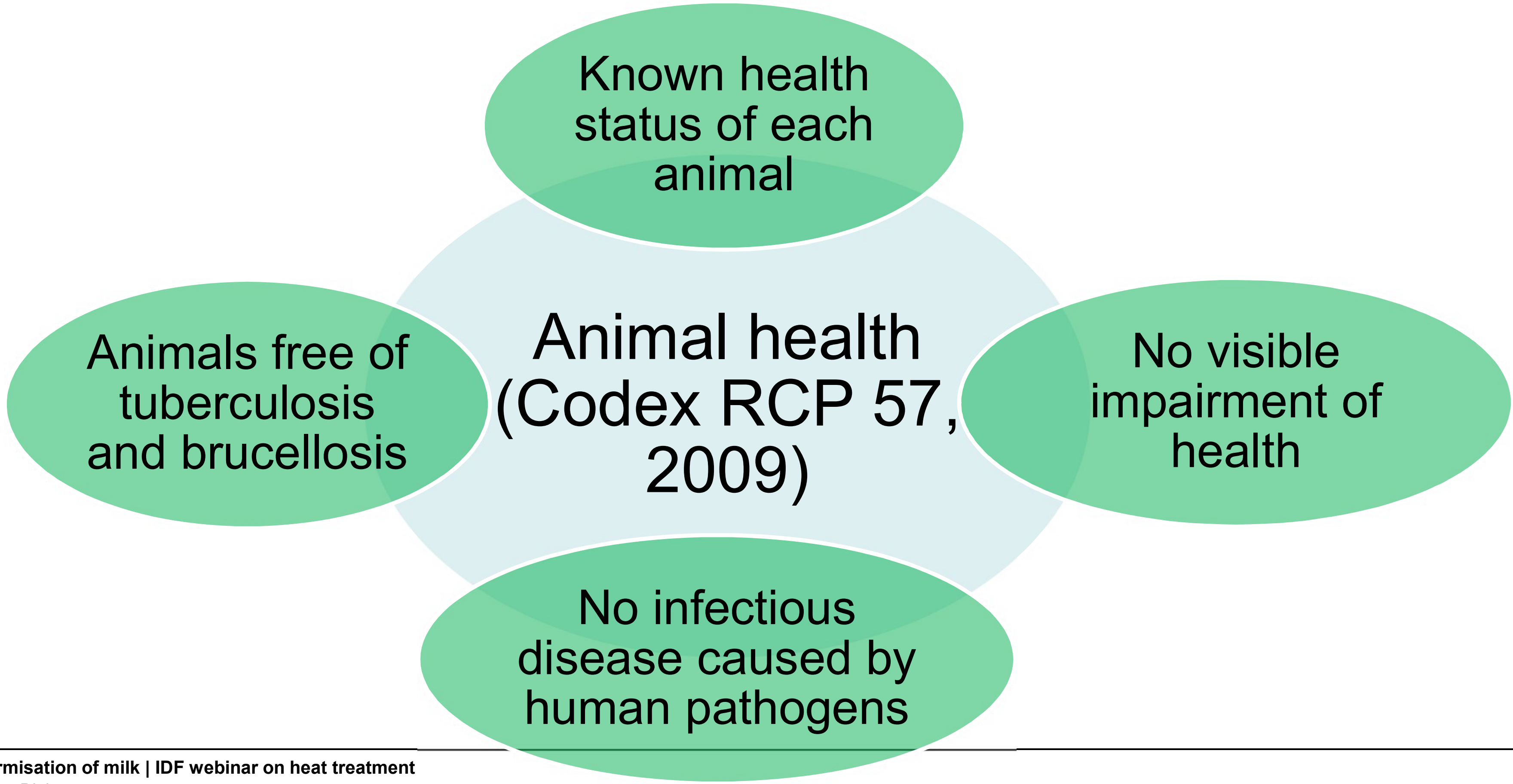
H: milk hygiene	F: heat treatment	t low temperature	a_w water activity	pH, acidity	Eh: ↓ redox potential	pres.: preservatives
Low bacteria count in raw milk <10'000	Thermisation: 65°C /15 s or 60°C /5 min or 57°C /30 min	Ripening at 11 – 14°C	54 – 69% moisture on a fat-free basis	Fast pH drop; unripened pH 4.5-5.3	E_h ≈ -250 mV (anaerobic)	Starter and NSLAB occupy ecosystem
< 24 h milking-cheese making	Scalding at 46 - 53°C	Cold storage after ripening	1.5-1.9% NaCl a_w: 0.964	Lactic acid, acetic acid.		> 75 d ripening: FFA, peptides, etc. formed. L. mono.: ↓ 0.5 log /m STEC: ↓1 log /m Staph. aur: ↓ 2 log /m

