# Farm management factors associated with bulk tank somatic cell count in Irish dairy herds

Kelly PT[1,2], O'Sullivan K[3], Berry DP[1], More SJ[2], Meaney WJ[1], O'Callaghan EJ[1], and O'Brien B[1]

[1] Moorepark Dairy Production Research Centre, Fermoy, Co. Cork, Ireland
[2] School of Agriculture, Food Science and Veterinary Medicine, University College Dublin, Belfield, Dublin 4, Ireland
[3] Department of Statistics, School of Mathematical Sciences, University College Cork, Cork, Co. Cork, Ireland

## ABSTRACT

The relationship between bulk tank somatic cell count (SCC) and farm management and infrastructure was examined using data from 398 randomly selected, yet representative, Irish dairy farms where the basal diet is grazed grass. Median bulk tank SCC for the farms was 282,887 cells/ml ranging from 82,209 to 773,028 cells/ml. Two questionnaires were administered through face-to-face contact with each farmer. Herd-level factors associated with bulk tank SCC were determined using linear models with annual somatic cell score (i.e., arithmetic mean of the natural logarithm of bulk tank SCC) included as the dependent variable. All herd level factors were analysed individually in separate regression models, which included an adjustment for geographical location of the farm; a multiple regression model was subsequently developed. Management practices associated with low SCC included the use of dry cow therapy, participation in a milk recording scheme and the use of teat disinfection post-milking. There was an association between low SCC and an increased level of hygiene and frequency of cleaning of the holding yard, passageways and cubicles. Herd management factors associated with bulk tank SCC in Irish grazing herds are generally in agreement with most previous studies from confinement systems of milk production.

**KEYWORDS:** bulk tank; dairy cattle; infrastructure; management; somatic cell count

## CORRESPONDING AUTHOR:

Patrick T Kelly
Teagasc, Dairy Production Department, Moorepark Production Research Centre, Fermoy, Co. Cork, Ireland.
Tel: +353 25 42222
Fax: +353 25 42340
E-mail: paddy.kelly@teagasc.ie

Irish Veterinary Journal
Volume 62 Supplement 45-51 2009

## INTRODUCTION

Ireland produces approximately 5,090 million litres of milk annually. In 2007, 528.5 million litres of milk were sold for human consumption and 140,400 tonnes of cheese produced (CSO 2008). Dairy cow milk was estimated to be worth €1.4 billion to the Irish economy in 2003 (CSO 2008). Given the huge economic importance of milk production in Ireland, the quality of this product is of the utmost importance. It has been shown that increased somatic cell count (SCC) adversely affects both the shelf life of milk (Barbano *et al.* 2006) and cheese yield (Barbano *et al.* 1991, Klei *et al.* 1998). Milk quality is required to be within certain thresholds according to European law (EEC 1992 Council Directive 92/46/EEC); SCC must not exceed a geometric average over three months of 400,000 cells/ml, with at least one test per month. Additionally, incentives and penalties are being increasingly applied by milk processors to help ensure high milk quality. Recent research indicates an annual increase in Irish bulk tank SCC of approximately 5,000 cells/ml, which is worrying for the dairy industry (Berry *et al.* 2006). Herd management has been shown in other international studies to be associated with bulk tank SCC (Barkema *et al.* 1998; Kiiman *et al.* 2006; Wenz *et al.* 2007). However, the management factors deemed to be important vary from farm to farm and country to country. Kiiman *et al.* (2006) concluded that the milking operator was the biggest factor affecting SCC. Wenz *et al.* (2007) documented that bedding material, housing facilities and cluster removers were all associated with bulk tank SCC. Barkema *et al.* (1998) reported that the most important factors associated with bulk tank SCC were teat disinfection after milking, the duration of clinical mastitis treatment and no drying after a wet treatment pre-milking. Rodrigues *et al.* (2005) reported differences in SCC between cows housed in forestalls and stallbarns, and Goldberg *et al.* (1992) documented that confined housing had a higher standard plate count than intensively managed rotational grazing.

Nevertheless, most research to date has been undertaken on confinement systems of milk production, whereas Ireland produces a large proportion of its milk from grazed grass with cows outdoors for the majority of the lactating period. The objective of the current study was to quantify the associations between herd management factors and bulk tank SCC in Irish, spring-calving, grass-based dairy herds. Results from this study will be useful in determining the proportion of Irish farmers undertaking different management practices and describing farm management practices associated with different levels of bulk tank SCC.

