	Health traits					
		Calvings				
Name bull	Dau. fert.	S	MGS	Mast. Resist.	Other diseases	Longevity
Inlag-ET	107	115	110	104	99	115
Torpane	108	96	107	103	103	
Flaka	104	106	102	103	108	112
Bredåker	100	106	103	102	98	107

	Functional traits				
Name bull	Stature	Legs	Udder	Milk speed	Tempr
	102	111	105	89	105
	97	96	101	102	102
G Ross	108	101	107	105	101
Botans	96	103	103	107	98
Stöpafors	103	97	105	108	96
Inlag-ET	100	101	97	92	98
Torpane	104	103	104	105	96
Flaka	97	99	104	92	96
Bredåker	94	94	100	110	107

1.9 Detailed information on udder health

1.9.1 Reader instruction

This chapter (1.9) gives background information on udder health and correlated traits. It is about direct (clinical mastitis) and indirect traits (somatic cell count, milkability and udder conformation traits). For the experienced reader reading only the bold printed words and text boxes should be sufficient.

1.9.2 Infection and defence

The first line of defence against an infection of microorganisms is the **mechanical prevention** of the mammary gland. This mechanical prevention is opposite to the ease of microorganisms to enter the teat canal: the easier the entrance, the weaker the mechanical prevention. The quality of this defence is related to the **milkability** and the **udder conformation** traits, like e.g. teat length and udder depth. However, when microorganisms enter the mammary gland, then the **immune system** causes an attraction of leukocytes to the place of infection, which results in an enlarged **somatic cell count**. So, a short-term increase in somatic cell count with or without accompanying clinical signs are on one hand a symptom of a failing first line of defence, but on the other hand indicating an appropriate immunological reaction. The picture below (Figure 1) shows the infection process, together with the destruction of a milk-secreting cell.

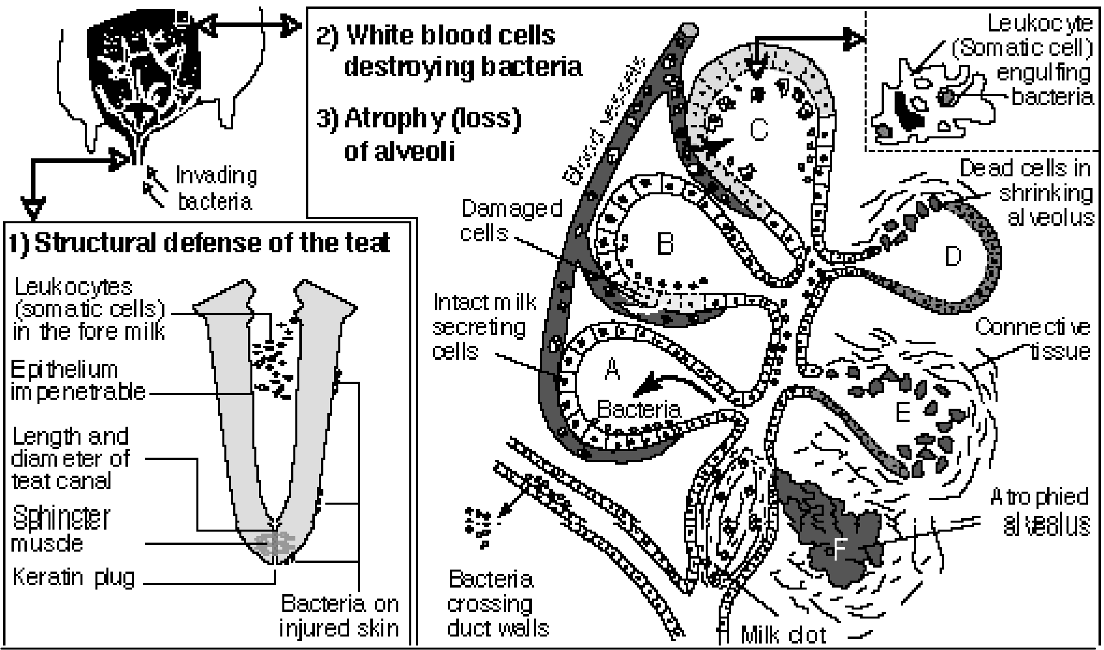


Figure 1. Infection process.

Mastitis causing bacteria

Contagious mastitis

a. - primary source: udders of infected cows,

b. - is spread to other cows primarily at milking time,

c. - results in high bulk tank SCC.

It is caused by:

a. *Streptococcus agalactiae* (> 40% of all infections),

b. *Staphylococcus aureus* (30 - 40% of all infections).

The S. *aureus bacterium* is hardly eradicable, but can be reduced to less than 5% of the cows in a herd. The *S. agalactiae* is fully eradicable from a herd.

Environmental mastitis

a. Primary source: the environment of the cow.

b. High rate of clinical mastitis (especially the lower resistant cows, e.g. Early lactation).

c. Individual scc is not necessarily high (less than 300,000 is possible) .

It is caused by:

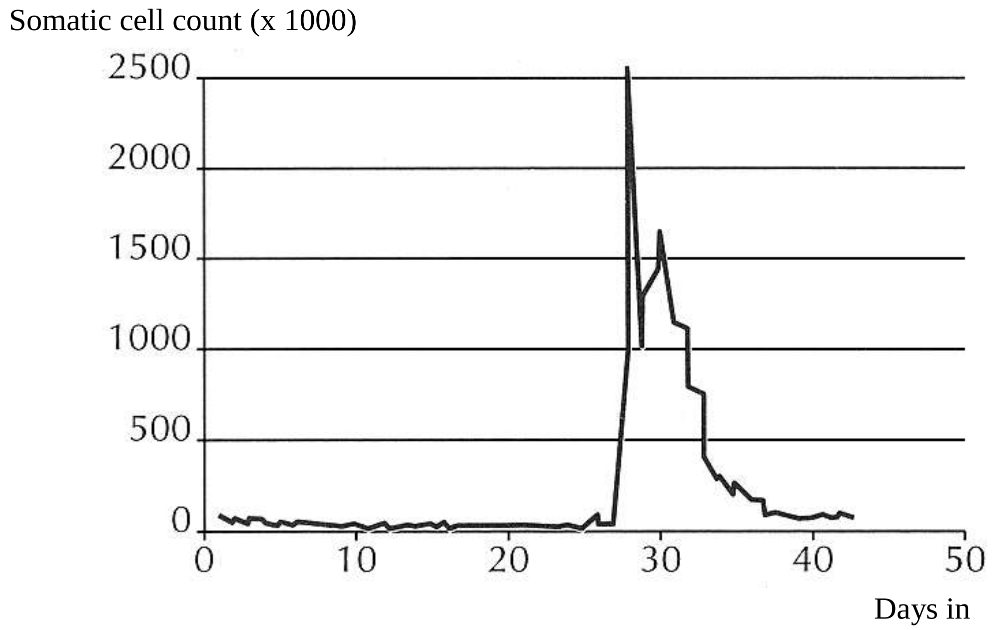
a. environmental *steptococci* (5 - 10% of all infections).
   - Streptococcus uberis.
   - Streptococcus bovis.
   - Streptococcus dysgalactiae.
   - Enterococcus faecium.
   - Enterococcus faecalis.