(Values in lower row: Tête de Moine AOP; for this cheese no thermisation applied)

Low bacteria count in raw milk for cheese with thermisation at delivery

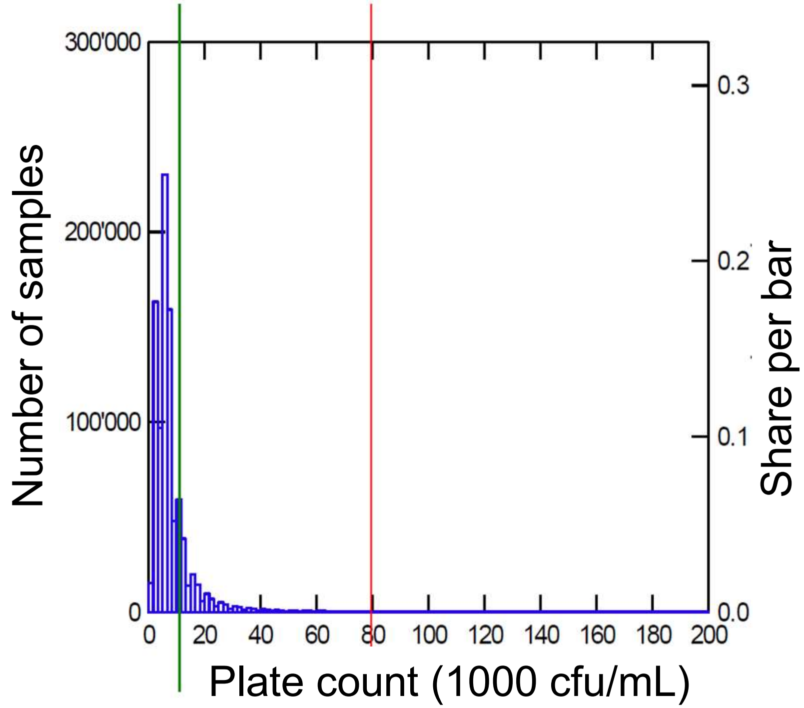
- Low count of spoilage bacteria
- Low count of pathogenic bacteria

Codex: Additional provisions for the production of milk used for raw milk products.

