



Microbiological risks and benefits of the consumption of raw milk and the effect of heat treatment

Food Micro 2014, Nantes

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02/09/2014

Federal Agency for the Safety of the Food Chain



Overview

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- Effect of heat treatment on microbiological risks
- Microbiological benefits
- Effect of heat treatment on microbiological benefits
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16-11-2016

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Milk production in Belgium

- $\pm 3.200 \times 10^6$ liter / year
- 98 % industrially processed
 - 1,5 % pasteurized
 - 16,7 % sterilized
 - 81,8 % UHT treated
- 2 %
 - Farm products
 - Raw milk directly delivered to
 - consumers (vending machines, farm visits, etc.)
 - small occasional processors (bakeries, ice cream producers, etc.)



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Microbiological risks

- Qualitative risk assessment based on scientific literature and expert opinion
 - Human pathogenic microorganisms that can be present in raw milk (farm environment)
 - Reported frequencies of occurrence of human pathogenic microorganisms in raw milk
 - Reported human cases and outbreaks caused by the consumption of raw milk
 - Estimate of severity of adverse effects on human health of these microorganisms after consumption of raw milk
- For raw milk from cows and raw milk from other animal species than cows (goats, sheep, horses, donkeys, etc.)



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Which microorganisms can be present in raw cow milk?

	From blood	Mastitis	Faeces/skin	Environment
Pathogenic bacteria				
<i>Salmonella</i> spp.	(x) (S. Dublin)	(x)	x	
<i>Brucella abortus</i>	x	(x)		x
<i>Mycobacterium bovis</i>	x		x	x
<i>Coxiella burnetii</i>	x		x	x
<i>Mycobacterium avium paratuberculosis</i>	x		x	x
<i>Listeria monocytogenes</i>	x	(x)	x	x
Human pathogenic <i>E. coli</i>			x	x
<i>Campylobacter coli</i> and <i>jejuni</i>			x	x
<i>Corynebacterium pseudotuberculosis</i>	(x)	(x)		
Human pathogenic <i>Yersinia</i>		x	x	x
<i>Bacillus cereus</i> (diarrhoea toxins)				x
Enterotoxin-prod. <i>Staphylococcus aureus</i>		x		x
<i>Arcanobacter pyogenes</i>		x		
<i>Streptococcus zooepidemicus</i>		x		
<i>Leptospira</i>	x			x (urine)
Pathogenic viruses				
Rift Valley Fever Virus	x			
Tick-borne Encephalitis Virus	x			
Pathogenic parasites				
<i>Cryptosporidium parvum</i>			x	x
Toxins				
<i>Clostridium botulinum</i> type B toxins	x (toxins)		x (spores)	x (spores)

Which microorganisms can be present in raw cow milk?

detection in raw milk, in farm environment, in/on cow

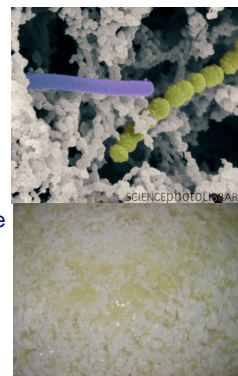
	From blood	Mastitis	Faeces/skin	Environment
Pathogenic bacteria				
<i>Salmonella</i> spp.	(x) (S. Dublin)	(x)	x	
<i>Brucella abortus</i>	X	(x)		x
<i>Mycobacterium bovis</i>	x		x	x
<i>Coxiella burnetii</i>	x		x	x
<i>Mycobacterium avium paratuberculosis</i>	x		x	x
<i>Listeria monocytogenes</i>	x	(x)	x	x
Human pathogenic <i>E. coli</i>			x	x
<i>Campylobacter coli</i> and <i>jejuni</i>			x	x
<i>Corynebacterium pseudotuberculosis</i>	(x)	(x)		
Human pathogenic <i>Yersinia</i>		x	x	x
<i>Bacillus cereus</i> (diarrhoea toxins)				x
Enterotoxin-prod. <i>Staphylococcus aureus</i>		x		x
<i>Arcanobacter pyogenes</i>		x		
<i>Streptococcus zooepidemicus</i>		x		
<i>Leptospira</i>	x			x (urine)
Pathogenic viruses				
Rift Valley Fever Virus	x			
Tick-borne Encephalitis Virus	x			
Pathogenic parasites				
<i>Cryptosporidium parvum</i>			x	x
Toxins				
<i>Clostridium botulinum</i> type B toxins	x (toxins)		x (spores)	x (spores)

Which microorganisms can be present in raw cow milk? reported raw milk outbreaks – association with human illness

