Milk Quality on Farms with an Automatic Milking System

Farm and Management Factors Affecting Milk Quality

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Farm and Management Factors Affecting Milk Quality

Yvonne van der Vorst Msc.
Kees Bos Bsc.
Wijbrand Ouweltjes Msc.
Judith Poelarends Msc.
Research Institute for Animal Husbandry
Lelystad, The Netherlands

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Correspondence:
Kees de Koning
P.O. Box 2176
8203 AD Lelystad
The Netherlands
kees.dekoning@wur.nl

Abstract

In the Netherlands, 28 farms were visited to gain more knowledge on possible risk factors affecting milk quality on farms that milk with an AM-system. Milk quality parameters that were studied were total plate count (TPC), bulk milk somatic cell count (BMSCC) and the level of free fatty acids (FFA).

Possible risk factors studied on the farms concerned general farm characteristics, animal health, AM-system, cleaning, cooling, housing, management of the farmer and the hygiene on the farm. The results showed that TPC was significantly related to milk yield of the herd, cleaning of the area around the AM-system and the hygiene on the farm. Farms with high TPC had a lower milk yield and the cleaning around the AM-system was not done properly. The overall hygiene on these farms was also not very good.

BMSCC appeared to be significantly related to milk yield of the herd and the number of milkings before replacement of the liners. A lot of farmers replace the liners much too late, resulting in a higher risk for BMSCC. Farms with a low BMSCC in general had a higher milk yield.
In addition farms with a high FFA level appeared to have on average more alert messages from the tank guard. Those farms also appeared to have less feeding places per cow and cows were dirtier compared to farms with a low FFA level.

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1. Introduction

Milk quality on farms with an automatic milking system (AM-system) has been subject to several studies in the past years (Billon, 2001; Klungel *et al*, 2000; Hoefman, 1998; Hogeveen et al, 2000; Klei et al, 1997; Rasmussen, 2001; Rasmussen et al, 2002; Pomies and Bony, 2000; Van der Vorst and Hogeveen, 2000, Van der Vorst *et al*, 2002). From these studies it is known that milk quality is affected by changing from conventional milking to automatic milking. The levels of total plate count and free fatty acids increase after introduction of an AM-system. With regard to somatic cell count and freezing point contradicting results have been found. To gain more insight in the milk quality courses after introduction of an AM-system an extended analysis was performed on milk quality data from three countries over a four-year period (Van der Vorst *et al*, 2002). This study showed that after introduction a rapid increase in total plate count, somatic cell count and freezing point can be observed. The level of free fatty acids also increased, but more gradually. After 6 to 12 months after introduction total plate count and somatic cell count improved again. The freezing point remained stable around the level it reached soon after introduction. The levels of free fatty acids did not recover after some time, nor was there a clear balance.
Particularly the bulk milk somatic cell count and the total plate count are internationally considered as important milk quality parameters. An increased freezing point and level of free fatty acids can cause problems during milk processing and might affect the quality image of the consumers. There are great differences among and within farms in milk quality. Some farms continually deliver first class milk, the quality of which has hardly changed after introduction, while other farms show a continuous decreased milk quality after introduction. Other farms show incidental peaks in, for example, total plate count. The underlying causes are not clear, but the differences among and within farms show that improvements are possible.

The data analysis mentioned above, was performed within work package 4 (WP4) related to the European project 'Implications of the Introduction of Automatic Milking on Dairy Farms' (www.automaticmilking.nl) (Meijering et al, 2002). As a follow-up of this data analysis the second goal of the work package was to gain more insight into the possible risk factors affecting the milk quality on these farms. For this a risk inventory was carried out which is presented in this report. Furthermore, parallel to WP4, the Research Institute for Animal Husbandry in The Netherlands performed a similar study (Van der Vorst and Ouweltjes, 2003). The results of this Dutch study are of great value to the study of WP4 and were taken into close consideration when setting up the work plan for WP4, which made use of the same farms.

The objective of this report was to identify risk factors related to high or low levels of total plate count, somatic cell count and free fatty acids found on farms milking with an automatic milking system.

By identifying the so-called risk factors that affect the milk quality on farms with an automatic milking system (AM-system), the milk quality may be improved.

2. Material and Methods

2.1 Background to study

Workpackage 4 (WP4) within the European project 'Implications of the Introduction of Automatic Milking on Dairy Farms' started on December 1, 2000. The first goal was to perform a data analysis on the milk quality of farms milking with an automatic milking system in the Netherlands, Denmark and Germany. This analysis has been finished and discussed in the report "Milk Quality on Farms with an Automatic Milking System, Effects of Automatic Milking on the Quality of Produced Milk" also referred to as D8. The second goal of this work package was to identify possible risk factors that affect the milk quality on these farms. Since this part was only started in 2002 a preliminary study was started in 2001 in the Netherlands to identify the risk factors on a larger scale. This study will be further referred to as the Dutch study (Van der Vorst and Ouweltjes, 2003). For the Dutch study 124 farms were visited. For WP4 a selection out of these 124 was made, and 28 were visited a second time. The main difference was that the Dutch study focused on four milk quality parameters (plate count, somatic cell count, freezing point, free fatty acids) while WP4 only focused on three (not freezing point). The reason for this was that the risk factors for the freezing point were better understood than for the remaining three parameters (Van der Vorst and Ouweltjes, 2003).
In this report the emphasis lays on the study performed for this WP4, however, whenever relevant, reference will be made to the Dutch study.

2.1.1 Workshop

Prior to the Dutch study a one-day workshop was organised in July 2001 on the Research Institute for Animal Husbandry, Lelystad, The Netherlands. The objective was to identify possible risk factors that might affect the milk quality of the milk produced on farms with an AM-system. Four quality parameters were considered: total plate count, somatic cell count, free fatty acids and freezing point (only used for the Dutch study, see 1.1). For this workshop, people were invited who were directly or indirectly related to automatic milking in the Netherlands. Present were Dutch representatives from: the dairy industry, manufacturers of AM-systems and milk cooling systems, the Ministry of Agriculture, Dutch Dairy Board (PZ), Animal Health Service, Milk Control Station (MCS), Nizo Food Research, consultants and Dutch farmers who milk with an AM-system.
For total plate count the risk factors listed were associated with hygiene (e.g. in the barn), cooling (e.g. type of cooling system), maintenance (e.g. changing of filters), cleaning (e.g. cleaning frequency) and the AM-system itself (e.g. efficiency of main cleaning). For somatic cell count the following risk factors were mentioned, namely overall health of the cows (e.g. occurrence of mastitis or leg/claw problems), hygiene (e.g. in the cubicles), the AM-system (e.g. spraying after milking), the barn (e.g. climate), the feeding of the cows (e.g. occurrence of negative energy balance after calving) and the farmer (e.g. checking cows for possible udder problems). The risk factors listed for free fatty acids were the AM-system (e.g. air inlet in the teat cups), the cows (e.g. stage of lactation), cooling (e.g. freezing of the first milk) and the feeding of the cows (e.g. ration).
The outcomes of the workshop were used for the set up of the Dutch study and the study within the European project on automatic milking and milkquality (WP4). WP4 was carried out after the Dutch study, so the results of the Dutch study could be used to investigate some more detailed risk factors in WP4.

2.2 General set up

The present study was split in two different parts focusing on long-term effects and short-term effects. The long-term effects are caused by factors that are generally present on a farm and influence the milk quality over a longer period of time. The short-term effects are caused by a sudden change of an aspect on a farm that leads to a sudden increase of for example the plate count. Both types of effects probably have different backgrounds why they influence the milk quality as they do or did. Therefore these factors were studied separately. However, different changes in the milk quality may also have the same cause. This will be kept in mind while analysing the risk factors.

2.3 Selection of farms

For the Dutch study addresses of dairy farms with an AM-system were collected with the help of KOM (Association for Quality Care Maintenance Milking Equipment). The farmers were asked permission by the dairy industry to use the milk quality data. Those farmers who did not wish to make their data available for the study were removed from the list. From the resulting data set, the farms that had used the AM-system for at least 18 months were selected. The reason for this was that these farmers were familiar with the AM-system and were no longer disturbed in their management due to possible starting-up problems. Farms of which it was known in advance, that they still milk a part of the herd in a milking parlour were excluded. This resulted in a list of 224 farms of which 124 farms were visited for the Dutch study between October 1, 2001 and January 2002. These farms were representative for the total of all farms milking with an AM-system in the Netherlands. From these 124, a selection was made based on their bulk milk quality performance during month 7 through 18 after introduction. By choosing these periods seasonal influences were prevented and the adjusting period of the farmer (on average first 6 months after introduction) had no or little influence on the average milk quality parameters. The farms were selected based on the fact whether their milk quality was above or below a certain level. The chosen levels are based on the overall averages found in the group of 124 farms. Per milk quality parameter the means, SD's and the minimum and maximum values were calculated and related to the overall values of the entire group to identify the deviates. The milk quality performance levels used, resulted in the following groups:

- Total plate count (TPC) (x1000 CFU/ml)
    - TPC low < 8
    - TPC high >14
- Bulk milk somatic cell count (BMSCC) (x1000 cells/ml)
    - BMSCC low <170
    - BMSCC high >265
- Free fatty acids (FFA) (mMol/100 g fat)
    - FFA low <0,55
    - FFA high >0,78

Using these criteria resulted in a selection of 59 farms. Several times it occurred that one farm was selected with regard to more parameters. A farm could be selected for the low TPC group as well as for the low BMSCC group. The aim was to visit at least seven farms per group, resulting theoretically in 42 farms to be visited. However, some farms were e.g. in the low TPC group as well as in the low BMSCC group. This resulted in 28 farms used for the present study WP4. Since the group of farms from which the selection was made was limited, this was accepted. Furthermore, it was not expected that this would interfere with the goal of the study to identify possible risk factors.
To study the short-term effects a selection was made from the farms used for the long-term effects study.

2.4 Long term effects

The intention of the study for long-term effects was to relate the milk quality of the farms to risk factors that are generally present on those farms. The milk quality parameters that were considered are described below, as well as which factors were studied and in what way. It was not intended to investigate relationships between milk quality parameters, because the set up of the study was not appropriate for this purpose.

2.4.1 Milk quality data

The milk quality data over the period January 1997 to November 2002 were provided by the national MCS (Milk Control Station) The following quality parameters were considered: total plate count, bulk milk somatic cell count, and free fatty acids (table 1).

Table 1 Milk quality parameters and frequency of control

Milk quality parameters	Freq./year	Interval
Total plate count (TPC)	26	Every 2 weeks
Bulk milk somatic cell count (BMSCC)	13	Every 4 weeks
Free fatty acids (FFA)	2	March/April & Sept/Oct

2.4.2 Studying possible risk factors

For studying possible risk factors on the farms, the following six means were used:
1. Questionnaire
2. Scoring list on management items
3. Periodic test report of the AM-system
4. Milk recording system data
5. Hygiene check list
6. Data from the management program AM-system

Two persons employed at the Research Institute for Animal Husbandry collected the data during farm visits. The two persons were trained in advance to make sure that the data collection and hygiene scoring were performed in comparable ways.