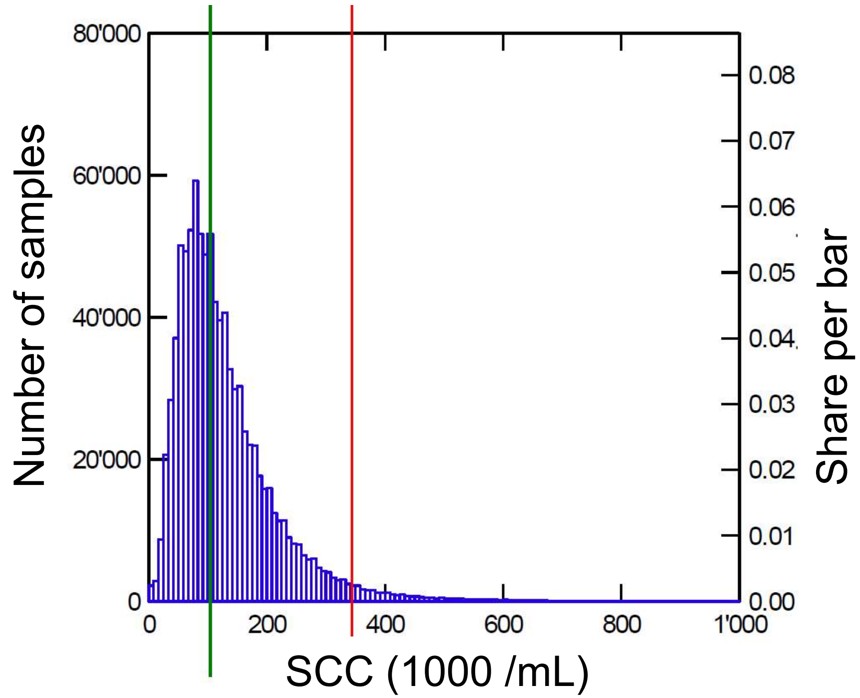


Raw milk quality in Switzerland

Aerobic mesophilic bacteria



Somatic cell count



Red line: Upper limit by Swiss food legislation

Green line: Limit for extra pay for milk for raw milk cheese manufacturing (company contract)

For raw milk cheese:

Plate count: mostly < 10’000 cfu/mL, typically ≈ 5’000

SCC: 50% are below 100’000 /mL

Prevalence pathogenic /toxin forming bacteria raw milk

Bacteria	Sample number [3]	Switzer-land	Ger-many	Italy	India	USA	Ni-geria	Gha-na	Ken-ya	Ethi-opia	NZ
Listeria monocytogenes	601	**0.33%**	4.60%	1.44%				8.8%			
VTEC / STEC [1), 2), 4)]	601	1.83%	1.35%	1.06%	1.8%[5)]	3.2%			0.8%[5)]	2.5%[5)]	
Salmonella ssp.	601	0.0%	0.00%	0.00%							
Campylobacter	601	**0.0%**	1.91%	0.67%							
Yersinia enterocolitica	601	**0.0%**	-	-							
Staph. aureus >300 cfu/mL	601	8.3%								10.8%	
Histamin forming lentilactobacilli		14-25%									
Coxiella burnettii[6)]	-	-					63%				0.0%

Swiss Data: 2013 – 2014; Germany: 2010 (n=296-326); Italy 2011 (n=765-1609); Ethopia (n=203)

1) Verotoxin or shiga-toxin producing *Escherichia coli;* 2) VTEC /STEC Screening: Method prEN ISO TS 13136 with germ isolation; 3) From 173 milk producers; 4) STx-gene & isolates; 5) E. coli O157:H7