## MATERIALS AND METHODS

### *Data collection*

Data were obtained on annual milk supply for all farmers supplying to one of the major milk processors in Ireland, the milk processor supplied data on milk volume and bulk tank SCC on a collection basis for the years 2000 through to 2007. Milk was collected from the farms at a frequency range of one to four days. The SCC of the bulk tank was taken at almost every milk collection. Annual herd milk supply for the calendar year of 2004 was divided into strata in increments of 10,000 litres with herds supplying yields at either end of the supply distribution being merged due to small strata sizes. A total of 450 herds were randomly chosen, with the percentage selected from each stratum being weighted by the frequency of herds within strata relative to the sample population. These farms were invited to participate in a questionnaire survey, 400 of them decided to take part.

Two questionnaires were administered to each farm, one of which was undertaken during the period April to July, 2006 and the second during the period December 2006 to March 2007. In the first (summer) questionnaire, there were 70 questions relating to factors such as pre- and post-milking practices, milking machines, cleanliness of the facilities, and the practice of milk recording. The second (winter) questionnaire had 30 questions relating mainly to factors such as housing dates, housing type, cleanliness of shed and frequency of cleaning. The questions in the surveys required objective measurements and factual responses from the farmer as well as subjective measures. Bulk tank milk samples were taken during the summer visit. The sample was taken from the bulk tank after the milk was agitated, using individual sterile sample bottles. 10µl of each sample was inoculated onto blood agar plates (base no. 2; MERCK product. Manufactured in Merck KGaA 64271 Darmstadt. Germany) and incubated at 37ºC overnight (16-18h). Bacteria were identified visually from the plates after incubation, by an experienced laboratory person.

Each participating farm was visited on two occasions (summer, winter), and the questionnaires were completed during a face-to-face interview with the farmer at each visit. The questionnaires were developed following detailed discussion with specialists working in the milk quality area and examination of the main factors known to affect SCC, such as milking parlour, milking practices, housing, and hygiene. Three people were involved in the administration of the survey. Prior to the start of the study, these people standardised their approach to the scoring of farm hygiene, which was based on a visual assessment of farm yards and parlours. In addition, a scoring system for cow cleanliness was devised, based on a random sample of ten cows from each herd. Each cow was given a composite score of one (clean) to four (very dirty) based on the component score of the udder, tail and legs. An overall (herd) cow cleanliness score was calculated by combining the individual cow scores. Farms were divided into five regions based on geographical location. Farm visits within each region were alternated across time to minimise any potential temporal by spatial bias. A paper copy of each questionnaire was completed on-farm, then subsequently entered into Microsoft Excel, where the data was managed for ease of analysis. The milk processing data was supplied in electronic form and managed using Microsoft Excel. The two sets of data were combined using SAS.

### *Statistical analysis*

Bulk tank SCC data for all milk collections in the 365 days prior to the first visit to a specific farm were obtained and the average of the natural logarithm of SCC calculated; this variable will be referred to as somatic cell score (SCS). A strong correlation (0.97) existed between mean SCS in the 365 days prior to the first farm visit and mean SCS 365 days post the first farm visit. All analyses were undertaken using linear models in PROC GLM (SAS, 2006) with SCS included as the dependent variable. Geographical location of the farm region was included in all models as a confounding effect. Initially, a series of regression models were constructed for each independent variable together with the confounding factor. Factors that were associated with SCS at a significance level of $P<0.30$, were retained for further analysis. Multiple regression models were developed using stepwise regression on the variables that fulfilled the initial selection criteria. Separate multiple regression models were generated using the questions from the summer questionnaire, winter questionnaire and from both. Statistical significance is defined as $P<0.05$ for all final multi regression models. Residual diagnostics did not indicate any concern for departures from the statistical assumptions of constant variability and normality.

## RESULTS

The average number of cows per herd was 55, ranging from 12 to 293 cows. The average number of heifers per herd was 12 and ranged from 0 to 67. There was a wide range in milk volume supplied to the processor in the 365 days prior to the farm visit varying from 17,087 to 1,324,474 litres. Farm SCC ranged from 82,209 to 773,028 cells/ml; the median SCC was 282,887 cells/ml. From the 303 bulk tank milk samples taken, 51% of the samples tested positive for the presence of *Staphylococcus aureus*, varying from 1 CFU to 'numerous' (i.e., 40 to 100 CFU); 11% of all milk samples had >40 CFU. No other bacteria were isolated.