b. - Coliforms (< 1% of all infections):
   - Escherichia coli.
   - Klebsiella pneumoniae.
   - Klebsiella oxytoca.

1.9.3 Clinical and subclinical mastitis

Mastitis can be subdivided in clinical and subclinical mastitis. Clinical mastitis is mastitis with outer visual or perceptible signs of the udder or the milk. Clinical mastitis is observed as abnormal milk, like flaky, clotted and / or “watery” milk. Possible perceptible signs on the udder are redness, painfulness and swollenness with fever.

Subclinical mastitis is not perceptible directly by a farmer or veterinarian, but is detectable with indicators. The most used indicator is the number of somatic cells per ml milk (somatic cell count). Other, less practised physiological indicators of subclinical mastitis are electrical conductivity of the milk, N-acetyl-ß-D-glucosaminidase, bovine serum albumin, antitrypsin, sodium, potassium and lactose content.



Daily somatic cell count with a clinical mastitis event at day 28 (Source: Schepers, 1996)
Figure 2. Daily somatic cell count with a clinical mastitis event at day 28 (Source: Schepers, 1996).

The somatic cell count is the most widely accepted criterion for indicating the udder health status of a dairy herd. An enlarged number of somatic cells in milk, which is unfavourable, points to a **defence reaction**.

Somatic cells in milk are primarily leukocytes or white blood cells along with sloughed epithelial or milk secreting cells. **White blood cells** are present in milk in response to tissue damage and/or clinical and subclinical mastitis infections. These cell numbers increase in milk as the cow’s immune system works to repair damaged tissues and combat mastitis-causing organisms. As the degree of damage or the severity of infections increase, so does the level of white blood cells. **Epithelial cells** are always present in milk at low levels. They are there as a result of a natural process inside the udder whereby new cells automatically replace old tissue cells. Epithelial cells result in normal milk SCC levels of <50,000.

The recommended industry standard for bulk SCC on delivery is one that is consistently <200,000. Many herds, which are successful in maintaining a herd SCC <100,000, have minimal to no mastitis infections.

> The somatic cell count is the number of somatic cells per millilitre of milk. Normal milk has less than 200,000 cells per millilitre.

So, somatic cells are partly white blood cells or **body defence cells** whose primary functions are to eliminate infections and repair tissue damage. Somatic cell levels or numbers in the mammary gland do not reflect the whole pool of cells that can be recruited from the blood to fight infections. Somatic cells are sent in high numbers only when and where they are needed. Therefore, high SCC indicates mammary infection. A certain number of cells is necessary once an infection invades the udder. Together with a favourite low SCC, the **speed of cell recruitment** to the mammary gland and the cell competency are the major factors in infection prevention.

1.9.4 Aspects of recording clinical and sub-clinical mastitis

Recording clinical mastitis is possible but not common practice (yet). Scandinavian countries are the only countries that include mastitis incidence directly in their national recording and evaluation programs. However, other countries are working on a national recording and evaluation scheme for mastitis incidence as well. Reasons for increased interest in recording clinical mastitis are in

a. Veterinary farm management support (i.e., identification of diseased animals and establishing treatment procedure).

b. National veterinary policy-making (i.e., drugs regulations and preventive epidemiological measures).

c. Citizens' and consumers' concerns about animal health and welfare and product quality and safety (i.e., chain management, product labelling).

d. Genetic improvement (i.e., monitoring genetic level of the population and selection and mating strategies).

It is to be emphasised that recording of clinical mastitis is difficult, as it requires a clear definition (as given in these guidelines), an accurate administration with for example dates of incidence and (unique) cow numbers. It is also important that the reasons for recording are made clear to stakeholders and that information is not only gathered centrally, but also processed to obtain clear information for farm management support to be reported back to the farmer.

The (phenotypic) occurrence of clinical or subclinical mastitis is influenced by the genetic merit of the animal (its breeding value) and by environmental effects. When considering the total phenotypic variance between animals, for clinical mastitis about 2-5 % is because of genetic differences between the animals. The remaining differences between animals are because of different environmental influences and measuring errors. Known systematic environmental influences are for example in parity of the cow or stage in lactation. An evaluation of udder health traits will have to carefully consider these systematic environmental influences.

On-farm management decision-support

Although these quidelines focus on evaluation of udder health for genetic improvement, information is also very useful for on-farm decision-support. Routinely recording of clinical incidents and somatic cell count allows the presentation of key figures for veterinary herd management.

Operational - individual animal level

Results of recording can be presented per individual animal. To support decision making, a note can accompany the presentation of the recording level when the level is above a certain threshold. For example, a SCC above 200,000 indicates that the cow may suffer from subclinical mastitis and requires treatment or it is advised to perform a bacteriological culturing. An additional listing might provide a direct overview of cows with attention levels for which further action is advised.

More sophisticated decision support may include correction of the observed level for systematic environmental effects (such as parity or stage in lactation) and time analysis.

Mastitis caused by different bacteria requires different preventive and curative measurements to be taken. Therefore, information from bacteriological culturing is generally very important in operational farm management.

Tactical - herd level

Publication of key figures on mastitis incidence, bacteriological culturing and SCC at herd level will provide decision support at the tactical term. A general recommendation is to present recent averages, but also to present the course of the averages over a longer time period. If available, it is advised to include a comparison of the averages with a mean of a larger group of (similar) farms. For example, the average on SCC might be compared with the average bulk somatic cell count for all farms delivering milk to the same factory.