Ad 1. Questionnaire
Based on the results from the workshop (see paragraph 1.2), a questionnaire was formulated which was used for the Dutch study in which 124 farms were visited. For WP4 the questionnaire was revised and additional questions were added. More questions were added e.g. focusing on the amount of time spent on several tasks, the teat cup liners, the temperature of the cleaning water and hygiene.
The questionnaire was subdivided into 9 subjects, described below:

- General farm data: number of AM-systems, date of introduction, number of cows, quota, housing, etc.
- General data: labour of work force, training, succession, number of persons working on farm: hours per person, hours per day, etc.
- Milk quality: control, target level, approach to problems, etc.
- Animal health: control, curative and preventive measures, cow management, sub clinical and clinical mastitis, method for drying off cows, conductivity, teat condition, etc.
- AM-system: orientation before purchase, settings, maintenance, use of data, failures, type of liners, cow traffic, fetching cows, milk flow rate, failure of system, use of alert lists, etc.
- Cleaning of AM-system: frequency, cleaning AM-system and teats, lengths of tubes, volume of water heaters, temperature of water, etc.
- Cooling: type, size, control, cleaning, failures, frequency milk collection, type, amount of cleaning chemicals, etc.
- Housing: number of cubicles, number of places at feeding rack, manure removal from slats, waiting area, scraping cubicles, bedding cubicles, cow traffic, feeding, etc.
- The farmer: control, cow management, timetable for the day, spending leisure time, type of farmer, labour reduction per activity, etc.

The feeding and some other factors like cow-traffic and breeding were studied earlier in the Dutch study, but no relationships were found.

The questionnaire consisted mainly of multiple-choice questions. If relevant, also open questions were asked. If found relevant, also questions were asked as to opinions and satisfaction about the AM-system and concomitant factors such as cow management, maintenance and repairs.
Anonymity was assured, so that the questions would be answered as reliably as possible. The questionnaire was tested with 6 farmers and discussed with colleague researchers of the Research Institute for Animal Husbandry, before it was used during the farm visits.

Ad 2. Scoring list on management items

Besides the questionnaire another method was used to gain insight into the farmers preference of different management items. For this a list was set up including 47 management aspects. The farmer was asked to rank all items from 1 to 5 (not important-very important). Next, he had to choose three items per milk quality parameter (TPC, BMSCC, FFA), which he believed to be most important to control. Items included were:

- cow traffic,
- health aspects
- cleaning aspects (of AM-system and barn)
- housing aspects
- control of cows
- technical aspects
- information from PC, AM-system and cooling guard

Ad 3. Periodic test report of the AM-system

The most recent periodic test report of the AM-system available on the farm was used, from which the following 7 items were copied down (per AM-system):

- Air inlet teat cups
- Air leaking of milk line
- Pulsation ratio (a+b and c+d)
- Vacuum
- Effective reserve
- Temperature of water at start and end of cleaning
- Type of vacuum pump

Ad 4. Milk recording system data

If available, the following data were included from the 2 latest annual overviews:

- Average 305-day milk yields
- % fat and protein
- Average age of herd
- Breed
- Number of cows (per group: heifers, second parity cows and cows of parity 3 or more)
- Average number of lactation days
- Calving interval (current)
- Standardised milk yield (BSK) = Dutch calculation on standardised milk yield of cows within farm.

Moreover, the following data were copied from the latest periodic (4-8 wks) milk recording data:

- Daily milk yield
- Number of cows
- Number of cows calved per month

Ad 5. Hygiene checklist

After the questionnaire was completed, the barn was scored for hygiene aspects. The list consisted of 4 items, described below:

- Hygiene

  Hygiene was visually inspected for the components: AM-system, bulk tank room, housing (cubicles, flooring) and the cleanliness of the cows (hind, legs, udder). A range of 1-5 was used of which 1 related to good and 5 to poor. The criteria were the following:

Component	Criteria paid attention to
First impression of the farm	Extent to which the farm is tidy and cleaned
First impression of the barn	Impression feeding path, humidity, cobwebs, manure, etc.
Impression of AM-system	Manure on floor and walls, cleanliness equipment
Impression of the waiting area	Presence of dirt, old or fresh manure
Floor AM-system	Presence of dirt, old or fresh manure
Teat cups	Presence of dirt, milk and manure
Robot arm	Presence of dirt, milk, manure or damage
Pre-milking device	Presence of dirt or manure, state of maintenance
Bulk tank room	Tidiness, cleanliness
Finishing AM-system room	Room, clear organisation, tidiness
Feeding path	Remains of feed, dirt and odour
Floor/slats	Presence of old or fresh manure
Storage bedding material	Outside or inside, whether or not in packages, whether or not humid
Water troughs	Clarity of water, odour, sediment
Climate in barn	Volume of barn, air humidity, odour
Illumination in barn	Presence of badly lit parts
Ventilation	Fresh air influx

- Particular items, such as: farm clothing, hygiene corridor, manure scraper near AM-system, isolated roof, colour of roof, guarding lids and wind breaking screens.
- The construction and type of the bulk tank room (sidewalls, floor, ridge).
- Other things, such as: distances and locations (distance to AM-system to tank, distance main tank to first rinsing valve, place of the AM-system in the barn etcetera).

Ad 6. Data from management program of AM-system
From the management program of the AM-system the following data on the 24 hours prior to the visit were collected:
- number of milkings per box
- hours of idle time per box
- time for cleaning per box
- number of refusals per box
- total milk yield per box
- average milk flow per box
- average milking interval of total herd

Some farmers did not have sufficient insight into the management programs to print out these values, or the system was not able to do that at herd level. This resulted in lacking values in the dataset.

2.5 Short-term effects

To study the short-term effects a selection was made from the farms used for the long-term effect study. The first farmers visited for the long-term effect study were asked whether they were also willing to co-operate in the short-term effect study. These farms needed to have access to 'Zuivelnet'. This is a Dutch Internet site providing all milk quality results for each farm. Farmers that wanted to participate gave us their access code and password.

In total 17 farms were selected for this part of the study:
- farms with low (n=5) and high (n=2) TPC levels
- farms with low (n=3) and high (n=2) BMSCC levels
- farms with low (n=3) and high (n=2) FFA levels

The milk quality (TPC, BMSCC, FFA) on 'Zuivelnet' of the 17 farms was checked twice a week from June until the end of October 2002. Depending on when the farm was visited for the long-term study

the farms were followed for 1 (visited in October) to 5 months (visited in June). Every time the milk quality of a farm was checked with 'Zuivelnet', it was judged per farm and per quality parameter whether the value was high or low enough to undertake action and to contact the farmer. Taken into account were: arithmetic average, geometric average and variation in milk quality parameters (TPC, BMSCC, FFA) during 2001 and 2002.
When a clear change (deterioration / improvement) in the milk quality occurred, that farm was contacted soon after that (preferably within 3 days). To decide whether the change in milk quality was big enough to contact the farmer, thresholds were used. For BMSCC the change had to be >100.000 cells/ml, for TPC >10 CFU and for FFA >0,20 mmol/100gr fat. Contacting the farms was initially done by telephone with use of a leading questionnaire. If the farmer knew the cause of the change in quality and his answer was estimated to be reliable, the conversation was noted and no further action was undertaken. If the farmer had no explanation for the change in quality, the farm was visited and intensively investigated. The goal of the visit was to trace the factor(s) that caused the sudden change in milk quality. So a broad range of risk factors was investigated at the farms. Data was gathered by means of on-farm measurements by the researcher, extracting data from the AM-system and a questionnaire with open questions. Which factors were measured depended on the quality parameter studied and on the specific farm situation. Below the most important items investigated are listed for TPC, BMSCC and FFA.

For TPC the most important items investigated were the following:

- Cows, e.g.:
    - cleanliness of the cows and the cubicles.
- AM-system, e.g.:
    - possible technical problems
    - frequencies of cleaning cycles
    - dosage of the cleaning agent
    - occurrence of disruptions of the system
    - cleanliness of the system.
- Cooling system, e.g.:
    - possible technical problems with the cooling
    - occurrence of disruptions of the system
    - cleanliness of the bulk tank.
- Management farmer, e.g.:
    - anything noticed by the farmer
    - changes made in the cleaning or cooling by the farmer or the maintenance mechanic
    - changes in the management of the farm
    - hygiene in the barn.

For BMSCC the most important items investigated were the following:

- Cows, e.g.:
    - clinical cases of mastitis
    - bacteriological results
    - other health disorders
    - change in milking frequencies
    - number of fresh cows
    - change in milk production
    - body condition
    - problems with teat condition
    - change in feeding
    - sudden or slow increase in BMSCC
    - climate in the barn
- AM-system, e.g.:
    - conductivity measurements
    - number of failed milkings (unsuccessful attachment and incomplete milking)
    - possible technical problems
    - number of cows not milked out

    - disinfection of the teats after milking
    - effectiveness of pre-treatment
- Management farmer, e.g.:
    - culling cows with high SCC,
    - anything noticed by the farmer
    - change in treatment of clinical mastitis or dry cows
    - replacement of teat cups

For FFA the most important items investigated were the following:
- Cows, e.g.:
    - milking frequencies and variability
    - health disorders
    - body condition
    - feeding
    - change in average stage of lactation
- AM-system, e.g.:
    - functioning of the system (attachment of teat cups, air inlet)
    - changes by the farmer or the maintenance mechanic
- Cooling system, e.g.:
    - freezing of milk.
- Farmer, e.g.:
    - Knowledge of FFA and the risk factors
    - changes in feeding

The ‘Zuivelnet’ internet site with milk quality data of the farms was checked from June until the beginning of October. When discussing the results it will be taken into account that this was the summer/beginning of fall.
Since FFA is only measured twice a year (spring and autumn) in the Netherlands, on the participating farms in the ‘FFA high’ and ‘FFA low’ group extra milk samples for FFA were collected every two weeks until the end of October.

2.6 Data Analysis

Before statistical analyses of the long-term effects, all data were checked for unlikely values. To get a more normal distribution, TPC, BMSCC and FFA were transformed with a natural logarithm.
Descriptive analysis was accomplished by tabulation of the data.

Two types of analysis were carried out on the data. Variables that could be expressed numerically, for instance milk yield, were analysed retrospectively with the following ANOVA-model:

$$Y = \mu + CLASS + e \qquad (1)$$

Y = Response variable (factors studied on farm level)
μ = Overall mean
CLASS = Effect of different strata (low, medium, high) of milk quality parameters.
e = random error

For this analysis farms were classified for TPC, BMSCC and FFA in 3 classes as described, based on their milk quality during the 12 months before the farm was visited. For variables that could not be expressed numerically the milk quality was used as response variable and the variables as treatments. Again, analysis was done with the above ANOVA-model but response and treatment were reversed.