**Tables 1 to 6** describe the univariate association between bulk tank SCC and milking process infrastructure, teat preparation, herd management, winter housing, parlour and roadway hygiene and the hygiene of winter housing, respectively. Not all milking parlour infrastructure variables were associated with bulk tank SCS (**Table 1**). Farmers that milked with a recorder jar plant had lower (P<0.001) SCS than farmers that milked using a direct pipeline. The presence of cluster removers and heated water in the parlour were also associated (P<0.05) with lower SCS. Separating milk from infected cows by way of the milking jar was also associated (P<0.01) with lower SCS than when a dump line or a churn was used. The number of milking units and the parlour design were not associated with herd bulk tank SCC.

Approximately half of the farms surveyed in this study practiced some form of teat preparation (**Table 2**), but there was no association between teat preparation and SCS. However, lower (P<0.05) SCS was observed on farms that disinfected teats after every milking. Farmers that used a dry cow therapy programme had lower (P<0.01) bulk tank milk SCS (**Table 3**) as had the 49% of farms that milk recorded (P<0.001).

Cleanliness of the farm, housing and milking parlour were strongly associated (P<0.05) with lower herd SCS (**Tables 4, 5 and 6**). Bulk tank SCS was lower in herds with clean facilities and/or that cleaned the housing area more frequently; herds that bedded cows on paper or sawdust bedding had the lowest (P<0.001) SCS. There was no association between bulk tank SCC and hygiene of calving area or let-in and out date of the cows. Furthermore, the overall dirtiness score of the cow was not associated with SCS. **Tables 7, 8** and **9** summarise the factors from the summer, winter and combined questionnaires, respectively that were significantly associated with bulk tank SCS in the multiple regression models. The solutions for the different levels of the factors were similar to those estimated from the

**Table 1: Factors associated with milking process infrastructure on 398 Irish dairy farms, and associations with bulk tank SCS (back transformed SCC*10$^3$/ml in parentheses) after controlling for region**

| Variable | Level | % | SCS (SCC) | SE | P |
|---|---|---|---|---|---|
| Parlour design | Side by side | 45 | 12.49(266) | 0.024 | ns |
| | Herringbone | 48 | 12.56(285) | 0.023 | |
| | Abreast, stall, byre | 7 | 12.51(272) | 0.061 | |
| Number of milking units | ≤5 | 13 | 12.50(269) | 0.044 | ns |
| | 6 | 33 | 12.55(282) | 0.027 | |
| | 7 and 8 | 24 | 12.53(278) | 0.032 | |
| | 9 and 10 | 16 | 12.47(260) | 0.040 | |
| | 12 to 30 | 14 | 12.54(279) | 0.042 | |
| Pipeline system | Direct pipeline | 62 | 12.58(292) | 0.020 | *** |
| | Recorder plant | 38 | 12.43(250) | 0.027 | |
| Automatic cluster removers | Yes | 5 | 12.37(237) | 0.068 | * |
| | No | 95 | 12.53(278) | 0.016 | |
| Heated water in parlour | Yes | 40 | 12.45(255) | 0.025 | *** |
| | No | 60 | 12.58(290) | 0.020 | |
| Frequency liners change | ≤once a year | 64 | 12.52(274) | 0.020 | ns |
| | >than once a year | 36 | 12.53(278) | 0.027 | |
| Procedure to isolate milk from mastitic cows | Churn/milking bucket | 55 | 12.53(277) | 0.021 | ** |
| | Through the milk line | 16 | 12.63(307) | 0.038 | |
| | Dump line | 5 | 12.52(273) | 0.069 | |
| | Into the milking jar | 24 | 12.43(251) | 0.034 | |

ns (not significant), * P<0.05, **P<0.01, ***P<0.001
Somatic cell count (SCC), somatic cell score (SCS)

**Table 2: Factors associated with teat preparation on 398 Irish dairy farms, and associations with bulk tank SCS (back transformed SCC*10$^3$/ml in parentheses) after controlling for region**