Farm averages might also be specified for different groups of animals at the farm. For example, SCC might be presented as an average for first lactation females versus later parity animals. This denotes which groups require specific attention in the preventive and curative management.

1.9.4.1 Health card

In Norway, Finland and Denmark each individual cow has a health card, which is updated each time the veterinarian treats the animal. For example in Norway is a strict regulation of drugs such that all antibiotic treatments are carried out by the veterinary, and the farmer is not allowed treating his own animals. Completeness and consistency requires a very accurate administration; a condition in order to let a health card system be useful for breeding programs.

1.9.4.2 Quality control

In the Netherlands, it is now included in the 'chain control on quality of milk' that the farm is regularly visited by a veterinarian to record health status of the cows. This gives a 'test-day' comparison of all cows in the herd. This information can possibly be used for national veterinarian monitoring programmes and for selection programmes.

In many countries a reliable recording of clinical mastitis incidents is hard to achieve, which makes this trait not the first step in developing an udder health index. Somatic cell count (SCC) is genetically highly correlated with clinical mastitis: 0.60-0.70. This means, that when analysing field data, an observed high level of SCC is generally accompanied by a clinical mastitis event. In other words, although milk of healthy cows also shows variance in SCC, in day-to-day field data, most of the variance in SCC is caused by clinical mastitis events.

Given its high correlation to clinical mastitis, SCC is an appropriate indicator of udder health, as

e. Somatic cell counts can be routinely recorded in most milk recording systems, giving better opportunities of accurate, complete and standardised observations.
f. About 10-15% of the observed variation in scc is caused by differences in breeding values of the animals, which is higher than in clinical mastitis.
g. It also reflects incidence of subclinical intramammary infections.

Bulk somatic cell count

Sofar, we have considered SCC on animal level. In farm management also the average bulk somatic cell count (BSCC) is of interest. In many countries the BSCC is a basis for milk price payment by the dairy industry. The BSCC can also play a role in decision-support.

High BSCC herds mainly deal with high levels of contagious, invasive organisms, which are mostly subclinical. Many cows are infected and substantial udder damage and milk losses are caused. When these infections become clinical, they are usually mild. Environmental infections are rarely seen because they are opportunists and can not compete with the highly invasive organisms. Low SCC herds have low levels of contagious, invasive pathogens. Thus, when they do have infections, they are usually environmental. Environmental infections are very vivid, with a severe illness and a possible death as a result. Environmental infections are not invasive, but opportunistic, thus most animals who get these are usually suppressed or heavily stressed, e.g. early lactation animals. A good management from the farmer can reduce the number of environmental infections.

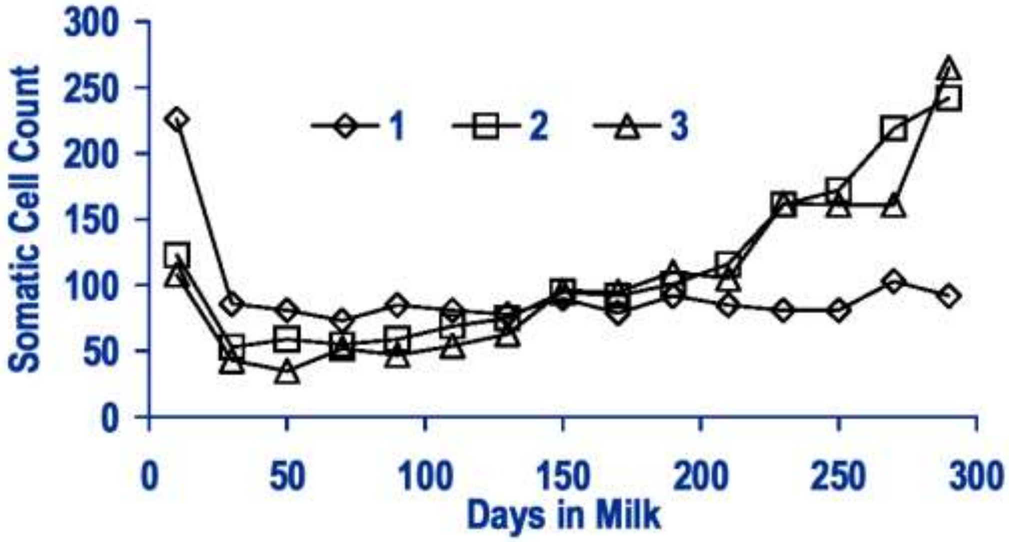


Figure 3. The upper 95% confidence limit for somatic cell counts in uninfected cows, in three different parities, in dependance on days in milk (Source: schepers et al., 1997).

The upper 95% confidence limit for somatic cell counts in uninfected cows, in three different parities, in dependence on days in milk (Source: Schepers et al., 1997).

