Are There Microbes in My Dairy?
Are there microbes in MY dairy??

Yes, and many of them are *necessary* for you, and for your products.
Many microbes are useful (or not harmful for humans).

Examples of Beneficial Microbes

- Starter cultures
- Inoculation and native cultures
- Fermented and probiotic food products
The Main Types of Microbes in Raw Milk

Useful microbes
- Lactic acid bacteria
- Starter cultures (bacteria, moulds, yeasts)

Spoilage bacteria
- Psychrotolerant ("psychrotrophs") bacteria like *Pseudomonas*
- Thermoresistant Clostridia causing butyric fermentation
- Coliforms

Relevant pathogenic bacteria
- *Listeria monocytogenes*
- *Salmonella*
- *Staphylococcus aureus*
  producing enterotoxins
- *Brucella* and *Mycobacterium bovis*
Raw Milk is a Living Ecosystem

Environmental conditions - Bacterial interactions
An isolated bacteria means nothing without the interaction in the ecosystem
The Ecosystem of Raw Milk - Barriers to the Growth of Pathogens:

- **ACIDOLACTIC BACTERIA**
- **LACTIC ACID**
- **BACTERIOCINS**
- **NON-LACTIC BACTERIA** (eg. *Brevibacterium linens*)
- **YEASTS AND MOLDS** (eg. *Geotrichum candida*)
Technological Barriers

• The diversity of microbial ecosystems can be utilised to protect milk products from pathogens (**Maoz et al., 2003; Eppert et al., 1997; Saubusse et al. 2007)

• This hurdle theory is an old concept (**Leistner, 1985) but now it is becoming known as an efficient tool to prevent development of pathogens (**Ghandi et Chikindas, 2007)
  • An example: The natural interaction of microbes and their metabolites in raw milk and in raw milk cheeses (**Millet et al., 2006)
  • For more information and references, see tool 9.6

** Authors of scientific studies
Environmental Factors Enabling Microbial Growth

- Moisture
- Nutrients
- Temperature
- Acidity (pH)
- Oxygen level
- Water activity: the quantity of free water in foods, available for microorganisms. Scale 0 (min)-1 (max)
Some Microbes are Undesirable or Harmful and Can Cause

Food spoilage (technical problems)

Food poisoning or infections

http://cheeseforum.org/articles/wiki-cheese-body-defects-mechanical-holes/
There is No Need of Being Afraid of Microbes, but It Must Be Understood That...

in the worst case, a series of small mistakes in hygienic practices might cause even a death of a consumer.

Photo: Microbiology International
Personal Hygiene is Important!

Photo:
Microbial colonies on solid medium.
• The surface was touched by a hand
• The plate was incubated for three days at 30 °C
• Each of these colonies originate from one or few microbial cells from the person’s hand
You cannot remove all the hazards but you can control the risks
Effects of Harmful Microbes in Foods?

1. Produce toxins → food poisoning and foodborne infections
2. Produce enzymes which degrade food components like fats, proteins and carbohydrates → food spoilage
3. High microbial counts exceed the safety limits → risk of harmful effect on consumers health
Pathogens Relevant to Dairy Manufacturing Processes

• Food safety criteria:
  • *Salmonella* spp.
  • *Listeria monocytogenes*
  • Staphylococcal enterotoxins *produced by Staphylococcus aureus*

• Process hygiene criteria:
  • Non toxin-producing *Staphylococcus aureus*
  • *Escherichia coli*
SALMONELLA SPP
FOOD SAFETY CRITERION
How *Salmonella* Affects Humans?

- **Adults:**
  - First symptoms: 8-48 h after eating
  - Typical symptoms: diarrhea, belly cramps, fever, vomits, headache
  - Duration: 2-4 days and often spontaneous healing

- **Immunosuppressed people:**
  - Septicemia, potentially life-threatening

- **Mortality rate:** approx. 0.2 %
SALMONELLA spp: Where Do They Live?

• Various species (all potentially pathogens)

RESERVOIR ANIMALS:
- Faeces
- Milk (rare but not impossible)
- Placenta, abortion...

RESERVOIR PEOPLE:
- Faeces

RESERVOIR: Where the infectious agent normally lives and multiplies, typically without injury to itself, and serves as a source of infection for others

OTHER ANIMALS: birds, fowls, rodents

WATER, SOIL:
- to be careful with fertilization (contaminated manure!)
- (see the guide: Milk Production sheet)

Teacheesy
SALMONELLA: Do They Survive in the Environment?

- Usually they do not grow
  BUT,
- They may survive for a long time:
  - In water: 3 months
  - In manure: 1 month
  - In slurry: 2-3 months
- Attention: rodents and fowls can be reservoir animals
SALMONELLA – How to Avoid It in Milk?

• To identify and isolate positive animals (faeces and even milk samples)
• To keep good hygiene during milking
• To clean milking machines properly
• After fertilisation with manure, wait one to three months before animals to grass
• Water: if possible, to protect drinking through and/or to chlorinate
• Attention with birds, fowls, rodents
Salmonella – How to Avoid Contamination in a Cheese Dairy?

• Avoid contamination in milk
• Good hygiene practices:
  • After using the toilets
  • Clean shoes and clothing
• To avoid working in case of disease symptoms related to gastrointestinal tract, like diarrhea
• To use good quality water
LISTERIA MONOCYTOGENES

FOOD SAFETY CRITERION
How *Listeria monocytogenes* Affects Humans?

- Often only mild symptoms: diarrhea, fever, headache.
- Main risks to « high risk population »: infants and small children, pregnant women, immunosuppressed people:
  - Meningitis
  - Abortion
- Low disease rate but high mortality rate in immunosuppressed people « high risk population »: 15 – 30 %
How *Listeria monocytogenes* Affects Ruminants?