| Variable | Level | % | SCS (SCC) | SE | P |
|---|---|---|---|---|---|
| Teat preparation spring | Wash only | 22 | 12.54 (279) | 0.034 | ns |
| | Wash and dry – paper towel | 5 | 12.52 (273) | 0.070 | |
| | Wash and dry– common cloth | 3 | 12.48 (263) | 0.087 | |
| | Dry wipe | 24 | 12.50 (267) | 0.032 | |
| | None | 46 | 12.54 (279) | 0.023 | |
| Summer | Wash only | 16 | 12.55 (283) | 0.039 | ns |
| | Wash and dry – paper towel | 2 | 12.34 (228) | 0.111 | |
| | Wash and dry – common cloth | 2 | 12.50 (268) | 0.104 | |
| | Dry wipe | 26 | 12.50 (270) | 0.031 | |
| | None | 54 | 12.53 (278) | 0.021 | |
| Winter | Wash only | 22 | 12.55 (282) | 0.033 | ns |
| | Wash and dry – paper towel | 7 | 12.53 (275) | 0.061 | |
| | Wash and dry – common cloth | 4 | 12.46 (257) | 0.076 | |
| | Dry wipe | 22 | 12.50 (269) | 0.034 | |
| | None | 45 | 12.53 (277) | 0.023 | |
| Disinfecting after milking | Never | 22 | 12.61 (298) | 0.033 | * |
| | Intermittently | 9 | 12.55 (281) | 0.052 | |
| | Every milking | 69 | 12.50 (267) | 0.019 | |
| Foremilking practiced | At each milking | 34 | 12.51 (270) | 0.027 | ns |
| | Once a day | 3 | 12.57 (288) | 0.089 | |
| | If filter/sock has cruds | 12 | 12.51 (272) | 0.046 | |
| | If SCC increases suddenly | 8 | 12.52 (272) | 0.055 | |
| | Other | 10 | 12.64 (308) | 0.051 | |
| | Never | 33 | 12.52 (273) | 0.027 | |

ns (not significant), * P<0.05, **P<0.01, ***P<0.001
Somatic cell count (SCC), somatic cell score (SCS)

**Table 3: Factors associated with herd management in summer on 398 Irish dairy farms, and associations with bulk tank SCS (back transformed SCC*103/ml in parentheses) after controlling for region**

| Variable | Level | % | SCS (SCC) | SE | P |
|---|---|---|---|---|---|
| Is milk recording practiced? | Yes | 49 | 12.46 (259) | 0.022 | *** |
| | No | 51 | 12.58 (292) | 0.022 | |
| Mastitis cows milked? | At start | 3 | 12.63 (305) | 0.098 | ns |
| | At end | 28 | 12.54 (280) | 0.030 | |
| | Anywhere in herd | 69 | 12.52 (273) | 0.019 | |
| Dry cow therapy applied? | Never and selected cows | 4 | 12.74 (342) | 0.083 | ** |
| | All cows | 96 | 12.52 (273) | 0.016 | |
| Gloves worn during milking? | Yes | 37 | 12.49 (266) | 0.026 | ns |
| | No | 63 | 12.54 (281) | 0.020 | |
| Tail management (tail hair clipping) | Cut > once a year | 48 | 12.51 (270) | 0.023 | ns |
| | Cut ≤once a year | 39 | 12.55 (283) | 0.025 | |
| | Ringed | 13 | 12.51 (271) | 0.043 | |

**ns (not significant), * P<0.05, **P<0.01, ***P<0.001**
**Somatic cell count (SCC), somatic cell score (SCS)**

analyses where the factors were individually included in the model. Cleanliness of the housing and milking parlour were factors that remained significant in all models as well as bedding type, the use of dry cow therapy and whether or not heated water was available in the milk parlour.

## DISCUSSION

Milk production, and thus milk quality, is of economic importance to Ireland and therefore herd management factors that are associated with milk quality need to be accurately quantified. Hence, the objective of this study was to quantify the association between herd management factors and bulk tank SCS. Because of the design of the study, it should be noted that the associations reported within do not imply cause and effect, and should not be interpreted as such. Nonetheless, this study provides an insight into the proportion of a random, but representative sample of Irish farmers that undertake different management practices as well as describing farm management practices associated with bulk tank SCS. Median SCC of the farms in the present study was 282,887 cells/ml, which is similar to the geometric mean of 250,937 cells/ml accounting for an annual increase of 5,000 cell/ml reported by Berry *et al.* (2006) for a large number of Irish dairy herds in 2004.