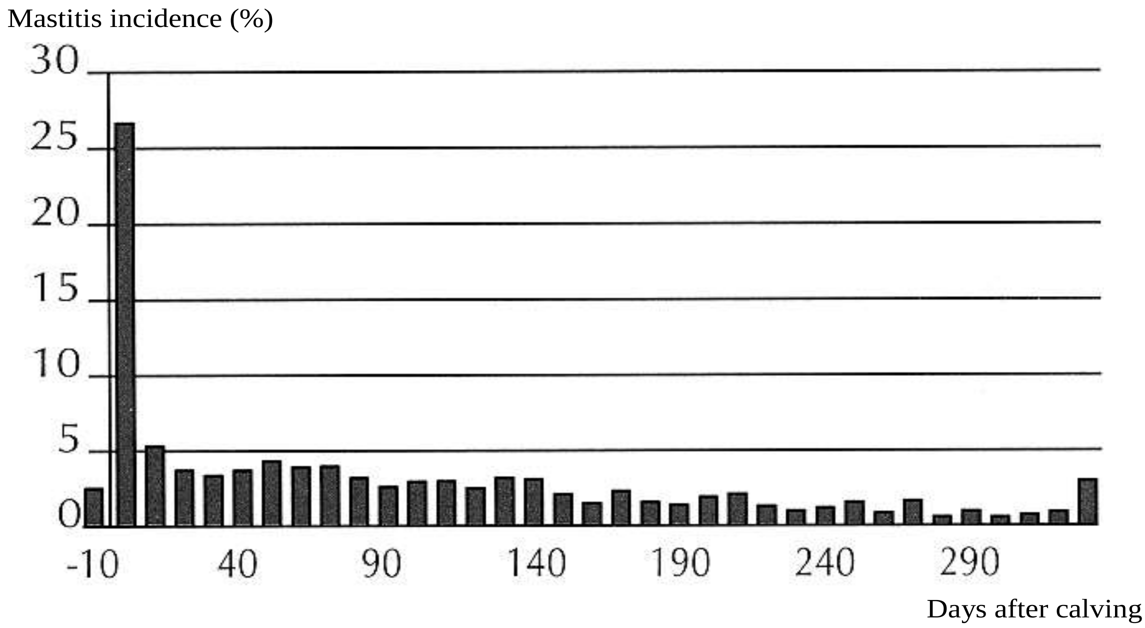


Figure 4. Frequency distribution of clinical mastitis incidents according to lactation stage (Source: Schepers, 1986).

Frequency distribution of clinical mastitis incidents according to lactation stage (Source: Schepers, 1986).

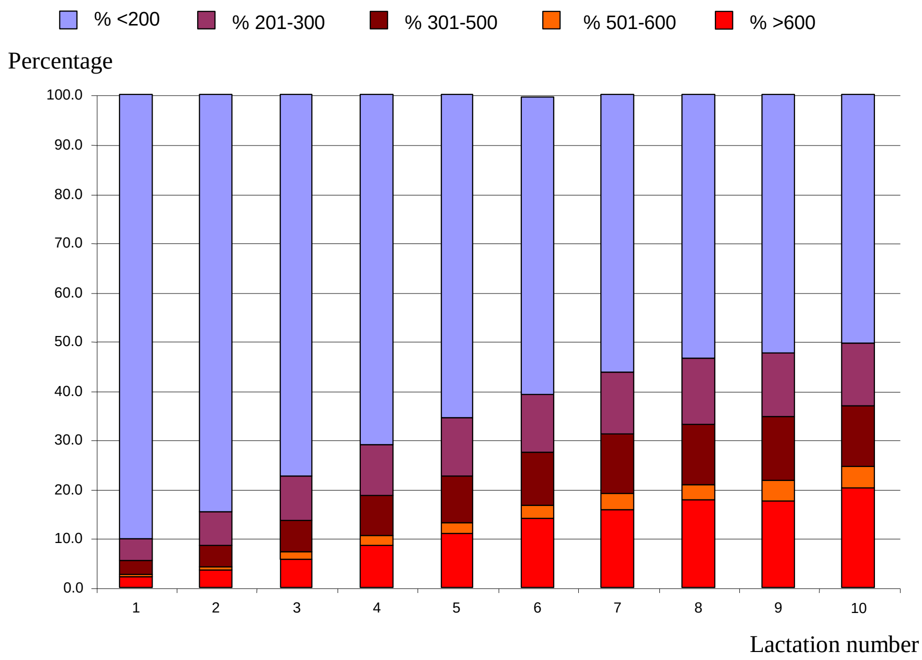


Figure 5. Percentage of cows of different SCC-classes (x 1000; year 2000 calvings, Australia) per lactation (Source: Hiemstra, 2001).

1.9.5 Relevance or lowering SCC

The importance of reducing clinical mastitis seems clear (high costs and impaired welfare), the importance of reducing subclinical mastitis might seem less obvious. However, there are **several reasons** for reducing the amount of subclinical mastitis (an increased number of somatic cells in milk (SCC)) in dairy cattle, like:

a. Daughters of sires that transmit the lowest somatic cell score (log-transformation of somatic cell count) have lower incidence of clinical mastitis and fewer clinical episodes during first and second lactation.

b. Decreased somatic cell count (SCC) has been shown to improve dairy product quality, shelf life and cheese yield. Increased SCC decreases cheese yield in two ways:

- By decreasing the amount of casein as a percentage of total protein in milk.
- By decreasing the efficiency of conversion of casein into cheese.

c. High SCC in milk affects the price of milk in many payment systems that are based on milk quality.

d. High SCC milk has a reduced flavour score because of an increase in salts.

1.9.5.1 Advantages of lowering somatic cell count

a. Clinical mastitis: low incidence and few episodes.

b. Improved dairy product quality.

c. Higher milk prices.

1.9.5.2 Natural defense system

Part of the somatic cells is white blood cells - they are an essential part of the cow's immune system. Trying to lower the incidence of cases with highly increased somatic cell count (as an indicator that a defense reaction was necessary) is advised. Trying to lower somatic cell count below natural levels in milk of healthy cows is not advised. An essential part of the natural defence system is also the speed of white blood cells recruitment.

1.9.6 Milkability

There is an unfavourable genetic correlation between milkability (milking speed, milking ease or milk flow) and somatic cell count. Faster milking cows tend to have a higher lactation somatic cell count. In general, an unfavourable genetic correlation between milkability (i.e., milking speed) and udder health is assumed. This is explained by a possibly **easier mechanical entry of pathogens** into the udder associated with an easier exit of milk out of the udder ant teat canal.

However, some remarks are to be made with respect to this correlation between milkability and udder health.

1.9.6.1 Non-linearity

The genetic correlation is assumed to be non-linear. This means that at low and mediate levels of milking speed there is no influence on udder health. Only with extremely high milking speed, also observed as leakage of milk before milking time, the teat canal is too wide facilitating easy entrance of microorganisms.