2.7 Used terms

KKM	Keten Kwaliteit Melk : Foundation for Quality Assurance of Farm Milk (in the Dutch Dairy Chain).
BSK	Bedrijfs Standaard Koe : Dutch calculation on standardised performance of cows within farm. In this calculation age, lactation stage and month of calving are taken into account. Only cows between 5 and 250 days in milk are used for this calculation.
TMR	Total mixed ration.
TEC	Teat end callosity classification: classification system for teat end callosity (Neijenhuis et al, 2000)
Mouth piece vacuum	Vacuum in the mouth piece of the liner, measured during milking.
Course measurement	Vacuum measurements done at several points in the installation during milking. Starting with the vacuum in the short milk tube, in the long milk tube (before take off sensors) and after the milk meter.
Milking control area	Area beside the milking unit where the farmer can use the control panel, and where the cows have no access to.

3. Results

3.1 Long term risk factors

3.1.1. Milk quality data

The 28 farms were originally classified for milk quality based on data from the period between 7 and 18 months after introduction of automatic milking. After completion of the farm data collection, but before statistical analysis, new milk quality data became available. Thus farms could also be classified based on data from the last 12 months before they were visited. These data do represent the current situation better than the older data, the more because the time span between introduction of automatic milking and the farm visit is quite variable. Automatic milking was introduced between November 1996 and December 1999. For each farm the geometric mean milk quality was calculated both for the period between 7 and 18 months after introduction and the last year before the farm was visited for data collection. From table 2 it can be seen that the overall differences are small.

Table 2 Overview of geometric mean milk quality in two 12-month periods on 28 visited farms

Trait	last year before visit			7-18 months after introduction		
	Mean	Min	Max	Mean	Min	Max
Total Plate Count (TPC) (*1000 Cfu/ml)	12.2	4.7	25.2	11.8	5.6	26.9
Bulk Milk Somatic Cell Count (BMSCC) (*1000 cells/ml)	228.4	127.0	340.2	213.0	109.8	317.2
Free Fatty Acids (FFA) (Mmol/100 g fat)	0.717	0.420	1.129	0.696	0.420	1.267

For TPC and BMSCC the course of the figures in both periods is given in figure 1. For each month the geometric mean is given from all records in that month for the 28 herds.

For FFA there were too few data to calculate monthly averages, since this milk quality parameter is only determined twice a year. In the period between 7 and 18 months after introduction the average in the first and last 6 months was 0.69 and 0.64 respectively, in the last year before the farm was visited the averages were 0.67 and 0.73 respectively. For none of the milk quality parameters there was a systematic change in either 12-month period. The classification of farms however did change because of using more recent data, as can be seen from table 3.

Table 3 Classification of herds for milk quality based on two 12 month periods

	Year before farm visit								
	TPC[a]			BMSCC[b]			FFA[c]		
7-18 months after introduction	Low	Medium	High	Low	Medium	High	Low	Medium	High
Low	6	1	1	5	5		4	3	
Medium	2	8	3		8	4	1	7	5
High		2	5		1	5		2	6

[a] TPC low <8, medium between 8-14 and high >14 CFU.
[b] BMSCC low <170.000, medium between 170.000-265.000 and high >265.000 cells/ml.
[c] FFA low <0,55, medium between 0,55 and 0,78 and high >0,78 mmol/100 gram fat.

For analysis both classifications were used, but it was assumed that the classification according to the year before the farm visit was most informative. Therefore the description of the results is based on this classification. For categorical variables the herd means of this period were used in the analysis. For significant relationships some more information is listed in appendix 1.

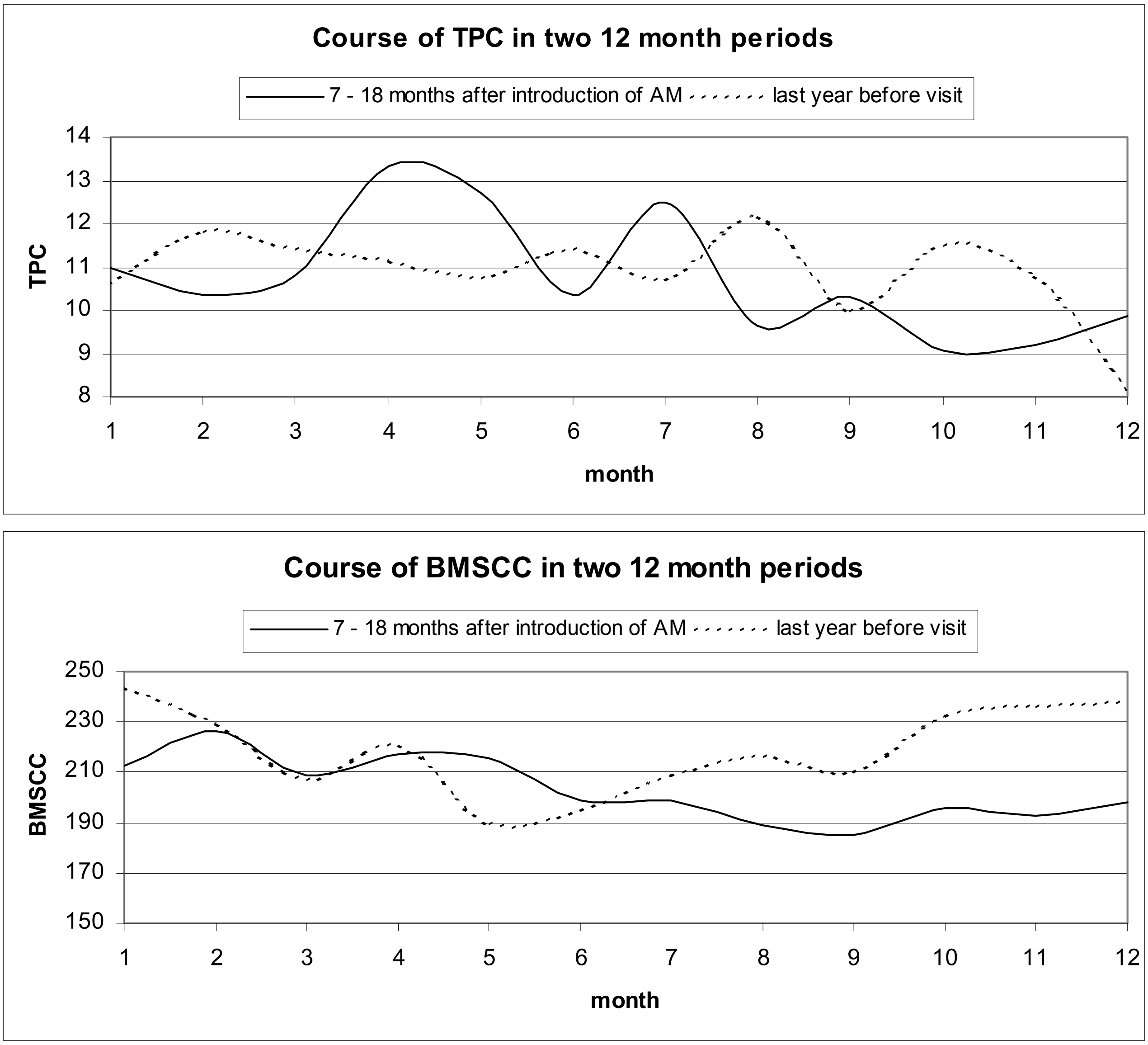

Figure 1 Course of TPC and BMSCC in two 12 month periods

3.1.2 Analysis of risk factors

General farm data

The size of the milk quota and the number of cows were not related to milk quality. 11 farmers have indicated that their quota had increased since they were visited earlier (in 2001), but their milk quality was not different from that of farms that kept the same quota. 15 farms have indicated they want to increase their quota. On average these farms had a lower TPC during the period 7-18 months after introduction, but during the last year before they were visited their milk quality did not differ from other farms. Farms that will be taken over had the same milk quality as the farms where this was not the case and the 13 farms where it was currently not known whether the farm will be taken over.

The results showed a significant relationship between the production level after introduction and both TPC and BMSCC. Both were lower for higher producing herds. FFA was not significantly related to production level, but on average higher producing herds had higher FFA levels in the bulk milk.

Usually the farmer was the person responsible for overall farm management; on some farms family members or partners were jointly responsible. This was not related to milk quality. The same is true for responsibility for cattle supervision. On average 2.2 persons were working with the animals, this varied from 1 to 4 and again was not related to milk quality. Per day on average 4.7 hours were used to take care of the animals, this varied between farms from 2 to 8 hours but was not related to milk quality. This is not surprising, because the number of animals per farm also varied. But even if the cow related labour time was expressed per animal, there was no relation with milk quality.

Animal health

On average mastitis incidence was estimated at 22%, with a range from 0 to 71%. The estimated incidence was not related to milk quality. Farmers were also asked how they record mastitis. The majority of the farmers (17) used standard sheets from their management system or the obligatory list for Keten Kwaliteit Melk (6 farmers). None of the farmers used standardised herd treatment protocols. There was no relationship between the way of recording mastitis and milk quality. Farmers who estimated to have a low incidence of sub clinical mastitis (<5%) and farmers who did not give a figure had similar BMSCC as farmers who estimated to have a high incidence of sub clinical mastitis (>20%). Farmers who reported figures between 5 and 20% on average did have lower BMSCC, but the difference was not significant. It is likely that farmers who are more aware of the importance of udder health do have a better idea about the incidence. More subclinical mastitis by definition is related to higher cell counts.
The majority of the farmers (25) routinely used dry cow therapy antibiotics when drying off cows. Not using antibiotics tended to be related to a higher TPC, but probably due to the low number of non-users the difference was not significant. Herds with high FFA levels between 7 and 18 months after introduction on average had short dry periods, but milk quality during the last year before the visit was not significantly related to the length of the dry period. The average length of the dry period was lowest for farms with high BMSCC and highest for farms with low BMSCC.

The farmers were asked about their opinion on conductivity as a tool to control mastitis. Only 2 farmers found it useless, most farmers (25) found it necessary. Five of them judged it as very useful. There was no significant difference in milk quality between farmers with different judgements.

15 farmers globally scored teat condition, the other 13 farmers never did this. Mostly they scored for callosity and roughness. On average these farmers had the impression that teat condition has improved since the introduction of automatic milking. Scoring teat condition was not related to milk quality.

Automatic milking system

Half of the farmers used synthetic rubber liners, the other half used silicon liners. The type of liner used was not related to milk quality. A tendency was that earlier replacement of liners was related to a lower BMSCC. Experts assume that silicon liners can last twice as long as rubber liners, if this is taken into account the relationship between liner replacement and BMSCC becomes significant. Delaying replacement was related to a higher BMSCC. On average also TPC and FFA levels were higher with later replacement, but these relationships were not significant. According to the farmers rubber liners were replaced after on average 4636 milkings, silicon liners after 9579 milkings. These figures are about double of what is generally advised.