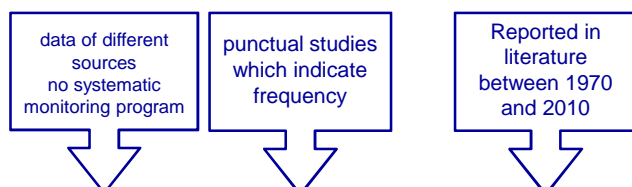
	From blood	Mastitis	Faeces/skin	Environment
Pathogenic bacteria				
<i>Salmonella</i> spp.	(x) (S. Dublin)	(x)	x	x
<i>Brucella abortus</i>	x	(x)		x
<i>Mycobacterium bovis</i>	x		x	x
<i>Coxiella burnetii</i>	x		x	x
<i>Mycobacterium avium paratuberculosis</i>	X		x	x
<i>Listeria monocytogenes</i>	x	(x)	x	x
Human pathogenic <i>E. coli</i>			x	x
<i>Campylobacter coli</i> and <i>jejuni</i>			x	x
<i>Corynebacterium pseudotuberculosis</i>	(x)	(x)		
Human pathogenic <i>Yersinia</i>		x	x	x
<i>Bacillus cereus</i> (diarrhoea toxins)				x
Enterotoxin-prod. <i>Staphylococcus aureus</i>		x		x
<i>Arcanobacter pyogenes</i>		x		
<i>Streptococcus zooepidemicus</i>		x		
<i>Leptospira</i>	x			x (urine)
Pathogenic viruses				
Rift Valley Fever Virus	x			
Tick-borne Encephalitis Virus	x			
Pathogenic parasites				
<i>Cryptosporidium parvum</i>			x	x
Toxins				
<i>Clostridium botulinum</i> type B toxins	x (toxins)		x (spores)	x (spores)

Why are some pathogens not acknowledged as a risk in raw milk?

- Growth bacteria in raw milk is limited due to the presence of background bacteria which are acidifying the milk (limited shelf life of raw milk)
- Clear relation between infectious dose and microbial risk in raw milk e.g.:
 - *Listeria monocytogenes*
 - *Bacillus cereus* diarrhoeal toxins
 - *Staphylococcus aureus* enterotoxins
- Special cases for which no risk can be excluded although no human cases are known
 - toxins of *Clostridium botulinum* type B which can contaminate the raw milk directly from the udder
 - *Coxiella burnetii*



Microbiological risks of raw cow milk



Pathogen	Presence in dairy cattle farms in Belgium	Presence in raw cow milk in Europe	Indication of the occurrence of human cases / outbreaks after raw cow milk consumption in Europe (and worldwide)
<i>Salmonella</i> spp.	present	0-2,9 %	5 (Europe) or 39 (world)
<i>Campylobacter jejuni</i> and <i>coli</i>	present	0-6 %	18 (Europe) or 39 (world)
Human pathogenic <i>E. coli</i>	present	0-5,7 %	13 (Europe) or 28 (world)
(<i>Listeria monocytogenes</i>)	present	2,2-10,2 %	(0 (Europe) or 2 (world))



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Microbiological risks of raw milk from goats, sheep, horses and donkeys in Belgium

Human pathogenic microorganism	Presence in farm in Belgium O = often, R = rare				Presence in raw milk (also abroad)				Responsible for reported raw milk outbreaks (also abroad)			
	Goat	Sheep	Horse	Donkey	Goat	Sheep	Horse	Donkey	Goat	Sheep	Horse	Donkey
<i>Bacillus cereus</i>	O	O	O	O	X	X						
<i>Campylobacter</i> spp.	O	O	O	O		X			X			
<i>Coxiella burnetii</i>	O	O	O	O	X	X			X			
<i>Helicobacter pylori</i>	O	O	O	O	X	X						
Human pathogenic <i>E. coli</i>	O	O	O	O	X	X			X			
<i>Listeria monocytogenes</i>	O	O	O	O	X	X						
MAP	O	O	O	O	X	X						
<i>Salmonella</i> spp.	O	O	O	O		X						
<i>Streptococcus</i> spp.	O	O	O	O	X	X	X	X				
<i>Cryptosporidium parvum</i>	O	O	O	O								
<i>Toxoplasma gondii</i>	O	O	O	O					X			
<i>Brucella</i> spp.	R	R	R	R	X				X			
Enterotoxin-producing <i>Staphylococcus aureus</i>	R	R	R	R	X	X	X	X	X			
TBEV	R	R	R	R	X	X			X			

Microbiological risks of raw milk from other animal species (abroad)

Human pathogenic microorganism	Presence in raw milk					Responsible for reported raw milk outbreaks				
	Camel	Llama	Buffalo	Yak	Reindeer	Camel	Llama	Buffalo	Yak	Reindeer
<i>Brucella</i> spp.	X		X		X	X				
<i>Salmonella</i> spp.	X									
Enterotoxin-producing <i>Staphylococcus aureus</i>	X		X							
<i>Streptococcus</i> spp.	X									
<i>Coxiella burnetii</i>	X									
<i>Helicobacter pylori</i>	X		X							
<i>Toxoplasma gondii</i>	X									
Human pathogenic <i>E. coli</i>			X	X						
<i>Listeria monocytogenes</i>			X							
MAP			X							
Human pathogenic <i>Yersinia enterocolitica</i>			X							