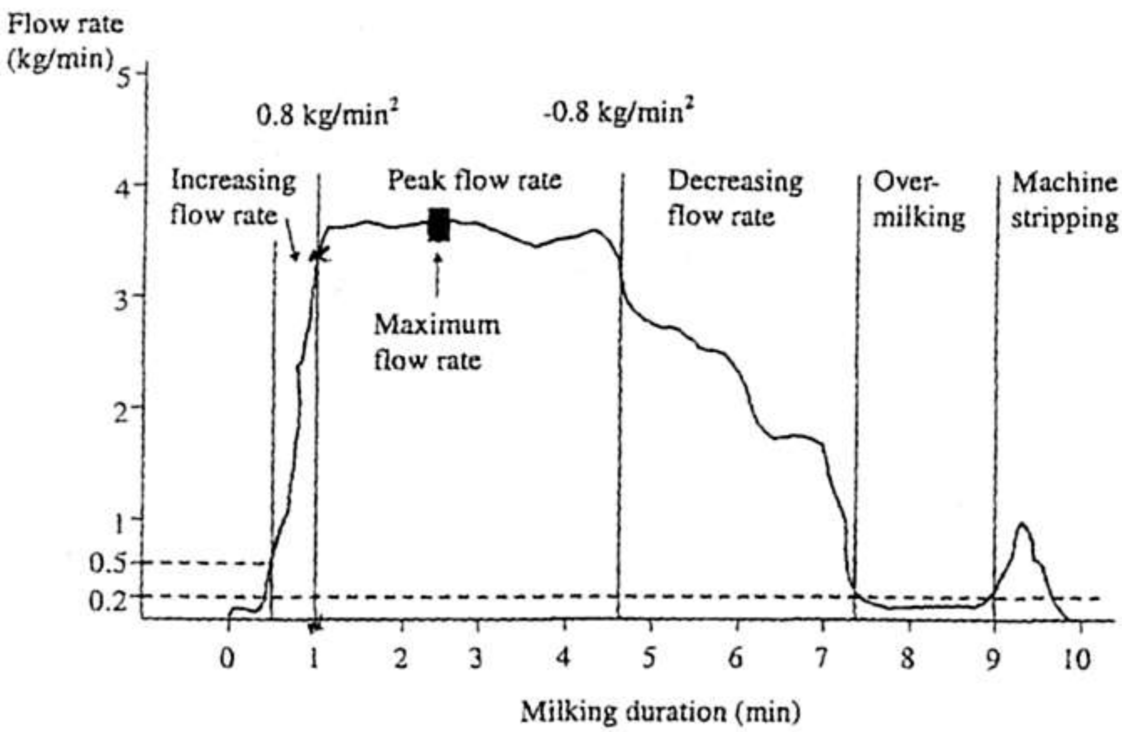


Figure 6. A generalised representation of the milk low curve (Source: Dodenhoff et al., 2000).
Figure: A generalised representation of the milk flow curve (source: Dodenhoff et al., 2000).

1.9.6.2 Complete draining with milking.

With each milking, the last fraction of milk contains 3 to 10 times more cells than the first fraction. This however depends on the completeness of withdrawing milk from the udder, which itself is again related to milking speed. A higher milking speed, facilitates a more complete draining of the udder causing a higher SCC. This supports the suggestion that milking speed is unfavourably correlated with SCC but not with clinical mastitis.

Another important point is that milking speed is associated with **the farmer's labour time** for milking. Increased milking speed per cow implies decreased costs for electrical power and decreased wear on milking equipment. Combining the two main aspects

a. Reducing milking speed, or more specifically leakage as wanted because of udder health.

b. Increasing milking speed because of reducing labour time

makes that milking speed is a trait with an intermediate, **optimum level**.

Recording of milking speed can be practised with advanced equipment. This advanced equipment can be:

a. An additional equipment to be installed at regular intervals or at specific recording herds as part of a (national) recording programme for milking speed, or

b. An integral part of the milking system at the farm, together with for example recording of milk conductivity, giving an integral, operational decision-support for the farmer in detecting cows with udder health problems.

An overall subjective scoring of milking speed can also be practised. The farmer can make a linear scoring of 1 very slow to 5 very fast (see also Section 5 of the ICAR Guidelines).

1.9.7 Udder conformation traits

Linear udder conformation is part of the recommended conformation recording in dairy cattle as approved by the World Holstein Friesian Federation (WHFF) and ICAR (see Section 5 of the ICAR Guidelines). Approved standard traits are:

Fore udder attachment	Rear udder height
Median suspensory ligament	Udder depth
Teat placement	Teat length

A full description of these traits is given in 1.10.6 below. The reason for approval of this set of traits is based on the fact that each of these traits can have a predictive value for udder health, or the trait influences workability (and thus milking time). We therefore also recommend recording of udder conformation according to the ICAR/WHFF-recommendations.

Based on literature studies some indicative relative importance of the traits can be given. The udder conformation trait with the largest influence on udder health is the udder depth. Shallow udders appear to be obviously healthier than deep udders. A reason why shallow udders are healthier may be that deep udders have an increased exposure to pathogenic bacteria and are more likely to be injured.

Fore udder attachment also has an important influence on the udder health together with teat length. Probably again the main aspect here is that improved udder conformation (better attachment and shorter teats) decreases exposure to pathogens.

Again, also other traits are of importance, but the genetic relationship with udder health may be lower, and different traits may provide similar genetic information. This generally causes udder health indexes to be based on a limited number of udder conformation traits only.

Example age effect on udder conformation

Table 4. The influence of age on udder conformation in Holstein Friesian and Jersey (Source: Oldenbroek et al., 1993).

		Lactation number		
Breed	**Trait (cm)**	**1**	**2**	**3**
Holstein	Distance rear udder-floor	60.5	55.6	51.8
	Distance between front teath	18.1	20.2	21.6
Jersey	Distance rear udder-floor	51.2	47.5	44.8
	Distance between front teath	14.2	14.9	15.5

Udder conformation changes over lifetime of the animal. Moreover, selection of cows favours (directly or indirectly) survival of cows with better udder conformation. This implies, that either observations are to be adjusted for age effects, or observations used for genetic evaluation are to be taken from a specified age only. In general, (inter)national evaluations are based on observations during first lactation only.

1.9.8 Summary

The most complete udder health index includes direct and indirect udder health traits. An example of a direct trait is the inclusion of clinical mastitis in the index as happens in the Scandinavian countries. In some other countries, like The Netherlands, Canada and the United States, only indirect traits are used in the udder health index. These indirect traits can be subdivided in three main groups: somatic cell count, milkability and udder conformation traits.

a. Recording clinical mastitis directly by a farmer or veterinarian: outer visual signs on the udder or the milk.

b. Recording subclinical mastitis: not visual directly, but only perceptible by indicators. The most frequently used indicator is the number of somatic cells in milk (SCC), which can be routinely recorded parallel to milk recording.