Almost all farmers (26) were satisfied with the way the cows are visiting the milking system. Cows were fetched between 2 and 6 times a day, the number of fetches was not related to milk quality. The estimate of the farmers of the number of days heifers need to get used to the system varied from 1 to 21 days, with an average of 8 days. Again there was no relation with milk quality. 19 farmers let their cows graze; milk quality was not different from farms without grazing. The average milking frequency was 2.8 times per day, and ranged between farms from 2.0 to 3.1. Average milking frequency was not related to milk quality. This was also true for average milk flow rate (2.2 kg/min), which varied from 1.7 kg/min to 2.6 kg/min.

The number of times the teat detection system was cleaned daily varied from 0 to 6, and was not related to milk quality. Only 6 farmers thoroughly cleaned the spraying mechanism more than once a year, the others did not clean this part of the system. The cleaning frequency of the spraying mechanism was not related to milk quality. Only 9 farmers indicated that the teats are touched well by the spraying fluid, most others reported that the teats are touched poorly. This was not related to milk quality. On most farms the milking system was serviced 6 to 8 times per year, only 4 farms had a lower frequency. The number of services was not related to milk quality. The number of maintenance tests of the milking unit was also not related to milk quality, but the data showed that herds with poorer milk quality for all traits on average had more maintenance tests. It is likely that more service tests are beneficial for milk quality (if the system is fine-tuned each time), but that on the other hand farms with problems will have more tests done in order to improve the situation.

Herds where alert lists were checked at regular times did have lower FFA levels than herds where alert lists were checked irregularly. The number of checks per day (on average 3, varying from 1 to 6), was not related to milk quality however. The same was true for the importance farmers gave to information from the milking unit. On average 20% of the animals were on alert lists, particularly long milking intervals and to a lower extent high conductivity levels were responsible for most alerts. The average percentage of animals on alert lists was not related to milk quality.

The effect of brand of AM-system on milk quality could not be examined because of the low number of farms for some brands.

Cleaning

The maximum interval between main cleaning cycles of the milking unit varied from 8 to 15 hours. The length of this interval seemed not to be related to milk quality. Most farms had fixed cleaning intervals (again type specific), only 5 farmers reported to have variable intervals. There was no difference in milk quality between farms with fixed or variable intervals.

On farms with a low TPC the milking control area and the floor in the unit were cleaned more often than on other farms, whereas on farms with a high TPC both cleanings were done less often than on other farms. For BMSCC there was a tendency in the same direction, but this was not significant.

Most farmers made sure the system is cleaned with cleaning agents. There was no difference in the number of times the cleaning was checked by the farmer between herds with high or low figures for all 3 milk quality parameters. Results showed that the system cleaning was checked by the maintenance mechanic more often on farms with low TPC than on farms with high TPC. On herds with low FFA levels the farmers checked the cleaning of clusters, milk hoses and milk filter unit more often than on herds with high FFA levels, but the difference is not significant. For TPC and BMSCC there was no difference between farms with high and low values in the frequency of checks of details of system cleaning by the farmers.

In many AM-systems, it is common to flush the cluster after each milking. Only 1 farmer indicated not to do so. On most farms a short cleaning cycle with cleaning agents was done after a colostrum cow or a cow treated with antibiotics, for some farmers however even then a simple flush with water was sufficient. Whether or not cleaning agents were used for each flush between milkings was not related to milk quality. On average the sock filter was replaced 2.4 times a day, varying from 1 to 3 times. There was no significant difference between herds with high or low values for the 3 milk quality parameters in the number of filter replacements per day. However the 3 herds that changed the filter once a day did have a higher TPC than herds that changed the filter more often. The average TPC for herds changing 2 or 3 times a day was very similar.

Cooling

In general on most Dutch farms milk is collected every 3 days. Herds in this study where milk was collected more often than this did have similar milk quality figures. The ratio between acid and alkaline cleaning agents for bulk tank cleaning on average was 1:5, and varied according to the farmers between 1:1 and 1:14. This ratio was not related to milk quality. The size of the buffer tank on average was 19% of that of the main tank, varying from 10 to 26%. Although the differences were not significant, on average lower (better) milk quality figures were found with relatively smaller buffer tanks. Most farmers usually, but not always, checked the tank cleaning. Milk quality was similar for farms where cleaning was checked after all, most or some cleanings. The majority of the farmers indicated that the tank monitoring system (“watchdog”) every now and then gives an alert. On farms with high FFA levels the farmers reported significantly more alerts. Some farmers saw others than themselves as primarily responsible for cooling, but most regarded themselves as responsible. Farmers with low FFA levels did less often feel responsibility for the cooling process than farmers with medium or high FFA levels. Different views on the responsibility for cooling were not related to TPC or BMSCC.

Housing

Results indicated that about half of the farmers (13) had an idea about the time between milking and lying down. Although the difference was not significant, farmers that did have an impression on average had a slightly higher cell count. It might be that these farmers have tried to reduce cell counts and thus became more aware of their cows behaviour, because generally quickly lying down after milking is regarded as a risk for new infections. On 16 farms the floor of the waiting area was cleaned with an automatic scraper. Farms with a low TPC and farms with low BMSCC did this more often than farms with high figures for these traits. A remarkable result was that farms with low FFA levels dis have relatively many feeding places per cow (1.45 for low FFA-herds vs. .88 for medium and .96 for high FFA herds).

Exactly 50% of the farmers were satisfied with their housing. Again, there was no significant relationship with milk quality, but farmers that were not satisfied on average had better milk quality. Most probably these farmers are more critical.

The farmer

Three farmers have indicated that they spent less time treating sick cows since the introduction of automatic milking, 9 farmers indicate that they spent more time on this. Both groups of farmers have higher BMSCC than farmers who spent equal time on treatment of sick cows. It could be that when udder health receives less attention, cell counts rise, whereas on the other hand a high cell count is related to more udder health problems and thus with more treatment time. The relationship between disease treatment time and FFA level was also significant, but here only the 3 farms where disease treatment time was less had lower FFA levels than the other farms. Most farmers spent more time between the cows and on management programs, and less time on cleaning and other activities around milking. This was not related to milk quality. On average the farmers reported to have more than 2 hours of labour time saved each day, with a range from 0 to 8 hours. The amount of saved labour was not related to milk quality. 6 of the farmers indicated that they do not like milking, these farmers on average had a higher TPC, BMSCC and FFA level but the differences were not significant. Furthermore the amount of time that was spent looking after the animals and on supervision was not related to milk quality.

3.1.3 Scoring list on management items

The farmers have scored 47 management aspects on a scale from 1 (not important) to 5 (very important) when working with an automatic milking system. None of the items scored by the farmers was significantly related to milk quality. The farmers indicated most items were relevant for them. For each aspect the average score was calculated, the 10 least and most important items are listed in table 4, in order of importance.

Table 4 Least and most important items in relation to automatic milking according to farmers

Least important	Avg. score	Most important	Avg. score
Scoring teat condition	2,41	Few mastitis cases	4,74
A low number of refusals	2,46	Good claw health	4,67
3* daily changing the filter	2,67	Few problem cows	4,59
No overcrowding of cubicles	2,85	Attention for cattle	4,56
Scoring body condition	3,15	Few failures	4,48
Breeding	3,26	Flushing after separating milk	4,48
Own check on cleaning	3,30	Fine-tuning of the system	4,44
Registration of diseases	3,37	Daily checking alert lists	4,44
Accurate logbook of maintenance	3,41	Good ventilation	4,44
High visiting frequency of cows	3,41	Always roughage at feeding rack	4,37

This indicates that teat condition scoring was not regarded as very important. The farmers also believed that 3 times daily changing of the filter is not that important. This is supported by the results of the questionnaire that indicated that more than 2 times a day changing of the filter was not related to better milk quality. The table also indicates that the farmers rely on the automatic cleaning of the system. This is in line with the results from this study that also did not show relations between cleaning procedures and milk quality. The importance of ventilation is supported by data from the questionnaire. Some of the scores indicate that the farmers did not only have milk quality in mind when they scored each aspect. For instance good claw health is certainly a prerequisite for a high voluntary milking frequency, but is not directly related to milk quality. This has to be kept in mind when reading the figures in table 4.

Furthermore the farmers were asked to mention the three aspects that were most important for TPC, BMSCC and FFA. Indeed some of the aspects with a high average score are not mentioned as most important for milk quality. Few mastitis cases is most often (12 times) mentioned as important for a low cell count, but good hygiene and conductivity are also mentioned regularly by the farmers (9 times). For TPC three times daily cleaning is mentioned most often (13 times) as important and good hygiene was second (mentioned 8 times). For FFA a high frequency of visits is mentioned most often (16 times), and fine-tuning and good maintenance are also mentioned relatively frequently by the farmers.

3.1.4 Periodic test report

From the available data 6 traits were calculated for each herd as far as available. If a herd had more than one unit the figures were averaged over units. A summary of the figures is presented in table 5.

Table 5 Data periodic test report of automatic milking system

Trait	Minimum	Mean	Maximum	#herds
Effective reserve (litres/min)	116.0	338.0	1045	24
Air inlet (litres/min)	10.0	22.8	50.0	23
Pulsator ratio	58.9	60.0	62.2	27
a + b fase (milliseconds)	506	651.7	713	28
Vacuum (kPa)	39.0	44.2	50.0	27
End temperature cleaning (ºC)	25.0	71.2	86.0	20

Air leakage of the milk line, temperature of water at start of cleaning and type of vacuum pump were missing on too many reports to be analysed statistically.

Herds with low cell counts on average had a higher effective reserve than herds with high cell counts, but the difference was not significant. There was a significant difference between herds with high and low cell counts in air inlet in the teat cups. Herds with low cell counts had a higher air inlet. For FFA there was a non-significant trend in the opposite direction. None of the other traits on the test reports showed significant relations with milk quality traits.

3.1.5 Milk recording data

From the milk recording data the average standardised yields (called BSK) is calculated for 23 herds for the last year before the herds were visited, and related to milk quality. Average fat and protein percentages were also available for most herds, but these were not studied. Average yield and number of cows were taken from the questionnaire, as these figures were available for all herds, whereas from milk recording data they were not. The average standard cow production was 41.7, with a range from 34.4 to 48.8. The analysis showed that a high TPC was related to a low standard cow production. Differences between herds with high and low TPC were significant. For BMSCC the differences were not significant but in the same direction, but for FFA there were no differences between herds with low or high values. This indicates that milk quality on average was better on farms with higher yielding cows.

3.1.6 Hygiene checklist

The person who questioned the farmer also scored a large number of hygiene aspects in the barn on a scale from 1 to 5, where 1 was clean and 5 was very dirty. The aspects were grouped in categories: milking unit, bulk tank room, cattle housing, cubicles, floors and the cows. Also the number of cows, which was 71 on average and the distance between milking unit and bulk tank (according to the farmer, the average distance was 19 m) were listed. Both variables were not related to milk quality. Results clearly indicated that herds with high TPC were less clean than herds with lower TPC. However herds with medium or low TPC did not have significantly different hygiene levels. The hygiene score for floors was the only category that was not related to TPC, although on average herds with high BMSCC were less clean. None of the categories was significantly related to BMSCC. Herds with a high FFA levels did have less clean cows than the other herds. The score for the bulk tank room was also significantly different for herds with distinct FFA levels. However, this was because herds with medium FFA levels had significantly cleaner bulk tank rooms and differences between herds with low and high FFA levels were not significant.