Rodrigues *et al.* (2005) documented that from the bulk tank milk samples taken on Wisconsin farms there was a small prevalence of contagious pathogens, and the type of facility was not associated with types of pathogens recovered. In contrast, Barkema *et al.* (1999) documented that there was a relationship between different pathogens and management practices. Backema *et al.* (1999) also reported that factors associated with bulk tank somatic cell count were related to the incidence rate of clinical mastitis caused by *S. aureus*. Also, Rodrigues *et al.* (2005) reported that many pathogens were identified from those farm bulk tank samples, while not to a single pathogen was identified from the bulk tank milk samples in the current study. Pitkälä *et al.* (2004) also identified many pathogens from milk samples of cows within confinement systems of either stanchion barns or loose housing. Barkema *et al.* (1999) showed that the incidence rate of *S. aureus* clinical mastitis was related to factors associated with bulk milk SCC. *S. aureus* cure rates are variable with a decrease in cure as SCC, duration of infection, number of quarters infected and age of the cow increase (Barkema *et al.* 2006).

### *Herd management*

The lower SCS observed in herds that practice milk recording is possibly due to increased farmer knowledge on individual cows and its importance as a factor associated with SCC was substantiated by its persistence in the multiple regression model. Hutton *et al.* (1990) also reported that farmers that were more aware of the mastitis status of the herd had lower SCC.

The beneficial association between the use of dry cow therapy and lower SCC is probably due to minimising the carry over effect of subclinical mastitis across lactations (MacMillan *et al.* 1983). Smith *et al.* (1985) also showed that dry cow therapy reduced the rate of streptococcal infections during the early dry period but had no effect during the prepartum period. Wenz *et al.* (2007) showed a trend between the use of dry cow therapy and low bulk tank SCC.

### *Teat preparation and hygiene*

In agreement with most previous studies (Barkema *et al.* 1998; Chassagne *et al.* 2005) clean farms, houses and milking parlours were strongly associated with lower SCS. The importance of cleanliness and hygiene was substantiated by these factors remaining in the multiple regression model. Nonetheless, no significant association was observed in the present study between cow cleanliness and SCS, which disagreed with Reneau *et al.* (2003) who reported lower SCC in cleaner cows in The Netherlands. Schreiner and Ruegg. (2003) also reported an increase in SCS and prevalence of intramammary environmental pathogens as udder hygiene score increased within a scale of one to four, four indicating dirty cows. The cleaner the roadway and holding yard; the less chance of dirt splashing on the cow's udder both before and after milking which may reduce the exposure of the teat ends to manure. Schreiner and Ruegg (2003) reported that the primary sources of exposure for environmental mastitis pathogens to the cow are the presence of moisture, mud, and manure. The more sanitised the machine, the fewer bacteria transmitted to the first line of cows from the last line of cows in the previous milking. This is increasingly important in herds with high milk SCC and mastitic cows at the end of milking. A higher frequency of passageway cleaning and cubicle cleaning and also specific bedding material types were associated with bulk tank SCC. In

**Table 4: Factors associated with the winter housing on 398 Irish dairy farms, and associations with bulk tank SCS (back transformed SCC*10$^3$/ml in parentheses) after controlling for region**

| Variable | Level | % | SCS (SCC) | SE | P |
|---|---|---|---|---|---|
| Cubicle bedding | Sawdust and other | 11 | 12.40 (244) | 0.049 | *** |
| | Shredded paper | 4 | 12.37 (236) | 0.082 | |
| | Straw | 4 | 12.55 (283) | 0.076 | |
| | Lime | 17 | 12.62 (301) | 0.038 | |
| | Mats and lime | 34 | 12.40 (242) | 0.027 | |
| | Mats | 19 | 12.51 (271) | 0.035 | |
| | None | 11 | 12.61 (301) | 0.049 | |
| Cubicles cleaned | Twice a day | 37 | 12.43 (250) | 0.027 | ** |
| | Once a day | 46 | 12.49 (265) | 0.023 | |
| | Every second day | 7 | 12.65 (313) | 0.063 | |
| | Weekly | 5 | 12.60 (297) | 0.073 | |
| | Never | 5 | 12.61 (299) | 0.070 | |
| How is the passage cleaned? | Mechanical scrapers | 55 | 12.46 (257) | 0.022 | *** |
| | Tractor | 23 | 12.59 (294) | 0.033 | |
| | Hand scraper | 6 | 12.57 (288) | 0.069 | |
| | Slats | 11 | 12.49 (265) | 0.050 | |
| | Mixture | 5 | 12.31 (221) | 0.068 | |
| How often is the passage cleaned? | Twice a day | 16 | 12.51 (271) | 0.043 | *** |
| | Once a day | 24 | 12.61 (301) | 0.035 | |
| | Every 1/2 hrs | 11 | 12.44 (253) | 0.051 | |
| | Every 3/4 hrs | 32 | 12.39 (240) | 0.030 | |
| | Every 5/7 hrs | 12 | 12.49 (267) | 0.048 | |
| | Twice a week | 4 | 12.62 (303) | 0.088 | |
| | Never | 1 | 12.69 (324) | 0.176 | |
| Calving area | Calving box | 85 | 12.48 (264) | 0.018 | ns |
| | Cubicles house | 4 | 12.55 (283) | 0.084 | |
| | Paddock | 4 | 12.60 (307) | 0.084 | |
| | Stalls | 3 | 12.53 (269) | 0.091 | |
| | Other | 4 | 12.45 (256) | 0.076 | |
| How often is the calving area cleaned? | Daily | 23 | 12.43 (251) | 0.034 | *** |
| | Twice a week | 17 | 12.63 (305) | 0.039 | |
| | Weekly | 11 | 12.38 (237) | 0.047 | |
| | Three times a season | 15 | 12.45 (256) | 0.041 | |
| | Twice a season | 24 | 12.48 (264) | 0.032 | |
| | End of season | 10 | 12.53 (276) | 0.050 | |