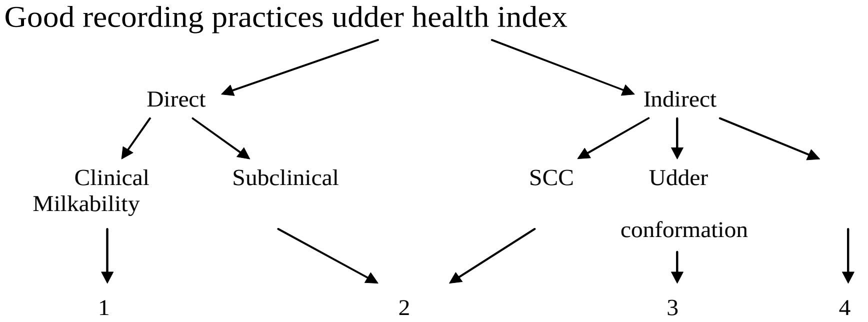


Figure 7. Good recording practices udder health index.

c. Recording udder conformation. There are several udder conformation traits with an influence on udder health. The most important one by far is udder depth, followed by fore udder attachment and teat length.

d. Recording milkability (i.e., milking speed) by actual measurement or (linear) appraisal by the farmer. Milkability is an optimum trait: high milking speed is favourable as it reduces labour time for milking, but it increases leakage of milk and thus bacterial invasion of the teat canal.

1.10 Decision-support for udder health recording

1.10.1 Reader instruction

This chapter gives a stepwise description of the possibilities to record udder health and correlated indicator traits. The starting-point is a situation in which not many efforts have been done yet, to improve udder health. In each step, a description is given on “What ?” to record, by “Who ?” this is done, and “When ? “.

1.10.2 Interbull recommendation animal ID

Each animal’s ID should be unique to that animal, given to the animal at birth, never be used again for any other animal, and be used throughout the life of the animal in the country of birth and also by all other countries. The following information contained in Table 5 should be provided for each animal. For further details please refer to INTERBULL bulletin no. 28 (2001) direct link here:https://journal.interbull.org/index.php/ib/article/view/371/371.

Table 5. Interbull recommended identification.

Breed code	Character 3
Country of birth code	Character 3
Sex code	Character 1
Animal code	Character 12

1.10.3 Interbull recommendation pedigree information

Birth date and sire and dam IDs should be recorded for all animals. Genetic evaluation centers should, in cooperation with other interested parties, keep track and report percentage of animals with missing ID and pedigree information. The overall quantitative measure of data quality should include percentage of sire and dam identified animals or alternatively percentage of missing ID's. Measures should be adopted to reduce the percentage of non-parent identified animals and missing birth information to very low numbers and ideally to zero. Examples of such measures are supervision of natural matings and artificial inseminations, avoidance of mixed semen, monitoring parturitions, comparison of birth date with calving date of dam, taking bull's ID from AI straws, etc. If there is the slightest doubt about parentage of a calf, utilization of genetic markers, e.g. micro-satellites, to ascertain parentage at birth is recommended. Until this goal is achieved, it is the INTERBULL recommendation that doubtful pedigree and birth information to be set to unknown (set parent ID to zero).

1.10.4 Step 0 - Prerequisites

Before an udder health system can be developed, a number of prerequisites should be accounted for:

a. Unique animal identification and registration.

b. Unique herd identification and registration.

c. Individual animal pedigree information.

d. Birth registration.

e. A well functioning central database.

f. Milk recording system (time information and logistics of sampling milk samples).

For these prerequisites in general, we refer to Interbull bulletin no. 28 (2001). Two aspects of these Interbull recommendations, animal ID and pedigree information, are cited below.

1.10.4.1 General definitions

A lactation period is considered to commence on the day the animal gives birth. A lactation period is considered to end the day the animal ceases to give milk (goes dry). The lactation number refers to the number of the last lactation period started by the animal. The number of days in lactation denotes the time span between calendar date of the mastitis incident and the day the last lactation period commenced. The number of days in lactation may be negative when the incident occurs during the dry-period proceeding next calving. For more detailed information on the definition of lactation period, please see ICAR guidelines Section 2.

1.10.5 Step 1 - Somatic cell count

What? In a milk recording system, with regular intervals milk samples are taken per cow. Samples are being gathered and taken to an official laboratorium for analysis on contents of fat and protein. In addition, milk samples can be used for among others analysis of milk urea or somatic cell count.

Somatic cell count (SCC) in milk samples is obtained using Coulter Counter or Fossomatic equipment. Standardised procedures are available from the International Dairy Federation (www.idf.org). In milk of first parity cows, SCC ranges from 50.000-100.000 cells per ml from healthy udders to >1.000.000 cells per ml from udder quarters having an inflammatory infection. A current IDF standard is that subclinical mastitis is diagnosed in udders with milk having a SCC >200.000 cells per ml.

SCC can be presented either in absolute SCC or in classes based on the absolute SCC. As the distribution of absolute SCC is very skewed, generally a log-transformation is applied to a Somatic Cell Score (SCS). Other log-transformations are also used, sometimes including a correction of SCC for milk yield and effects like season and parity. SCS again can be analysed as a linear trait or used to define classes.

SCC and SCS are generally recorded on a periodical basis, especially when included in the regular milk-recording scheme. Per record, the unique animal number and day of sampling are to be supplied. When recorded on a periodical basis, animals just starting their lactation may be included. Milk in the first week of lactation has a strongly augmented level of SCC and records on animals less then 5 days in lactation are generally ignored in further analyses.

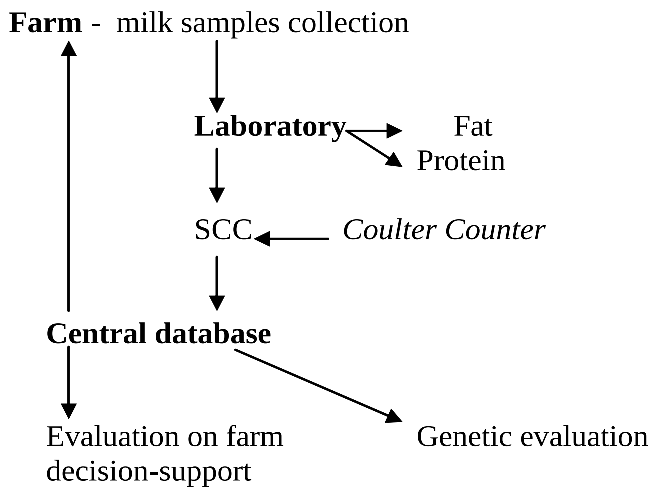


Figure 8. Somatic cell count recording practice.