Herds where the tidiness of the area around the milking unit on the side of the control panel was poor did have a higher TPC than herds where this was considered good. For 8 herds the access to drinking water was considered poor, for the other herds access was considered good. These 8 farms on average did have a higher FFA level, but the difference was not significant. The 17 herds with good illumination in the barn on average had a lower TPC and BMSCC than herds where this was considered poor (10), but only the difference in TPC was significant. Herds with bad ventilation did have a higher TPC than herds with good ventilation, but BMSCC and FFA level did not seem to be related to ventilation. Therefore it was remarkable that the 6 herds with an additional mechanical ventilation unit in the barn did show a significantly lower BMSCC than herds without such equipment, but did not have significantly different TPC. Other relationships between milk quality and hygiene aspects that were assessed were not found.

3.1.7 Data from management program of AM-system

From the available figures 5 traits were calculated per herd, if there was more than one milking unit figures were averaged over units. Figures could not be calculated for all herds because on some farms the figures were not available. A summary is given in table 6.

Table 6 Summary of data from AM-management program

Trait	Minimum	Mean	Maximum	#herds
Number of milkings/box	109.5	157.4	209.0	23
Hours of idle time/box	1.32	5.25	9.58	23
Kg milk/box	973	1488	2094	22
Average milk flow rate (l/min)	1.4	2.15	2.6	22
Cleaning time/box (min)	68.0	110.5	144.0	22

None of the traits did show significant relationships with milk quality, the only tendency was that herds with high TPC had a lower milk yield/box.

3.2 Short term risk factors

At the start of the study certain thresholds for changes in TPC, BMSCC and FFA were used. If a change in milk quality was above that threshold, the farm was contacted. However, for BMSCC there were few farms with an increase or decrease of more than 100.000 cells/ml. Therefore it was decided to lower the threshold to be able to contact more farms to investigate risk factors for sudden changes in BMSCC.
In Appendix 2 every farm that was contacted in this short term study, is described briefly including the changes in milk quality.

The main characteristics of the farms that were contacted (by phone or visit) are in the following table.

Table 7. Main characteristics of the farms contacted for the short-term study.

	No. of cows	Milk quota (x1000kg)	TPC* (x1000 Cfu/ml)	BMSCC* (x1000 cells/ml)	FFA* (mmol/ 100gr fat	Installation month AM-system	Milking frequency*
Farm 1	62	480	12	143	1,27	October 1999	2,3
Farm 2	98	700	16	181	0,65	February 1999	2,6
Farm 3	46	505	24	310	0,82	April 1999	2,5
Farm 4	78	1.100	7	118	0,71	March 1999	2,7
Farm 5	79	1.070	7	149	0,52	May 1998	2,9
Farm 6	52	605	10	172	0,86	July 1998	2,7
Farm 7	69	720	9	292	0,58	April 1998	2,8
Farm 8	90	600	6	110	0,57	May 1998	3,0
Farm 9	66	569	10	217	1,01	August 1999	2,9
Farm 10	83	1.000	21	239	0,70	September 1998	2,6
Farm 11	66	845	12	245	1,16	February 1999	2,3
Farm 12	53	487	14	231	0,42	September 1999	2,5
Farm 13	52	505	7	259	0,44	September 1999	2,7

* Average value after installation of the AM-system.

For changes in BMSCC 10 farms were contacted (visit as well as phone call). These were mainly farms with already high BMSCC, that had an increase or decrease in BMSCC. In total 7 farms were contacted for changes in TPC, especially because of increases in TPC. For FFA 13 farms were contacted. These were mainly farms with already a high FFA value that had an increase or decrease.

3.2.1 Overall impressions

BMSCC
Reasons for an increase in BMSCC mentioned by the farmers were the (increase in) presence of cows with high somatic cell count and clinical cases of mastitis. Also the poor resistance of the cows and the overall health of the cows were mentioned by some farmers. In addition warm weather and a poor hygiene has no positive effect on the udder health in general.
As a reason for a better BMSCC a better climate in the barn by an increase in the ventilation was mentioned once. Culling cows with high somatic cell count or not milking them in the tank anymore will also lower the BMSCC.

TPC
For TPC several reasons for an increase appeared during the study. Sometimes the cleaning of the tank or the system is not done properly. Reasons for this can be that the temperature of the cleaning solution is too low or the amount of cleaning agent is too low. This was e.g. once caused by a leak in

the hose supplying the cleaning agent. Another two farmers had their water heater only working at night to lower the electricity costs, resulting in an insufficient amount of cleaning water. This will affect the water temperature of the main cleaning cycles. Also technical problems may occur, e.g. some farmers had a problem with a valve that got stuck or was leaking. Sometimes the cleaning of the AM-system or bulk tank was not done properly e.g. by polluted spray balls in the tank.

FFA

Reasons for problems with FFA may be both technical and related to management. For example, some technical problems, that might have cause the high FFA value, mentioned by the farmer or found during farm visits were: a leaking milk flow sensor, a too long post run time of the milk pump, last milk interval not taken into account, a valve of the milk pump causing bubbling of milk, a high rotation speed of the stirring blade and air leakage. Management factors that may be a risk are the milking frequency of the cows in late lactation and the calving pattern. Cows in late lactation produce milk that is more sensitive to lipolysis (causing higher FFA values). If the milking frequency is too high this may be a problem. However if the frequency of those cows is good, but if there are a lot of cows in late lactation, there may still be a problem. Farmers are aware of this risk factor. Another thing that is often mentioned by farmers is the feeding and the body condition of the cows. But the exact relationship is not known. The problems with FFA are more difficult to solve than with BMSCC or TPC according to the farmers, because not much is known about this subject.

4. Discussion

As mentioned the farms were selected for this study based on their milk quality parameters between 7 and 18 months after introduction of automatic milking. As indicated in table 3 some of the farms were classified differently afterwards, based on information that became available after they were visited. Because the information collected for this study describes the current situation on the farm at the time of the visit, it is likely that factors that affect milk quality are better related to milk quality during the last 6 months or one year before the visit took place than with milk quality earlier on. Besides this, the time span since automatic milking was introduced varies between farms. Therefore, results described here are based on relationships between herd and management factors and milk quality during the year before the herds were visited. Relationships between these factors and milk quality between 7 and 18 months after introduction of automatic milking are similar, but usually less conclusive.

The results of this study on 28 farms largely agree with those of the Dutch study on 124 farms in the Netherlands. In that study the relationship between milk quality and hygiene was not as clear as in this study, but this is probably caused by the more differentiating scoring range and aggregation of several items into components (AM-system, bulk tank room, housing, cubicles, flooring, animals). The earlier study revealed a relationship between milk flow rate and BMSCC that was not shown in this study. A possible explanation for this is that both a low and a high milk flow rate were related to higher cell counts and thus the difference in milk flow rate between herds with high and low BMSCC is not significant.

On the long-term hygiene on the farm appeared to be important for TPC as well as for BMSCC. Both milk quality parameters were higher on farms with a poor hygiene. The TPC value was related to hygiene in the clean part of the AM-system and the waiting area. Also the overall impression of the farm was related to TPC. The relationship with hygiene is logical because with a poor hygiene, the chance for bacterial growth and the chance of contamination of milk increase. However, a direct relationship between hygiene on the farm and TPC is difficult to prove under experimental conditions (Slaghuis et al, 1991). It was also found that TPC and BMSCC are lower on higher producing farms. It may be that these farms have better overall management, resulting in a good milk production, animal health and hygiene (Koning et al, 2002). Relationships between these factors were not analysed. Barkema et al (1999) also found that on low BMSCC farms the hygiene is better than on farms with high BMSCC. This study was carried out on conventional farms (Barkema et al, 1999).
The part of the short-term study focused on TPC revealed mostly technical and management factors responsible for a sudden increase in TPC. The temperature of the cleaning solution was a risk at some farms. It does not have to cause an increase in TPC immediately, but it increases the risk of high TPC. Problems occur when the milking installation or bulk tank is not cleaned properly and bacteria get more chance to grow. Sudden changes in milk quality are not always related with sudden management changes. Organisational blindness of the farmer will not result in immediate problems, but on the long term problems may arise. Also a less optimal cleaning system will not affect TPC values immediately but the chance of a sudden high TPC value increases after some time.

It was remarkable that on average farmers replace their teat cup liners (rubber as well as silicon) much too late. The analyses showed that this is a long-term risk for increased BMSCC. Farmers know after how many milkings they replace the liners. It may be of help if the AM-system could give them alerts to replace the liners.
Short-term factors related to an increase in BMSCC were mostly an increase in the number of high somatic cell count cows or the occurrence of mastitis. Some farmers also mentioned the warm weather. This may be through a decreased resistance of the cows due to heat stress and/or because of an increased growth of bacteria in the environment. It was also found that farms with mechanical ventilation have a lower BMSCC. A technical factor that was also found to be important for BMSCC was the level of air inlet in the teat cups. There was an unexpected relationship between air inlet and BMSCC. The results showed a higher air inlet on farms with low BMSCC. Perhaps a higher air inlet might cause less teat washing in the liner.

For FFA the analysis and interpretation of the results is more difficult. It appeared that a regular check of the attention lists and check of the cleaning was related to a lower FFA value. This may indicate a better overall management of the farmers who do this regularly. Farms that had more alerts from the cooling system had a higher FFA value than other farms. However, type of alert was not registered. Moreover, in the short-term study on the farms with high FFA no problems with cooling were found or we were not able to find them. The short-term study mostly revealed technical factors and sometimes management factors influencing FFA. Especially cows in late lactation seemed to be a risk. Their milk is much more susceptible to lipolysis than milk from cows in early lactation. Lipolysis causes higher FFA in milk. A calving pattern spread evenly around the year may decrease the risk of a rise in FFA in a certain period because of the herd being in late lactation. If cows are in late lactation it is important that their milking frequency is not too high. The technical factors related to FFA mainly concerned air inlet in the system, bubbling of the milk and a too long post run time of the milk pump, which increases the lipolysis. An interesting aspect is that air inlet in the teat cup seemed to have a positive effect on BMSCC and a negative effect on FFA levels. There is a hypothesis that there is a relationship between FFA, feeding and body condition, especially the occurrence of a negative energy balance, but this could not be found in this study and should be investigated further.
A remarkable result of the long-term study was that FFA seemed to be related with the number of places at the feeding fence and the accessibility of the water trough. The more places at the feeding fence and the better the accessibility of the water troughs, the lower the FFA. Also dirty cows were associated with a higher FFA. The exact relationships are unknown, but it may be related to stress occurring in the cows if there are not enough places to eat, if the location of the water troughs is not optimal or maybe if the barn is overcrowded. This kind of stress will probably concern individual cows and not the complete herd. It might be that stress induces the susceptibility of the milk to lipolysis, but more research is necessary.
One thing that was very apparent was the variability in FFA between days. Normally FFA is only measured twice a year on every farm. This makes a good statistical analysis difficult because of the limited number of measurements. The rather big variability in FFA makes it even more difficult to analyse.

