Immunity and the mammary gland defense system

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The Function of the Immune System

1. Protect from pathogens
2. Distinguish between self/non-self
3. Memory

The Immune System

A) natural/adaptive = innate/acquired
B) cell-mediated/humoral
C) active/passive
D) primary/secondary
The mammary gland Immunity

Blood System

Barrier Between glands

Barrier Body- Udder

Udder Epithelial cells
The mammary gland Immunity

Selective transfer

Body → Udder

Mucosal lymph system

mouth

respiratory

digestion

lymph node

supra-mammary lymph node

anus
The implication of the body-udder barrier and the barrier between the two udder-halves:
1. acquired immunity in the body is only partial and at a lower level in the udder
2. Not all the immune responses in the mammary glands will be recognized by the body
“Most mammary glands, most of the time are sterile with no contaminating microorganisms”
Teat canal
The major barrier, protecting penetration of bacteria into the mammary glands
Infection “cycle” in the mammary gland

- recovery
- Bacteria
- removal
- clinical infection
- death
- chronic infection
Interaction between the intruder and the mammary gland immunity

**innate immunity**
mainly PMN from the blood stream

No establishment of immune memory

removal recovery

clinical infection

death
Bacteria penetrating the teat canal come across cells from the immune system.

If the encounter is with polymorphonuclear cells (PMN) or macrophages, the event can end successfully: removal or killing of the intruder with no sign of infection but more important, without establishment of immune memory.
When the intruder is encountered by macrophage or dendritic cells, it can be presented to B and/or T cells via the supra-mammary lymph node which will lead to systemic response and/or sporadic B (possibly B1) and T cells, which will lead to a local response.
Why is it important to know the mammary gland immunity?

The major income from dairy animals is derived from their milk production; therefore, factors that reduce milk quantity and quality can cause overwhelming economic losses to the farmers.

The increasing public concern on food safety is focused among other on milk quality in the desire to minimize antibiotic residues in milk on the one hand, and reducing somatic cell counts (SCC) on the other hand.
High correlation between udder infection and bulk milk tank SCC

Udder infection is the most important single factor influencing bulk SCC

% and type of udder infection in the herd
High correlation between bulk milk tank SCC and milk products

Storage time influences the quantity and quality of milk products

High BMTSCC
Low BMTSCC

Time of storage
**Somatic cells in sheep milk**

<table>
<thead>
<tr>
<th></th>
<th>Not infected</th>
<th>Infected (Sub clinic)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCC (1000)</td>
<td>&gt;300</td>
<td>500 - &gt; 3,000</td>
</tr>
<tr>
<td>Epithelial</td>
<td>30-40%</td>
<td>&lt; 5%</td>
</tr>
<tr>
<td>Lymphocytes</td>
<td>5-15%</td>
<td>~ 5%</td>
</tr>
<tr>
<td>Macrophages</td>
<td>~ 10%</td>
<td>~ 10%</td>
</tr>
<tr>
<td>PMN</td>
<td>20-40%</td>
<td>85%</td>
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</tbody>
</table>
Fresh curd from uninfected milk (~$1 \times 10^5$ cells)
Fresh curd from infected milk (~$1 \times 10^6$ cells)
Cheese from uninfected (left) or infected (right) milk
The mammary gland immunity functions at a low level, that mainly involve innate immunity.

Not in all chronic infection there are acquired immunity.

Products of the acquired immunity in the milk (i.e., antibodies) are lower than that of the blood stream (10-25%).
Treatment (during lactation, at dry-off) !!!!!
”Dry-off treatment of Assaf sheep: efficacy as a management tool for improving milk quantity and quality”

![Graph showing average milk yield, flock infection, and bulk tank somatic cell count over years 2003 to 2005.](image)
Average milk yield per individual lactation increased by 19%, from 395 to 487 l over the 2 years of the study. Over the same period the bulk tank milk SCC decreased from about $2,500 \times 10^3$ in 2003 to less than $1,000 \times 10^3$ in 2005. The percentage infection level of the flock, as tested 2 weeks PP, decreased from about 60% in 2003 to about 22% in 2005.

It was found that IMI, mainly with CNS, reduced individual milk yield by 0.189 l d$^{-1}$, equivalent to an overall annual milk loss of 42 L per ewe.
Among the IMI-affected ewes, the milk yield began to fall immediately PP, and the diminution continued throughout the lactation.
MASTIVAC I: a vaccine that protects cows from *Staphylococcus aureus* mastitis

Thanks for your attention