Who? Milk samples are taken either by an officer of the milk recording organisation or by the farmer. Logistics of handling samples (from the farmer to the laboratories) are generally organised by the milk recording organisation. It is important that these logistics include a strict unique identification of herd and individual cow number with each milk sample. Lab results will be transferred to the milk recording organisation, the last one also taking care of reporting the results in an informative way to the farmer.

When? Sampling of milk of individual cows for analysis of fat and protein content, and thus also for SCC, is generally done with a three-, four- or five-weeks interval. With common milking systems, twice a day, sampling includes both morning and evening milking. With automated milking systems (robotic milking), sampling can be automatically performed on a 24-hours basis, taking samples from each visit of the cow to the robot.

1.10.6 Step 2 - Udder conformation

What? There are several characteristics that can be measured on the conformation of the udder. The most common ones are fore udder attachment, front teat placement, teat length, udder depth, rear udder height and median suspensory ligament (ICAR Guidelines Section 5). Scoring these traits happens by scaling from 1 to 9. The figures below show the possibilities:

Fore udder attachment (FUA)

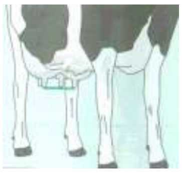

1
loose

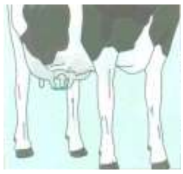

5


9
tight

Front teat placement (FTP)


1
wide


5


9
narrow

Teat length (TL)


1
short


5


9
long

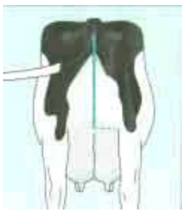
Udder depth (UD) (code 1 is lower than hock)


2
deep


5


9
shallow

Rear udder height (RUH)


1
low


5


9
high

Median suspensory ligament (MSL)

1
weak

5

9
strong

A report per cow is made of the six udder conformation traits mentioned above. An example of such a report is in Table 6 below.

Table 6. Example of linear scoring report.

Inspector	Piet Paaltjes
Organisation	Top-cow-bred
Herd	Hiemstra-dairy UBN 3459678
Date of inspection	May 24, 2002

Cow number	Fore udder attachment	Front teat placement	Teat length	Udder depth	Rear udder height	Median suspensory ligament
1543895**0538**5	5	4	3	6	8	7
1543895**0539**2	3	3	5	2	4	4
1543895**0540**4	7	6	5	7	7	8
1543895**0541**3	2	2	6	3	3	4
....						
.....						

Who?

Specialised inspectors score the udder conformation from the data processing organisation. Their specialism can be guaranteed through regular meetings, where new standards can come up for discussion. The WHFF organises international standardisation of inspectors for the Holstein Friesian breed. The inspectors bring the records to the data processing organisation, where the records will be processed, stored and used for evaluation. Again, it is important that the reports include a strict unique identification of herd and individual cow number. The inspectors also leave a copy of the report with the farmer.

In order to let the udder conformation information be useful for estimating udder health, linkage of the udder conformation data to the SCC-information should be warranted.

When?

In most current conformation scoring systems, only the cows in their first lactation are scored. This makes scoring at least once a year necessary, assuming a calving interval of 12 months. However, it would be better to score more than once a year, for example once per 9 months. A heifer with a calving interval of 11 months will be dried off after 9 months. Such a heifer can be missed, when scoring only once per 12 months is performed.

1.10.7 Step 3 - Milking speed

What?

The milkability (or milking speed) can be measured routinely on a large scale by subjectively scoring (the milking speed of certain small numbers of cows can be measured with advanced equipment). A milkability-form contains the individual cows together with the possibilities “very slow, slow, average, fast or very fast milking”. An example of a milkability-form is in Table 7.

Table 7. Milkability-form example.

Person scoring	Farmer				
Organisation	Top-Cow-Bred				
Herd	Hiemstra-dairy UBN 3459678				
Date of recording	May 24, 2002				
Cow number	Very slow	Slow	Average	Fast	Very fast
1543895**0538**5	x				
1543895**0539**2		x			
1543895**0540**4			x		
1543895**0541**3		x			x
....					
.....					

Who?

The milkability-forms have to be filled up by the farmer. The farmer can send the form to the milk recording organisation or give the form to the officer of the milk recording organisation during the milk recording. After this the information can be used for the evaluation. Again, it is important that the forms include a strict unique identification of herd and individual cow number.

In order to let the milkability information be useful for estimating udder health, linkage of the milkability data to the SCC-information should be warranted.

When?

As the milking speed does not really change over lactations, estimating the milking speed only in the cow's first lactation is sufficient. Again, assuming a 12 months calving interval, makes a scoring of the milking speed once a year necessary.

1.10.8 Step 4 - Clinical mastitis incidence

What?

In recording of udder health, the following general trait definition is recommended (following IDF recommendations):

a. Clinical mastitis = inflammatory response of the udder: painful, red, swollen udder, with fever. This results in abnormal milk, and possibly outer visual or perceptible signs of the udder. Besides the cow can show a general illness.

b. Healthy udder = absence of clinical or sub-clinical mastitis.

Table 8. Example of form for farmers recording mastitis incidents.

Person scoring	Farmer	
Organisation	Top-Cow-Bred	
Herd	Hiemstra-dairy UBN 3459678	
Period of inspection	January-June, 2002	
Ear tag number cow	Date	Details
0538	January 26	Extremely clotted and watery "milk"
0576	February 5	-
0529	April 17	Teat injury
0541	May 31	Culled June 2nd
0602	June 2	Veterinary treatment
....		

Who?

A veterinarian or the farmer can record clinical mastitis incidence. The obtained information has to be processed (at the farm, by the veterinary service, or e.g., the milk recording organisation) and sent to a central database, which can be done by telephone or computer either from the farm directly or from the processing organisation.

When?

Except for some specific infections during the growing period, mastitis is related to the lactation of the adult female. Individual mastitis incidents are to be recorded specifying calendar date, and a database link (using a unique animal number) then will have to provide lactation number and number of days in lactation. For this purpose the database will have to include birth date and calving dates of the individual animals.