In general it appeared that farmers are aware of the risks for high TPC and BMSCC, but less is known about the risks for high FFA. For increases some possible risk factors were found, but usually sudden decreases that were mostly not intended by the farmer, remained unclear.

5. Conclusions

- Herd size and the amount of labour time saved are not significantly related to milk quality.
- Replacing liners in time is beneficial for BMSCC and probably also has beneficial influence on TPC and FFA. In practise farmers with automatic milking units wait far longer with liner replacement than generally advised, both for rubber as for silicon liners.
- Differences in handling cleaning by the farmer do not seem to be related to differences in milk quality. Regular monitoring of cleaning by the serviceman however was related to lower TPC.
- The influence of fine-tuning of the system probably is distorted because herds with milk quality problems do this more often than other herds. Usually 6 to 8 service checks are carried out per year.
- A good level of hygiene around the milking unit is important to realise a low TPC. Cleaning the waiting area by regularly removing the manure occurs more often on herds with a low TPC than on herds with a high TPC. Farmers generally assume cleaning of the AM-system is more important than hygiene of the cows but they are aware of the importance of hygiene for TPC.
- Changing the filter more often than twice a day does not affect milk quality.
- It is remarkable that both many feeding places per cow and easy access to drinking water on average show a lower FFA.
- According to the farmers a little over 2 hours of labour time are saved daily. Particularly activities around milking and cleaning of milking equipment take less time. More time is spent between the cows and on management programs. The amount of time saved is not related to milk quality.
- A high yield per cow is related to a lower TPC.
- Good ventilation is beneficial for both TPC and BMSCC.
- There can be a great variability in FFA between days.
- Farmers know more about TPC and BMSCC than FFA. Reasons for increase in FFA are difficult to indicate.

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List of Abbreviations

AM	Automatic Milking
TPC	Total Plate Count
BMSCC	Bulk Milk Somatic Cell Count
FFA	Free Fatty Acids
Meq	Milli equivalents
NL	The Netherlands

Appendix 1 Overview of significant relationships

Figures with different subscripts within each row differ significantly (p<0,05)

Table 8. Class means for factors related to TPC

	Class (number of values)		
Description	low (8)	medium (11)	high (9)
Production level after introduction	9338kg[a]	9126kg[a]	8083kg[b]
Cleaning milking control area (times/week)	13.2[a]	6.7[b]	4.2[b]
Cleaning floor robot (times/week)	16.62[a]	14.00[a]	6.67[b]
Cleaning floor waiting area (times/day)	11.3[a]	5.1[b]	4.2[b]
Standardised yield (BSK) (kg/cow/day)	43.6[a]	42.0[a]	38.4[b]
Hygiene score milking robot*	2.32[a]	2.34[a]	2.99[b]
Hygiene score bulk tank room*	2.04[a]	2.05[a]	3.14[b]
Hygiene score cow housing*	2.21[a]	2.29[a]	3.04[b]
Hygiene score cubicles*	2.17[a]	2.39[a]	3.15[b]
Hygiene score cows*	2.13[a]	2.27[a]	2.63[b]

* 1 = clean … 5 = dirty

Table 9. Class means for factors related to SCC

	Class (number of values)		
Description	low (5)	medium (14)	high (9)
Production level after introduction (305 days)	9500kg[a]	9065kg[a]	8159kg[b]
Cleaning floor waiting area (times/day)	13.4[a]	5.5[b]	4.4[b]
no. of milkings before liner replacement	3820[a]	4079[a]	6194[b]
Air inlet in teat cups (litres/minute)	31.5[a]	21.4[b]	18.3[b]

Table 10. Class means for factors related to FFA

	Class (number of values)		
Description	low (5)	medium (12)	high (11)
Messages tank guard[$]	.80[a]	.83[a]	1.36[b]
Farmer responsible for cooling tank[#]	.40[a]	.90[b]	.91[b]
Number of feeding places per cow	1.45[a]	.88[b]	.96[b]
Hygiene score bulk tank room*	2.65[a]	1.87[ab]	2.92[b]
Hygiene score cows*	2.20[a]	2.20[ab]	2.52[b]

* 1 = clean … 5 = dirty; [$] 0 = no messages, 1 = some messages, 2 = often messages; [#] 0 = no, 1 = yes

Table 11. Mean TPC per factor class for related factors

Variable	class (number of observations) and mean TPC		
Serviceman controls of cleaning	no (5) 17.7[a]	1-4 times (9) 12.5[ab]	>4 times (14) 10.0[b]
Tidiness around milking unit	good (23) 10.8[a]	poor (5) 18.6[b]	
Illumination of stall	good (17) 10.5[a]	poor (10) 15.8[b]	bad (1) 4.7[ab]
Ventilation	good (9) 9.9[a]	poor (15) 11.2[ab]	bad (4) 20.7[b]

Table 12. Mean SCC per factor class for related factors

Variable	class (number of observations) and mean SCC		
Disease treatment time	less (3) 280[a]	equal (16) 202[b]	more (9) 258[a]
Illumination of stall	good (17) 223[a]	poor (10) 246[a]	bad (1) 150[a]
Mechanical ventilation	yes (6) 170[a]	no (22) 244[b]	

Table 13. Mean FFA per factor class for related factors

Variable	class (number of observations) and mean FFA		
Fixed control times	no (11) 82.5[a]	yes (17) 64.8[b]	
Disease treatment time	less (3) 48.4[a]	equal (16) 72.2[b]	more (9) 78.6[b]

Appendix 2 Description of farms in the short-term effect study

Farm 1

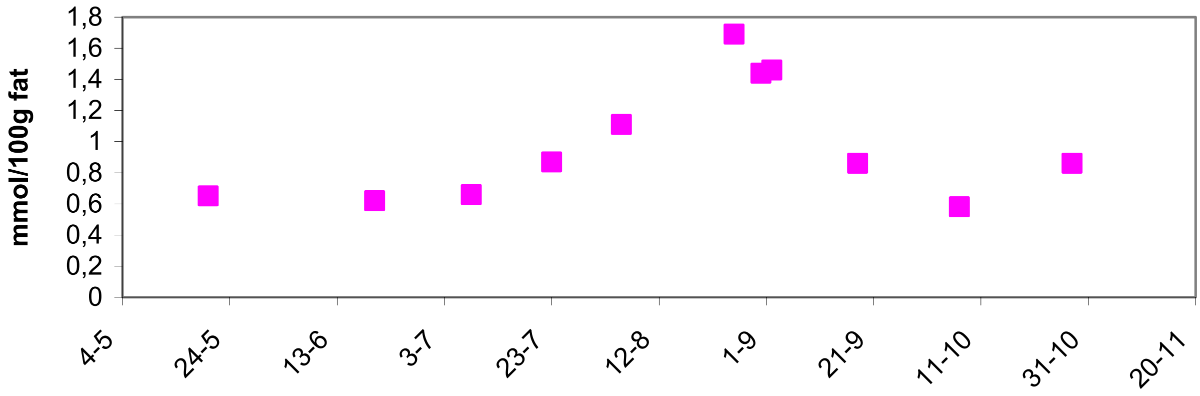

Figure farm 1 - FFA values (2002)

Action 1
The farm was visited because of lower FFA values in May and June 2002, compared to the average values before 2002. The milking frequency was lowered for animals at the end of the lactation and those with less production. It is known that very short milking intervals can cause a higher FFA value
Action 2
The farm was visited because of the high FFA values in August and September. According to the farmer they were mainly caused by feeding. The feeding ratio was fresh grass or silage and concentrates. It is known that a very unbalanced ratio might have effect on FFA. Although a general relation between feeding and FFA is not known from literature.
The reason for high values for this farm may be a combination of factors. It is possible that feeding is affecting the susceptibility for lipolysis of the cows. The pre-milk unit showed some air leakage and the post runtime of the milk pump was too long. Moreover milk is pumped from buffer tank to main tank after 2-3 hours (filling degree buffer tank 22%), causing a high risk of freezing milk. The pump of the buffer tank (used to pump the milk from buffer to main tank) is very powerful.

Farm 2
Table 14. FFA values of farm 2

Date	FFA (mmol/100 gram fat)
21-05-02	0,91
01-07-02	0,63
03-09-02	0,54

Action 3
One of the milk flow sensors had air leakage causing a high FFA value. After fixing the sensor the values came back to normal.

Farm 3

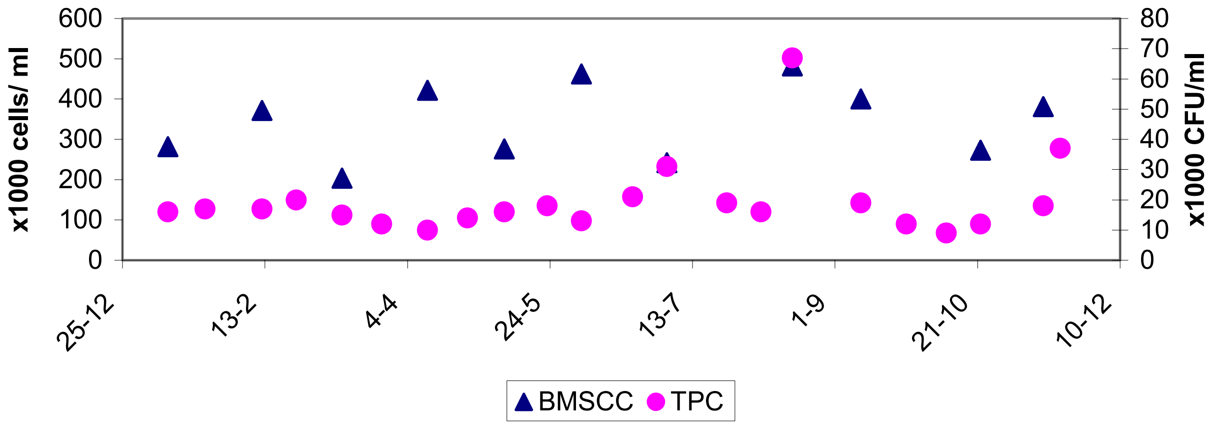

Figure farm 3 - BMSCC and TPC values (2002)

Action 4
The BMSCC value of August 17th was high. The farmer is very well aware of the problem. He sometimes separates the milk from high cell count cows to keep the BMSCC below the penalty level of 400.000 cells/ml (geometric). But this is not done consistent. According to the farmer the weather had a negative effect on the BMSCC.
He does not cull cows with high cell counts and therefore he runs too many risks. The weather also affects the value, but this is not the main reason.
Action 5
On August 17th also the TPC value showed an increase. According to the farmer the increased value was caused by debris in the bulk tank, from milk inlet to stirring blade. The stirring blade itself was also dirty. A too low start temperature of the cleaning water could cause this. The capacity of the boilers was insufficient. Moreover due to an insufficient drainage of the tank, cleaning water residues were found.