**ns (not significant), * P<0.05, **P<0.01, ***P<0.001**
**Somatic cell count (SCC), somatic cell score (SCS)**

**Table 5: Factors associated with parlour and roadway hygiene on 398 Irish dairy farms, and associations with bulk tank SCS (back transformed SCC*10$^3$/ml in parentheses) after controlling for region**

| Variable | Level | % | SCS (SCC) | SE | P |
|---|---|---|---|---|---|
| Cleanliness of the parlour | Clean | 43 | 12.45 (255) | 0.024 | *** |
| | Slightly dirty | 48 | 12.57 (288) | 0.023 | |
| | Dirty | 9 | 12.60 (297) | 0.054 | |
| Cleanliness of claw piece | Clean | 42 | 12.45 (256) | 0.024 | *** |
| | Slightly dirty | 45 | 12.55 (282) | 0.024 | |
| | Dirty | 13 | 12.67 (317) | 0.043 | |
| Condition of the liners | New | 81 | 12.58 (269) | 0.018 | ** |
| | Slightly cracked | 12 | 12.69 (291) | 0.048 | |
| | Cracked | 7 | 12.47 (324) | 0.062 | |
| Collecting yard cleaning frequency | After every milking | 17 | 12.44 (253) | 0.038 | * |
| | Daily | 37 | 12.50 (267) | 0.026 | |
| | Weekly | 15 | 12.57 (289) | 0.041 | |
| | Every second day | 13 | 12.55 (283) | 0.044 | |
| | Every third day | 6 | 12.56 (285) | 0.063 | |
| | Slates | 6 | 12.58 (291) | 0.063 | |
| | As required and other | 6 | 12.66 (313) | 0.064 | |
| Cleanliness of yard | Clean | 26 | 12.47 (261) | 0.032 | * |
| | Slightly dirty | 43 | 12.53 (278) | 0.025 | |
| | Dirty | 31 | 12.58 (292) | 0.031 | |
| Cleanliness of road | Clean | 25 | 12.50 (269) | 0.031 | ** |
| | Slightly dirty | 51 | 12.49 (265) | 0.022 | |
| | Dirty | 24 | 12.62 (302) | 0.038 | |
| Condition of road way | Very good | 17 | 12.49 (265) | 0.038 | ns |
| | Good | 59 | 12.51 (272) | 0.021 | |
| | Poor | 24 | 12.56 (286) | 0.032 | |

**ns (not significant), * P<0.05, **P<0.01, ***P<0.001**
**Somatic cell count (SCC), somatic cell score (SCS)**

agreement, Chassagne *et al*. (2005) showed that cleaner dry cow sheds were observed more frequently in the lower SCC category. Also, Barkema *et al*. (1998) reported that the cleanliness of cubicles and a greater frequency of cubicle cleaning were associated with lower bulk milk SCC. Wenz *et al*. (2007) documented that both the bedding material and the housing facility for cows were associated with bulk tank SCC.