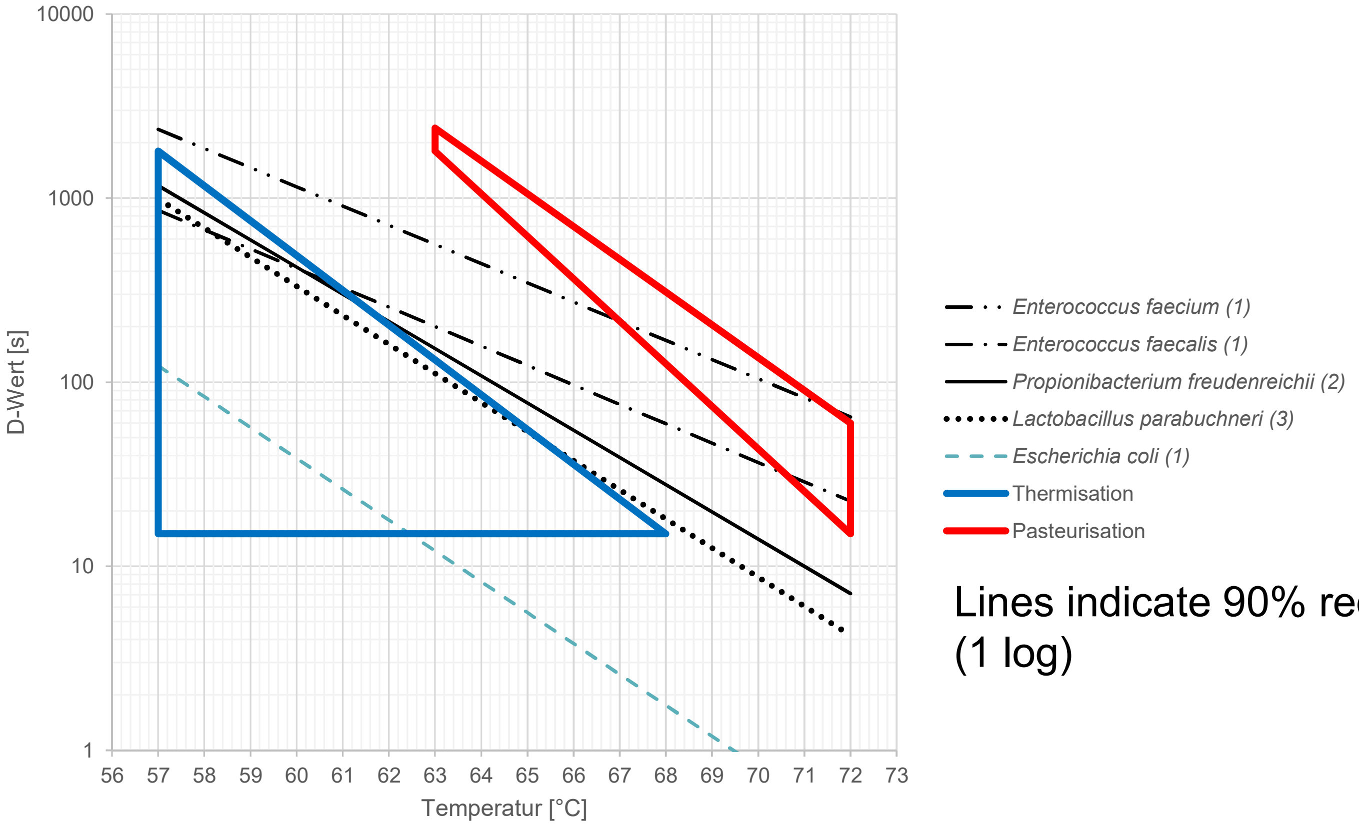
6) *Mycobacterium bovis*, *Brucella abortus* + *Coxiella burnettii* have largely been eradicated in developed nations. Still persist or re-emerging in some countries in Africa

Thermisation of cheese milk

Tilsiter (CH). Made from thermised milk and raw milk

- Conditions: 65°C /15 s or 60°C /5 min, or 57°C /30 min
- Often only applied to the evening milk prior to storage over night.
- Primary purpose:
  Reduce the risk of undesired fermentation in semi-hard cheeses
- Other purpose: Hurdle for food safety of semi-hard cheeses.
- Advantages compared to pasteurisation:
  - Enzymes, such as lipoprotein lipase (partially), and protease cathepsin D (mostly) are still active and contribute to cheese ripening
  - Thermoduric desired bacteria, such as pediococci are less inactivated
  - Diverse LAB and NSLAB contribute to ripening, flavour and texture
  - Reduces protein loss through migration of ß-casein out of micelles after cold storage of milk
  - Higher microbial diversity is a contribution to gut health

Inactivation of cheese spoilage bacteria by milk thermisation or pasteurisation



Lines indicate 90% reduction (1 log)

(1) According to Sörqvist (2003),
(2) Based on data from Sollberger (1993),
(3) Based on data from Sumner et al. (1990); now called *Lentilactobacillus parabuchneri*

Inactivation of pathogens /toxin-forming bacteria during thermisation + ripening of semi-hard cheese