Farm 4

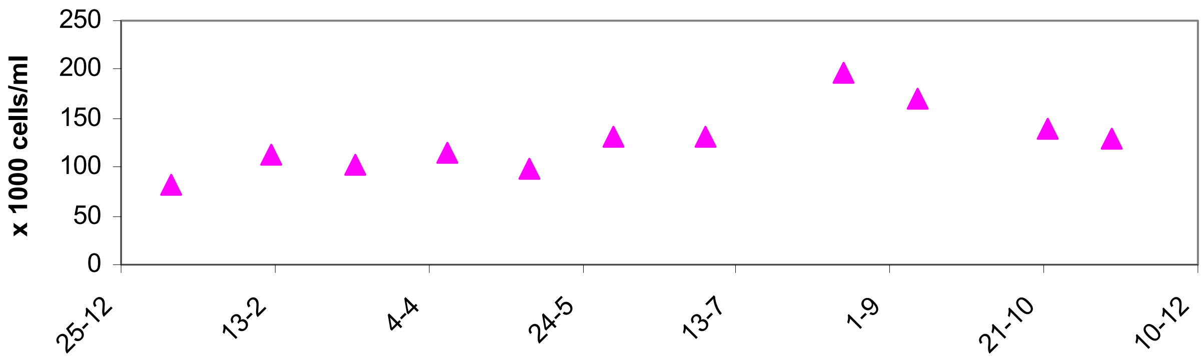

Figure farm 4 - BMSCC values (2002)

Action 6
A high BMSCC value was seen on August 17th. Data from the milk recording organisation showed that there were a few cows with a SCC of more than a million cells/ml. This was new to the farmer. One of those cows is culled. The other cows where treated immediately. Afterwards BMSCC decreased again.

Farm 5

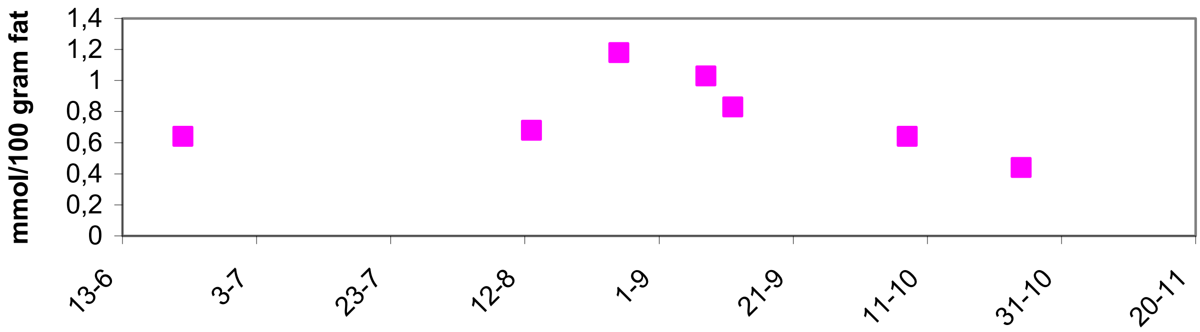

Figure farm 5 - FFA values (2002)

Action 7
On August 26th the FFA level was increased to above the penalty level. It was found that the last milking time was not taken into account because of a failure of the AM-system. This resulted in cows being milked with very short milking intervals.
Action 8
On the 25th of October the FFA value was lowered. Compared to the period before there were a lot of fresh cows. It is known that cows in late lactation contribute to a higher FFA level. A clear reason why the value was this low could not be found.

Farm 6

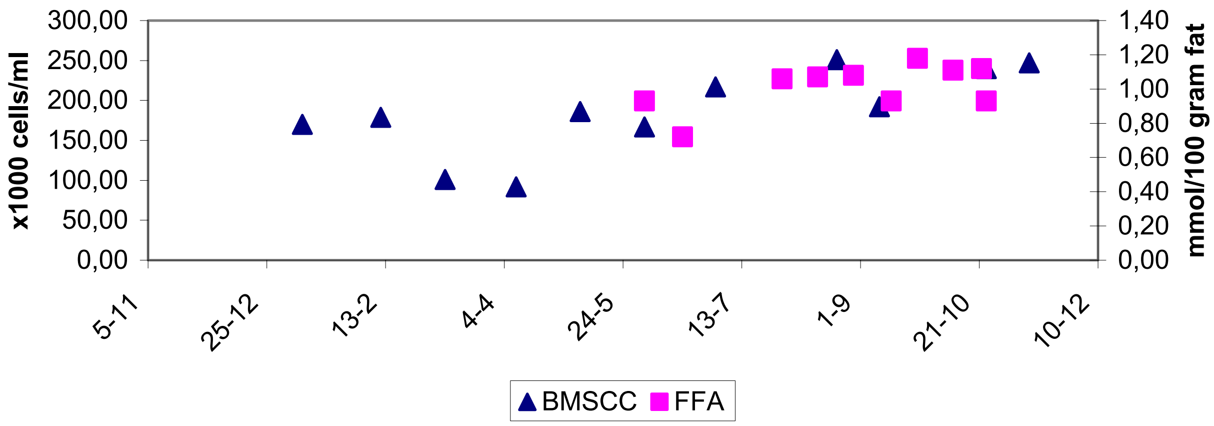

Figure farm 6 - BMSCC and FFA values (2002)

Action 9
The farm was contacted while BMSCC had increased on August 22nd. There were two animals with high cell count and a milk yield of 50 kg per day. Another cow had severe clinical mastitis and the treatment was not sufficient. Also the hot weather may have had a negative effect. However the increase in BMSCC is within limits and is close to normal variation.
Action 10
Lower FFA level on September 14th. Nothing was changed on the farm, so the reason for decrease of FFA could not be found.
Action 11
There was a difference in the FFA level within two days of sampling on October 22nd and 24th. No explanation for the difference could be found. However, average FFA levels are rather high (> 0,80) on this farm.

Farm 7

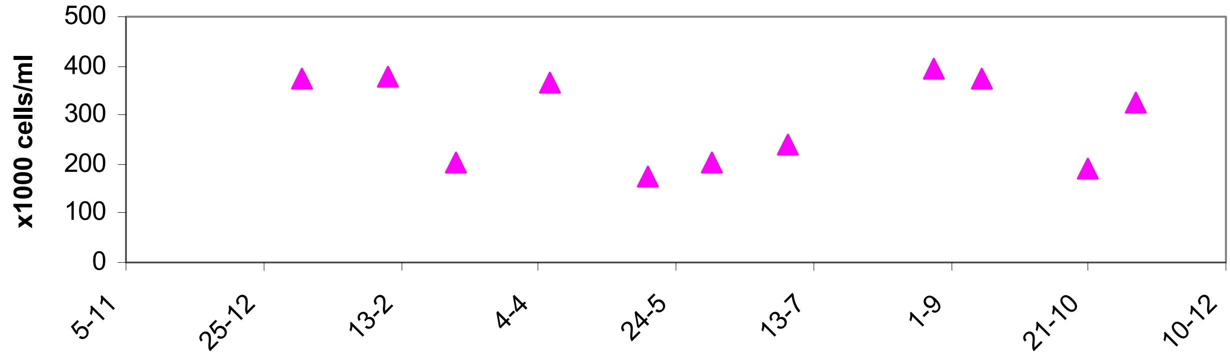

Figure farm 7 - BMSCC values (2002)

Action 12
BMSCC value on August 26th was increased. Two cows with high cell count were dried off. The resistance of the cows is reduced at this moment and the warm weather may cause heat stress.
Action 11
The BMSCC value of the 21st of October is much lower again. No reason could be found why this value was lower than the previous samples. Next sample is elevated again. The variation seems to be within the normal variation of BMSCC on this farm.

Farm 8

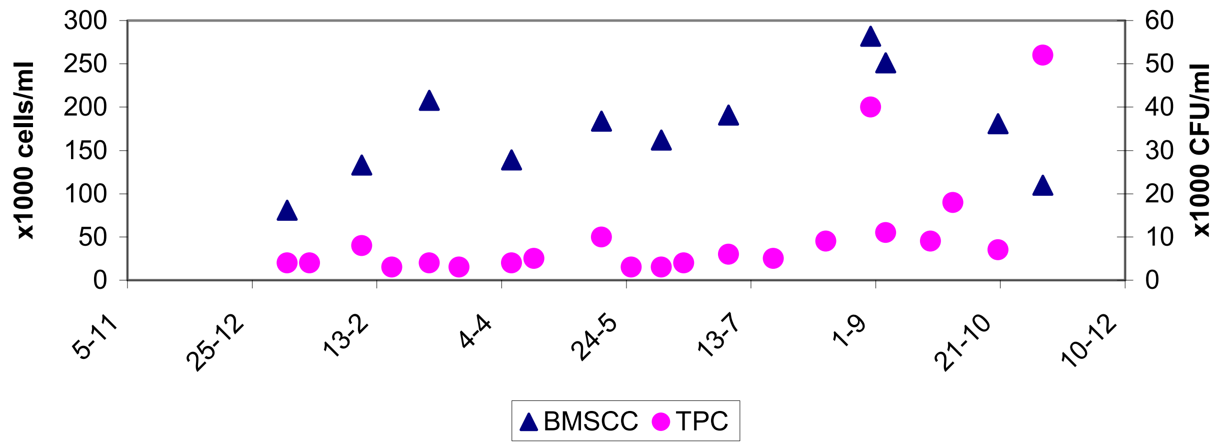

Figure farm 8 - BMSCC and TPC values (2002)

Action 12
On august 30th the BMSCC was increased. Probably there were some high cell count cows. The farmer has only conductivity to identify cows at risk, because he does not have an individual cell count program. The hot weather may have caused heat stress.
Action 13
On October 20th a lower BMSCC value was found. One animal with a bad quarter was culled. Moreover the ventilation of the barn was improved since the first contact.
Action 14
On August 30th the TPC value was increased. Too less cleansing agent was used during the main cleaning of the AM-system. Due to a leakage in the detergent supply system. The farm was contacted again on the 10th of October but the leakage was still not fixed.