The incidence of mastitis is generally expressed per lactation period, specifying lactation period number (or parity of the cow). Standardised length of the lactation period is 305 days. However, for mastitis incidence a standardised period of 15 days prior to calving until 210 days after calving is advised (or to date of culling if less than 210 days after calving).

Clinical mastitis can be recorded on a daily basis, i.e., all (new) incidents are registered when they are (first) observed and/or when they are (first) treated. Cows having no incidents are afterwards coded 'healthy'. Clinical mastitis can also be recorded on a periodical basis, e.g. by a veterinarian visiting the farm monthly, coding all animals momentary diseased or healthy.

Additional information on mastitis incidence may be obtained from culling reasons. Culling reason potentially makes it possible to identify cows with mastitis that are culled instead of treated. When the culling reason is mastitis, this can be considered as an additional incident.

With registration on a daily basis, it becomes feasible to define the length of the incident. However, this requires very careful observation and registration. An incident may be defined as 'repeated' when the observation or veterinary treatment is 3 days or longer after the former observation or treatment. Other additional information on udder health is in recording the quarter.

Table 9. Examples of clinical mastitis specifications.

Specification data	Specification definition		Reference
Norwegian Red, first parity	Clinical mastitis (0/1) -15-210 days, including culling reasons	20.5 % of the cows had clinical mastitis	Heringstad *et al*. 2001 (Livestock Production Science, 67: 265-272)
US Holstein Friesian, first parity	Total number of clinical episodes	On average 0.48 (sd 1.03, range 0 to 8)	Nash *et al*., 2000 (Journal of Dairy Science, 83: 2350-2360)

1.10.8.1 Summarising mastitis

Basic observation: clinical mastitis, subclinical mastitis, healthy.

To be coded as:

a. Clinical vs (2) subclinical vs (0) healthy, or
b. Clinical vs (0) subclinical + healthy, or
c. Clinical + subclinical vs (0) healthy.

Primary data is unique cow number + observation mastitis + calendar date. This allows combination with other herd data, pedigree data, reproduction and milk recording data. This also allows calculation of a contemporary group mean (e.g., based on all animals in the same herd and parity).

Other aspects are:

a. Recording of incidents per lactation period -10 to 210 days in lactation
b. Repeated observation when 3 days or longer after last observation
c. Inclusion of culling for mastitis as additional incident.

1.10.8.2 Other udder health information

a. Bacteriological culturing of milk samples to find the specific bacterium responsible for the inflammation (e.g., *Staphylococcus aureus, coliform, Streptococcus agalactiae*) - recommendations on standard methodology are provided by the IDF
b. Removal of teats, teat injuries - there are standards for scoring of teat injuries, but these are not included in any official guideline

For the recording of subclinical mastitis, we can also use measurements others than SCC, either from on-line recording in the milking parlour or from centralised analysis of milk samples. In these recommendations, no further attention is paid to conductivity of milk, NAG-ase, and cytokines. A lot of work in this area is in progress and some of it is already implemented in automated milking systems - for further information we refer to information of the ICAR Recording and Sampling Devices sub-Committee.

1.10.9 Step 5 - Data quality

Recorded data should always be accompanied by a full description of the recording programme.

a. How were herds selected?

b. How were recording persons (e.g., veterinarians, and farmers) selected and instructed? Any standardised recording protocol used?

c. What types of recording forms or (computer) programs are used? - What type of equipment is used?

d. Is there any (change of) selection of animals within herds?

Each record should at least include a unique individual animal number, and the recording date. In case of mastitis, also a unique identification of person responsible for the recording is to be included. The unique individual animal number should facilitate a data link to a pedigree file (e.g., sire), milk recording file (e.g., calving date, birth date) and to a unique herd number. When this data links can not be established, each record on mastitis and somatic cell count should also include pedigree, birth date, calving date and parity and unique herd number.

After completion of recording, precise specification is required of any data checking, adjustment and selection steps.

Examples:

a. What types of data checks are practised? (E.g., does the unique number exist for a living animal, or is recording date within a known lactation period?)

b. Are averages and standard deviations within herds or per recording person standardised?

c. Is a minimum of records per herd, per animal or whatever applied before data analysis is started?

Consistency and completeness of the recording and representativeness of the data is of utmost importance. Any doubt on this is to be included in a discussion on the results. The amount of information and the data structure determine the accuracy of the result; measures of this accuracy should always be provided.

For general information on data quality, we refer to Interbull bulletin no. 28, and the reports of the ICAR working group on Data Quality.

1.11 Decision-support for genetic evaluation

1.11.1 Genetic evaluation

Information from a single farm can be combined with information from other farms to serve as a basis for a genetic evaluation (per region, country, or breeding organisation, or even internationally). A first prerequisite is of course that information is recorded in a uniform manner. A second prerequisite is a (national) database with appropriate data logistics to combine pedigree files (herd book, identification and registration), milk recording files and files with reproductive data.

1.11.2 Presentation of genetic evaluations

It is recommended that breeding values on udder health for marketed sires are available on a routinely basis, i.e., included in a listing of marketed sires by official organisations. The udder health index might be considered one of the major sub-indexes. The udder health index itself should preferably be composed of predicted breeding values for direct traits and predicted breeding values for indirect, indicator traits (i.e., udder conformation, SCS and milk flow).

Combination of direct and indirect information maximises accuracy of selection on resistance towards clinical and subclinical mastitis. In turn, the udder health index should be used to compose an overall performance index, for an overall ranking of animals.

The udder health index can be presented

a. Either in absolute units (e.g., monetary units or % of diseased daughters) or in relative terms.

b. Using either an observed or standardised standard deviation.

c. Relative to either an absolute or relative genetic basis (e.g., as a deviation from 100).

It is recommended that a uniform basis of presenting indexes for functional traits is chosen per country or breeding organisation.

Within the udder health index, the weighting of predicted breeding values (PBVs) for direct and predictor traits is to be based on the information content - dependent on relationship between trait and udder health, and the accuracy of the PBVs (i.e., the number of underlying observations). As the information contents generally differ per sire, relative weighting within the udder health index should be performed on an individual sire basis.

Weighting of the udder health index as part of an overall ranking index is to be based on the relative (economic, ecological and social-cultural) value of genetically improved udder health relative to other traits.