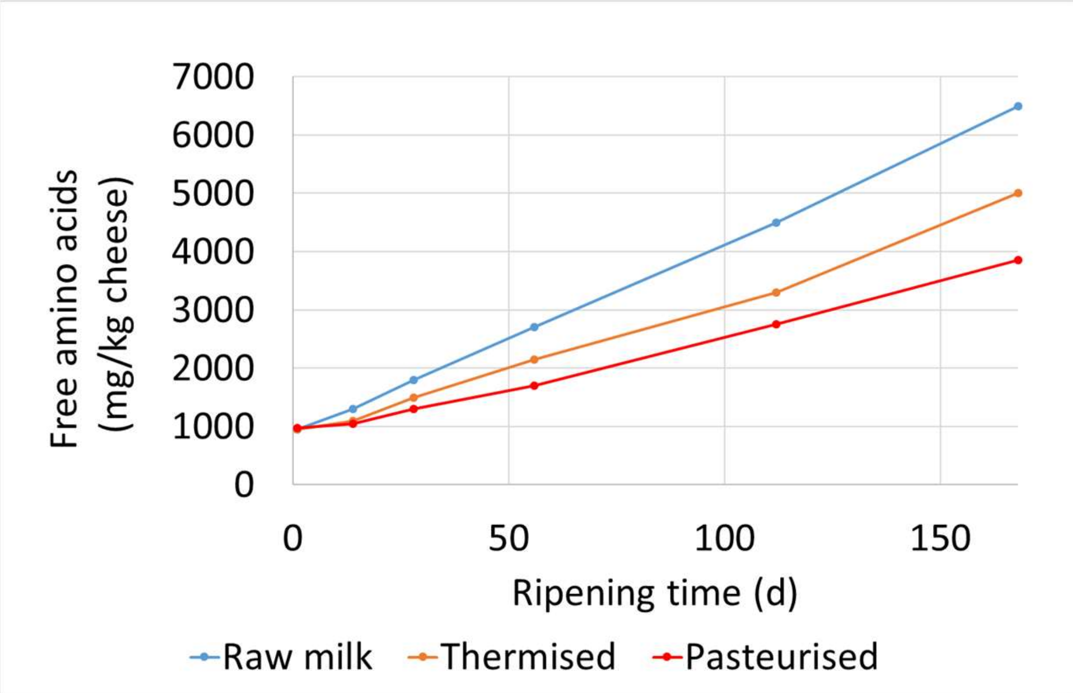
Bacteria	D 65 (s)	Reduction 65°C /15 s	Reduction during ripening per month (log) [2)]
Listeria monocytogenes	21.6	0.7 log (80%)	< 0.5
Samonella spp.	2.6	5.7 log	≈ 1
Shig-toxin producing E. coli	[1)] 3.4	4.4 log	≈ 1
Staphylococcus aureus	15.4	0.9 log (89%)	2 – 3 toxins stable
Histamine-forming Lentilactobacilli	14.4	1.0 log (91%)	Slow after 30 – 60 days

[2)] Cheese made from raw or thermised milk needs to be ripened for ≥ 60 days in the US and many other countries

[1)] Average of six strains of *E. coli*

Eugster and Jakob, MSI (2019)

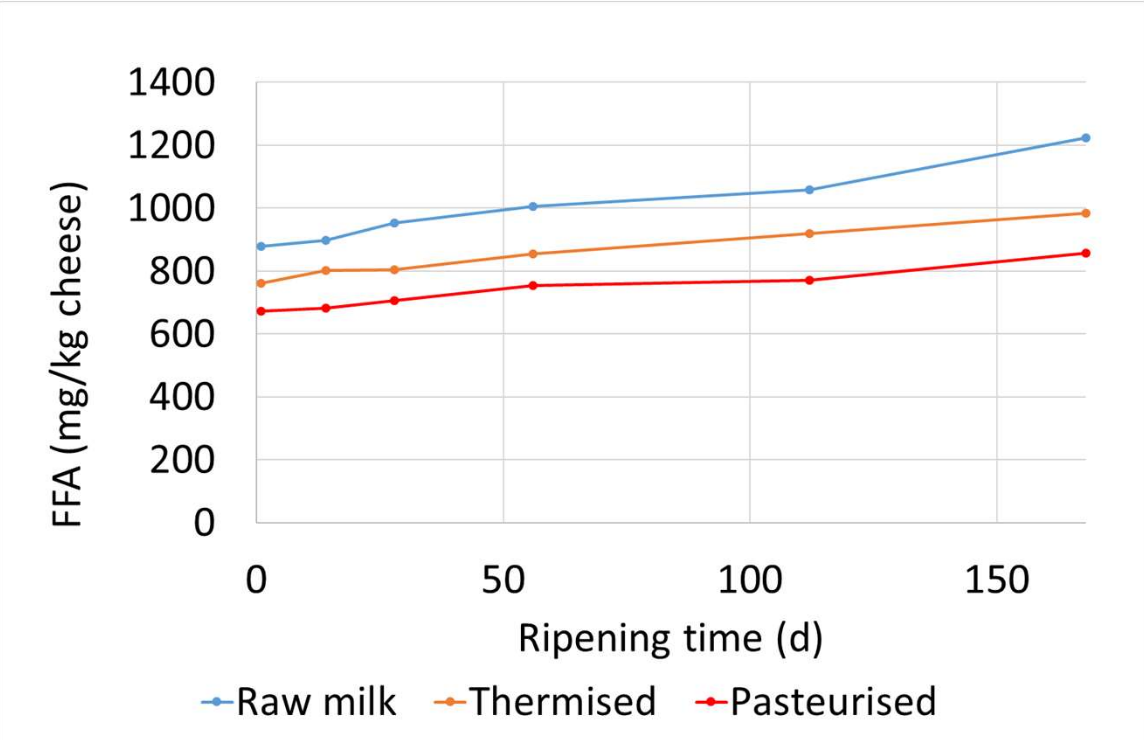
Proteolysis in cheese from thermised milk (cheddar)