Effect of heat treatment on microbiological risks

RAW MILK	PASTEURIZATION (6 log)	Commercially sterile product	
		UHT (min. 12 log)	STERILIZATION (min. 12 log)
Vegetative cells			
<i>Coxiella burnetii</i>	Elimination	Elimination	Elimination
<i>Salmonella</i> spp.	Elimination	Elimination	Elimination
<i>Campylobacter jejuni</i> and <i>coli</i>	Elimination	Elimination	Elimination
Human pathogenic <i>E. coli</i>	Elimination	Elimination	Elimination
<i>Listeria monocytogenes</i>	Elimination	Elimination	Elimination
<i>Yersinia enterocolitica</i>	Elimination	Elimination	Elimination
<i>Clostridium botulinum</i>	Elimination	Elimination	Elimination
<i>Bacillus cereus</i>	Elimination	Elimination	Elimination
Spores			
<i>Clostridium botulinum</i> spores	Germination, toxin production	Elimination	Elimination
<i>Bacillus cereus</i> spores	Germination, toxin production	Elimination	Elimination
Toxins			
<i>Staphylococcus aureus</i> enterotoxins	No destruction	Destruction	Destruction
<i>Bacillus cereus</i> toxins	No destruction	Destruction	Destruction
<i>Clostridium botulinum</i> toxins	No destruction	Destruction	Destruction



→ **Significant reduction of microbiological risks**

Microbiological benefits and effect of heat treatment on microbiological benefits

RAW MILK		PASTEURIZATION (6 log)	UHT (min. 12 log)	STERILIZATION (min. 12 log)
Antimicrobial systems				
Enzymes: Lactoperoxidase, lysozyme, xanthine oxidase	activity limited at refrigT°	Partial inactivation	Inactivation	Inactivation
Proteins: Immunoglobulin & lactoferrin Bacteriocins (e.g. nisin)	mainly colostrum	Active Active	Denaturation General no effect	Denaturation General no effect
Lactic acid bacteria				
Limiting growth pathogens	activity limited at refrigT° (soaring/coagulation of milk > refrigT°)	Elimination Possible growth spores & post-pasteurization bacteria	Elimination	Elimination
Probiotic bacteria				
<i>Lactobacillus</i> <i>Bifidobacterium</i> <i>Enterococcus</i>	limited effect due to low amounts in raw milk	Elimination	Elimination	Elimination

Commercially
sterile product

Conclusions



- Consumption raw milk = real microbiological risk
 - in Belgium especially *Salmonella*, *Campylobacter* and human pathogenic *E. coli* for raw cow, goat and sheep milk; raw horse and donkey milk has lower microbiological risks
- Heat treatment = historically and scientifically proven to be an efficient method to guarantee microbiological safety of milk
 - pasteurization eliminates all relevant pathogens (vegetative microorganisms, no spores or heat stable toxins)
 - Sterilization and UHT treatment result in commercially sterile product
- Antimicrobial systems limited active and benefits of lactic acid & probiotic bacteria not relevant; inactivated by heat treatment

Recommendations

- Attention for consumption of all types of raw milk which is sold directly from producer to consumer
- Occasional consumption during farm visit
- Vending machines: good management & information concerning risks of raw milk consumption
- Especially for sensitive persons (YOPI's)

- **Raw milk: shortly heating till cooking point before consumption**

- Informative brochure consumers →



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More information

- Risk/benefits raw/heated cow milk
 - Sci Com advice 15-2011
 - Claeys *et al.* 2013. Raw or heated cow milk consumption: review of risks and benefits. *Food Control* 31(1), 251-262.
- Risk/benefits raw/heated milk from other species
 - Sci Com advice 11-2013
 - Claeys *et al.* 2013. Raw or heated cow milk consumption: review of risks and benefits. *Food Control* 31(1), 251-262.
 - Verraes *et al.* 2014. A review of the microbiological hazards of raw milk from animal species other than cow. *International Dairy Journal* 39, 121-130.

Ongoing work

- Microbiological risks of raw milk products
 - Sci Com advice ongoing

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Thanks to...

Staff Direction for Risk Assessment

Sabine Cardoen, Wendie Claeys

Working group members

L. Herman (Chair WG Sci Com), L. De Zutter (Sci Com), G. Daube (Sci Com), H. Imberechts (Sci Com), K. Dierick (WIV-ISP)

Scientific Committee FASFC