Teat preparation is well researched for its association with SCC and intramammary infection rate but the results differ slightly, with the current study finding no association between pre-milking teat preparation and SCS, which is in agreement with Hutton *et al*. (1990) who reported that there was no significant difference in numbers of herds using teat preparations in the study between high and low SCC groups. However, in contrast it has also been shown that the utilisation of pre-milking teat preparation compared with no teat preparation is significantly associated with lower bulk tank SCC (Goodger *et al*. 1993), reduced presence of bacteria (Pankey 1989) and reduced incidence of new intramammary infections (Galton *et al*. 1988, Neave *et al*. 1969). Goldberg *et al*. (1992) concluded that insufficient hygiene prior to milking may repress the effect of improved management practices. The difference in results between the current study and previous studies may be due to cows in the present study being milked while at pasture and therefore being less dirty and under less pathogenic load, with the subsequent effect of reducing any potential benefits of teat preparation as may be observed in confined cows. Barkema *et al*. (1998) found the use of teat disinfection to have a reducing effect on bulk milk SCC and Chassagne *et al*. (2005) showed that teat spraying was more predominant in the low SCC group, both of which support the current study.

**Table 6: Factors associated with cow housing and degree of cow hygiene on 398 Irish dairy farms, and associations with bulk tank SCS (back transformed SCC*10³/ml in parentheses) after controlling for region**

| Variable | Level | % | SCS (SCC) | SE | P |
|---|---|---|---|---|---|
| Cleanliness of loafing area | Clean | 43 | 12.46 (267) | 0.024 | ** |
| | Slightly dirty | 43 | 12.48 (268) | 0.024 | |
| | Dirty | 14 | 12.64 (312) | 0.041 | |
| Condition of cubicle shed | Very good | 9 | 12.46 (257) | 0.054 | ** |
| | Good | 85 | 12.47 (262) | 0.018 | |
| | Poor | 6 | 12.68 (322) | 0.067 | |
| Cleanliness of cubicles | Clean | 56 | 12.43 (249) | 0.021 | *** |
| | Slightly dirty | 35 | 12.54 (281) | 0.027 | |
| | Dirty | 9 | 12.66 (315) | 0.053 | |
| Total dirt score of the cow (worst score 120) | <40 | 19 | 12.49 (269) | 0.037 | ns |
| | <60 | 65 | 12.47 (270) | 0.019 | |
| | ≥60 | 16 | 12.58 (296) | 0.039 | |

ns (not significant), * P<0.05, **P<0.01, ***P<0.001
Somatic cell count (SCC), somatic cell score (SCS)

**Table 7: Factors associated with bulk tank somatic cell score on 398 Irish dairy farms during summer, based on a multiple regression model**

| Variable | Level | SCS (SCC) | SE | P |
|---|---|---|---|---|
| The pipeline system | Direct pipeline | 12.65 (313) | 0.044 | *** |
| | Recorder plant | 12.53 (277) | 0.049 | |
| Heated water in the pit | Yes | 12.54 (279) | 0.046 | *** |
| | No | 12.64 (310) | 0.045 | |
| Cleanliness of parlour | Clean | 12.53 (276) | 0.047 | ** |
| | Slightly dirty | 12.63 (307) | 0.047 | |
| | Dirty | 12.61 (300) | 0.061 | |
| Use of dry cow therapy | Never | 12.69 (324) | 0.082 | * |
| | All cows | 12.49 (267) | 0.022 | |
| Is milk recording practiced? | Yes | 12.56 (285) | 0.047 | * |
| | No | 12.62 (304) | 0.045 | |

ns (not significant), * P<0.05, **P<0.01, ***P<0.001
Somatic cell count (SCC), somatic cell score (SCS)

### *Milking parlour*

This study showed a difference between recorder plants and direct pipelines with regard to SCS, the explanation of which requires additional information on the parlour design, as it is unknown if the vacuum was affected or the milk line height was different on these farms. The farms with automatic cluster removers had lower SCS, potentially due to consistent cluster removal at a specific milk yield and less chance of over milking. Natzke *et al*. (1982) showed that the increase in new infections from over milking is due to an increase in the number of quarters infected in an already infected cow rather than the number of newly infected cows increasing. Hutton *et al*. (1990) reported that cluster removers were less frequent on high SCC herds than low SCC herds. Wenz *et al*. (2007) also documented that the use of automatic cluster removers was associated with lower bulk