- Primary proteolysis not significantly influenced (not shown)
- Secondary proteolysis higher in cheese from thermised milk compared to pasteurised milk
- Peptidases probably originating form the indigenous milk microflora or residual activity of milk proteinases contributed to proteolysis in cheese from thermised and from raw milk
- Active cathepsin D contributes to proteolysis, and to flavour development

Hickey et al., JDS 47, 2007

Lipolysis in cheese from thermised milk (cheddar)



Hickey et al., JDS 47, 2007

- Esterases from starter culture have important influence
- With thermised and raw milk, additional other sources of lipolytic enzymes which increase FFA content:
  - Lipoproteinlipase and from indigenous microflora
  - In thermised milk, lipoprotein-lipase is partially active (65°C/20 s → 50% ↘)
  - Lipolysis possibly limited by access to substrate or cheese environment (cheddar)
  - In other cheese varieties with higher pH more activity as pH optimum is 9.2

Thermisation before cold milk storage and further processing

Thermisation before cold storage of milk

- Initial quality of raw milk is very important:
  - RM quality highly correlated with counts after 65° /15 s and 3 d storage at 6°C
- Purpose:
  - To extend the keeping quality of raw milk by thermisation on delivery to dairy plants or on farms → cold storage for an additional 3 days
  - To limit the growth of psychrotrophic bacteria,
  - These form heat-resistant enzymes causing spoilage of UHT milk, cheese, or other products with a long shelf-life.
- Markedly reduces the number of spoilage bacteria
- Markedly reduces the heat-labile psychrotrophic microflora responsible for spoilage at low temperatures
- Thermisation at 62-68°C for 15 s is practised widely: shelf-life 4°C +3 to 4 days

(Griffiths et al., 1986, Deeth, 2022)

Reduction of total bacteria, coliforms and psychrotrophs by thermisation

Bacterial count (cfu /mL) in milk thermised at 66-68°C /15 s, stored for 3 d at 2 - 5°C, 2 dairies):

	Control	Thermised	Reduction
Total count	2.1×10^6	2.2×10^4	2.0 log
	3.2×10^5	8.2×10^3	1.6 log
Coliforms	3.5×10^2	1.8×10^1	1.3 log
	6.3×10^2	0.5×10^1	2.1 log
Psychrotrophs	2.1×10^5	1.5×10^2	3.1 log

- The psychrotrophs are reduced the most, by 3 logs
- Important: Not all pathogens are inactivated, not suitable to ensure food safety.

(Deeth, 2022, Rukke et al, 2011)

Conclusions

- For raw milk cheese and cheese from thermised milk, superior milk quality is extremely important
- Thermisation, together with other hurdles, helps to avoid spoilage and to ensure food safety of semi-hard and sometimes soft cheeses
- Cheeses made from thermised milk, compared to the ones from pasteurised milk, have more proteolysis and a tendency for more lipolysis: Improves cheese flavour, texture and characteristics, and microbial diversity for gut health
- Thermisation of milk before cold storage and further processing extends the possible cold storage time by 3 to 4 days at 4 - to 6°C.
- Bacteria counts of thermised milk after cold storage is directly correlated with the bacteria count of the raw milk before thermisation.

Thank you for your attention

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