- Meningitis
- Abortions
- Subclinical mastitis
- Eye problems
- Endocarditis

PRESENT IN ALL ANIMALS IN GENERAL
Listeria monocytogenes: Where Does It Live?

UBIQUITOUS GERM: EVERYWHERE

- Faeces, also from healthy humans
- Breast excretion (rare but possible)
- Soil, plants
- Fodder, mainly silage
- Stagnant water
- Evaporators in maturations rooms
**Listeria monocytogenes, In Which Conditions It Grows?**

- **TEMPERATURE** (cold resistant)
  - Growth Temperature: 0°C to 45°C
  - Optimum: 30-37°C
  - Lethal: >60°C

- **SALT** (very resistant)
  - ≤ 19.5° Baumé
  - 21% w/v

- **pH**: 4.39-9.40
  - Optimum: 7
  - aW: 0.92-0.97

No growth:
- pH ≤ 4.4, or
- aW ≤ 0.92, or
- pH: ≤ 5 and aW: ≤0.94

*aW* (Water activity): The quantity of free water in foods, available for microorganisms. Scale 0 (min) to 1 (max)
Risk Factors for *Listeria monocytogenes* Contamination in MILK

• Contamination by feaces of animals during milking → avoid with good hygiene
• Contaminated water
• Contaminated feed, especially silage
• Subclinic mastitis
• Reservoir in wild animals as red deer, wild boars and rodents
How to Avoid *Listeria monocytogenes* in a Cheese Dairy?

- To prevent milk contamination
- Good hygiene practices:
  - Personal hygiene, clean shoes and dress
  - To avoid direct or indirect contact of food with soil (e.g. splashing)
- To avoid stagnant water and condensation
- Clean evaporators carefully
- Avoid dust from silage area
STAPHYLOCOCCUS AUREUS

PROCESS HYGIENE CRITERION

FOOD SAFETY CRITERION ONLY IN CASE OF PRODUCTION OF STAPHYLOCOCCAL ENTEROTOXIN
STAPHYLOCOCCUS AUREUS

• Main reservoir: mucous of animals and humans (nostrils, throat, teat), superficial wounds, hair

• Also in air, water, surfaces

• Very persistent in the environment
Many *Staphylococcus aureus* Strains Produce Enterotoxins

- When do *S. aureus* bacteria produce enterotoxin?
  - The level of contamination: > 1,000,000 cfu/g, and
  - Good environmental conditions: pH > 4.5, T > 10 °C, aW > 0.88, salt up to 20 %
  - Not all *S. aureus* strains

- The toxin is resistant to:
  - Pasteurisation
  - Low moisture
  - Freezing
  - Proteolytic enzymes present in stomach (pepsin and rennin)
How *S. aureus* Affects...

**PEOPLE**

- Vomit, abdominal cramps, diarrhea, headache
- Usually not life-threatening; mortality is highest in risk groups: immunosuppressed people and children under five years

**ANIMALS**

- Clinical and subclinical mastitis:
  - Sheep and cows: the most common cause of mastitis
  - Goats: in 2,5% of mastitis but high secretion to milk
- In suppurative wounds: metritis, vaginitis, abscesses
Staphylococcus aureus, In Which Conditions it Grows?

- **GROWTH TEMPERATURE**
  - From 7°C to 48°C
  - Optimum: 35-40°C
- Survive well in refrigerated and frozen temperatures
  - SALT (very resistant)
  - > 20% w/v
- **pH:**
  - 4-10
  - optimum: 6-7
- **a_w:**
  - 0,83-0,99

*a_w* (Water activity): The quantity of free water in foods, available for microorganisms. Scale 0 (min) to 1 (max)
Staphylococcus aureus, How Contamination Occurs?

Animals with mastitis by S. aureus

Contaminated materials

Colds

Skin of udders

Wound from animals or from the milking person

Hands of producers

Final product

Milk
ESCHERICHIA COLI

PROCESS HYGIENE CRITERION
ESCHERICHIA COLI

• Common in the intestines of animals and people
• Presence in food indicates poor hygiene
• Most strains are non-pathogenic (specific strains producing shiga-toxins are pathogenic)
• Causes defects in cheese:
  • Gas production
  • Off-flavors
There are Rare Pathogenic *E. coli* Strains

**ADULTS:**
- Gastrointestinal symptoms: bloody diarrhoea, fever, dehydration

**BABIES:**
- Hemolytic uremic syndrome (especially in children)
- Meningitis and septicemia

**ANIMALS:**
- Gastroenteritis versus septicemia
- Clinical mastitis
**ESCHERICHIA COLI, How Does It Live?**

- **GROWTH TEMPERATURE**
  - Temperature: 7°C to 46°C
  - Optimum: 35-40°C
  - Survive well in refrigerated and frozen temperatures

- **SALT:**
  - No growth > 6% w/w

- **pH:**
  - 4.4-9
  - Optimum: 6-7

- **a_w**: 0.95-0.995

*a_w* (Water activity): The quantity of free water in foods, available for microorganisms. Scale 0 (min) to 1 (max)
ESCHERICHIA COLI, How Contamination Occurs?

Intestines (animals and people) → Faeces go to milk during milking → Contaminated water → Dirty milking materials and bad hygiene → E. coli Mastitis (rare) → Insufficient refrigeration
How to Prevent Contamination in a Cheese Dairy?

• To prevent milk contamination
• Fast and sufficient refrigeration of milk
• Good hygiene practices: hands, clean materials and equipment
• Avoid contaminated water
• Pest control (reservoir)
• Lactic cheeses: right acidification
Are Cheeses Safe Foods?

Some official data about it can be found in tool 9.10