Farm 9

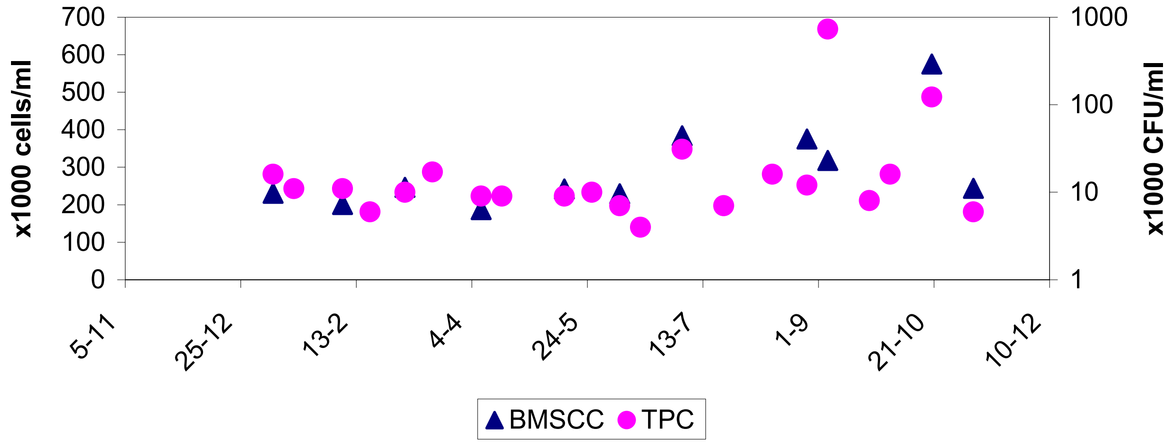

Figure farm 9 - BMSCC and TPC values (2002)

Action 15
The farm was visited in September for high BMSCC in July, August and September. No reason for the higher BMSCC values could be found. However, the hygiene at the farm is not very good.
Action 16
On 20 October a high BMSCC value was found. Two animals with high cell count where culled. Another two cows with high cell count where dried off with (long activity) antibiotics. The BMSCC decreased afterwards to acceptable values.
Action 17
The farm was visited in September because of a high TPC value on September 5th. The spray balls of the main tank were polluted with sawdust and therefore the cleaning was insufficient, causing debris in the main tank.
Action 18
A reason for the sudden increase on October 2nd could not be found. The next TPC result again was low again.

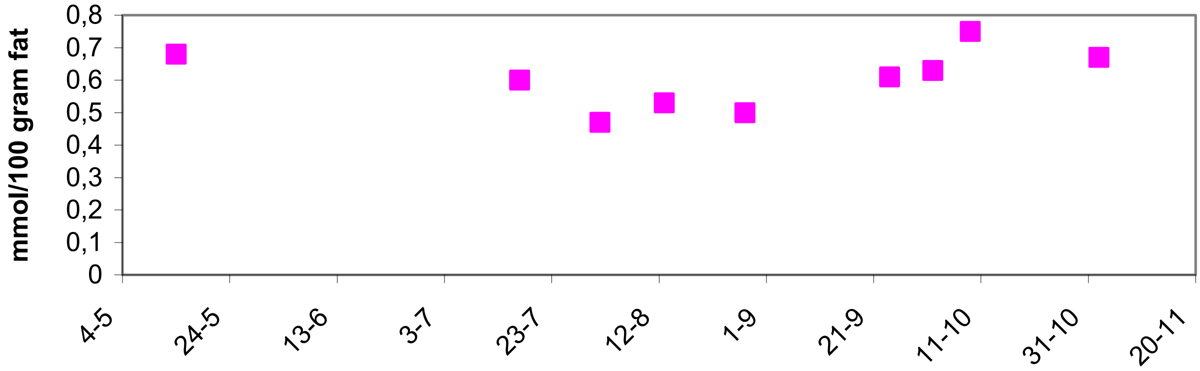

Figure farm 9 - FFA values (2002)

Action 19
Average FFA level for 2001 was 0,87, no reason for the lower level in 2002 could be found. A reason for the higher value in October could not be identified either.

Farm 10

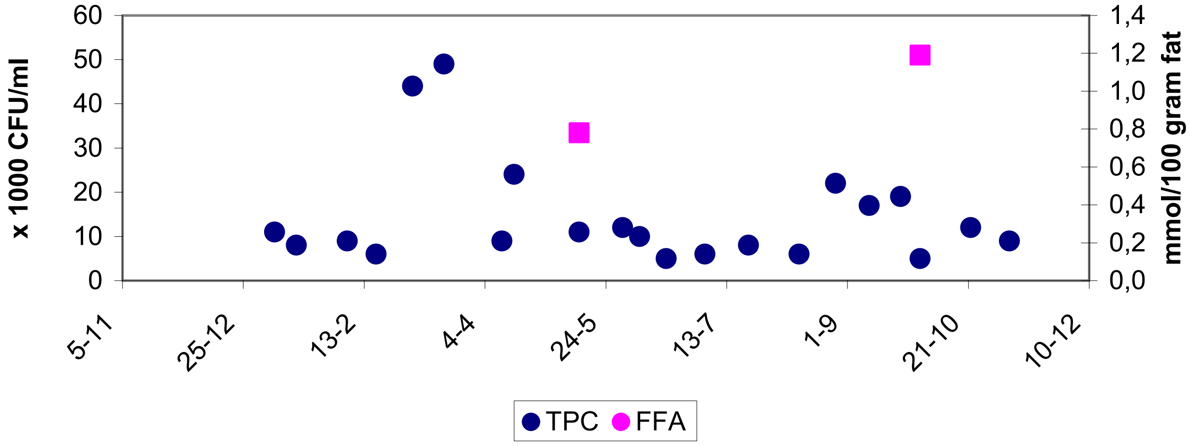

Figure farm 10 - TPC and FFA values (2002)

Action 20
On the 27th of August the TPC was increased. One of the valves was not functioning correctly. After the cleaning of the main tank the milk is pumped from the buffer tank into the main tank. It takes up to 8-10 hours before the buffer tank is cleaned. In this period there was some water with milk residues leaking to the main tank, because of the broken valve.
Action 21
On the 1st of October the FFA level was above the penalty level. No reason could be found for the increase of FFA.

Farm 11

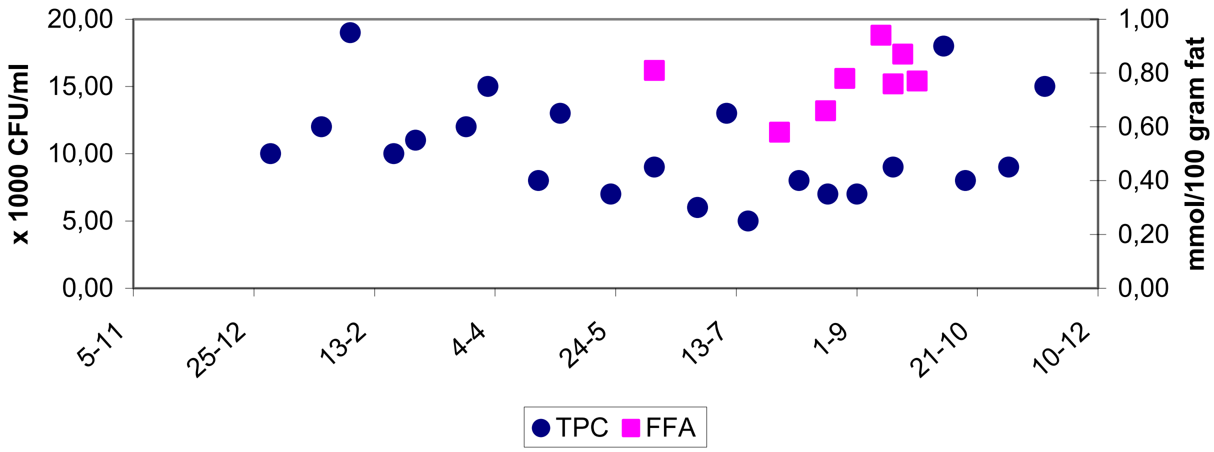

Figure farm 11 - TPC and FFA values (2002)

Action 22
The TPC is always below 20.000 CFU/ml. The reason for the increased TPC of October 7th might be found in a broken valve in the delivery line. There are two AM-systems connected to one delivery line and this one-way valve is therefore a critical point.
Action 23
On September 11th the FFA level was increased. The valve of the milk pump was not functioning correctly. During pumping the milk was mixed heavily in the recorder jar. However the FFA values remained rather high after fixing this problem.

Farm 12

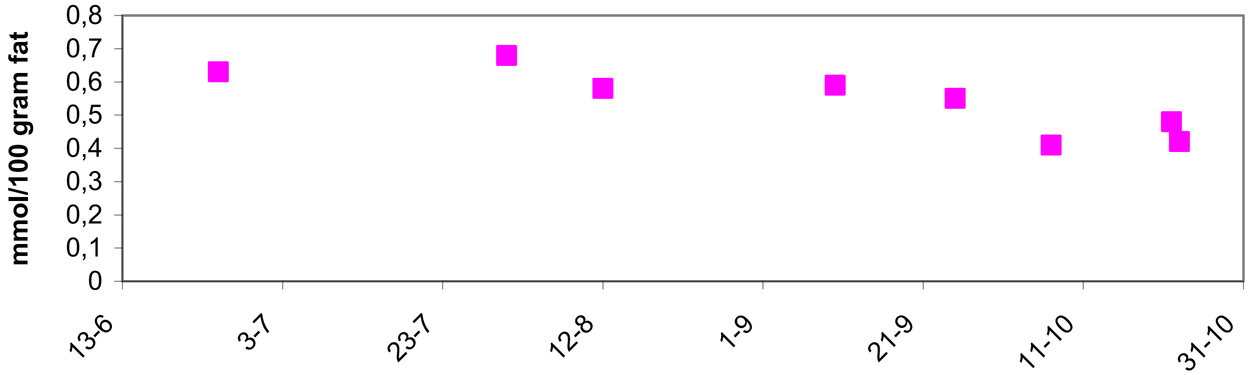

Figure farm 12 - FFA values (2002)

Action 24
The FFA values are rather low for a farm with an AM-system. On October 10th the farm was contacted to find out why the FFA level had decreased again. However no clear reason could be identified.

Farm 13

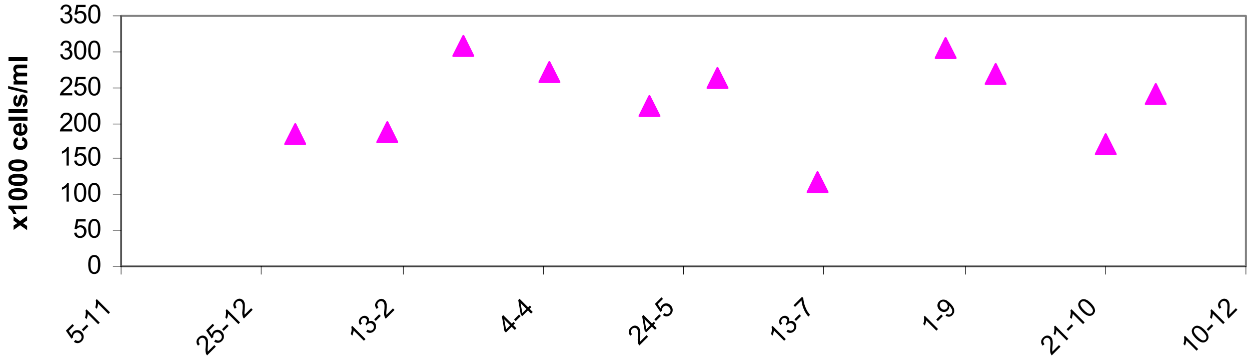

Figure farm 13 - BMSCC values (2002)

Action 25
BMSCC shows a variation from 100 to 300. On October 24th the farm was contacted to find out why BMSCC had decreased. The farmer reported that one cow with a SCC of more than a million cells is not milked in the tank anymore. This was the only measure taken by the farmer to lower the BMSCC.