**Table 8: Factors associated with bulk tank somatic cell score on 398 Irish dairy farms during winter, based on a multiple regression model**

| Variable | Level | SCS (SCC) | SE | P |
|---|---|---|---|---|
| Cleanliness of cubicles | Clean | 12.43 (251) | 0.041 | * |
| | Slightly dirty | 12.51 (272) | 0.047 | |
| | Dirty | 12.58 (292) | 0.058 | |
| Cubicle bedding of cows | Sawdust and other | 12.47 (260) | 0.064 | ** |
| | Shredded paper | 12.36 (234) | 0.090 | |
| | Straw | 12.55 (281) | 0.084 | |
| | Lime | 12.61 (302) | 0.050 | |
| | Mats | 12.53 (276) | 0.051 | |
| | Mats and lime | 12.45 (255) | 0.047 | |
| | None | 12.60 (295) | 0.057 | |
| How often is the calving area cleaned? | Daily | 12.42 (249) | 0.048 | ** |
| | Twice a week | 12.64 (308) | 0.051 | |
| | Weekly | 12.45 (256) | 0.059 | |
| | Three times a season | 12.50 (267) | 0.054 | |
| | Twice a season | 12.50 (270) | 0.050 | |
| | End of season | 12.54 (280) | 0.062 | |
| How often is the passage cleaned | Twice a day | 12.58 (290) | 0.047 | * |
| | Once a day | 12.61 (299) | 0.037 | |
| | Every 1-2 hrs | 12.52 (274) | 0.055 | |
| | Every 3-4 hrs | 12.46 (257) | 0.039 | |
| | Every 5-7 hrs | 12.50 (268) | 0.052 | |
| | Twice a week | 12.45 (254) | 0.108 | |
| | Never | 12.46 (258) | 0.205 | |

ns (not significant), * P<0.05, **P<0.01, ***P<0.001
Somatic cell count (SCC), somatic cell score (SCS)

**Table 9: Factors associated with bulk tank somatic cell score on 398 Irish dairy farms during summer and winter, based on a multiple regression model**

| Variable | Level | SCS (SCC) | SE | P |
|---|---|---|---|---|
| Cubicle bedding of cows | Sawdust and other | 12.51 (270) | 0.062 | *** |
| | Shredded paper | 12.47 (260) | 0.082 | |
| | Straw | 12.57 (288) | 0.086 | |
| | Lime | 12.71 (330) | 0.057 | |
| | Mats | 12.62 (303) | 0.054 | |
| | Mats and lime | 12.55 (282) | 0.048 | |
| | None | 12.71 (331) | 0.060 | |
| The pipeline system | Direct pipeline | 12.65 (313) | 0.044 | *** |
| | Recorder plant | 12.53 (276) | 0.049 | |
| Heated water in the pit | Yes | 12.54 (280) | 0.047 | ** |
| | No | 12.64 (308) | 0.045 | |
| Use of dry cow therapy | Never | 12.72 (335) | 0.082 | ** |
| | All cows | 12.46 (258) | 0.025 | |
| Cleanliness of the parlour | Clean | 12.56 (284) | 0.048 | * |
| | Slightly dirty | 12.64 (310) | 0.048 | |
| | Dirty | 12.57 (288) | 0.061 | |

ns (not significant), * P<0.05, **P<0.01, ***P<0.001
Somatic cell count (SCC), somatic cell score (SCS)

tank SCC. In agreement with the present study, Hutton *et al.* (1990) also reported that milking clinically infected cows last was more common in low SCC herds.

## CONCLUSIONS

This study described the facilities and work practices of a representative sample of Irish dairy farms. It also indicated different management practices and farm infrastructure associated with milk SCS. Some of the management practices associated with low SCS included the use of dry cow therapy, participation in a milk recording scheme, and the use of teat disinfection post-milking. An association between low milk SCS and an increased level of hygiene and frequency of cleaning of the holding yard, passageways and cubicles was also observed. Additionally, when a regression model was used on the data, the cumulative effect of best practices, such as use of dry cow therapy on all cows, having a clean parlour, heated water in the parlour, a recorder jar pipeline milking system and shredded paper for bedding cows, was calculated as 246,984 cells/ml, i.e., milk SCC was lower by 246,984 cells/ml when these best practises were in place compared to the poorest alternative in each case.


## ACKNOWLEDGEMENTS

The participating milk processor and farmers are gratefully acknowledged for their contribution to this study and without whom this study would not have been possible.


## REFERENCES


Barbano DM, Rasmussen RR and Lynch JM (1991) Influence of milk somatic cell count and milk age on cheese yield. Journal of Dairy Science 74, 369-388.

Barbano DM, Ma Y and Santos MV (2006) Influence of raw milk quality on fluid milk shelf life. Journal of Dairy Science 89, E15-19E.

Barkema HW, Schukken YH, Lam TJGM et al. (1998) Management practices associated with low, medium, and high somatic cell counts in bulk milk. Journal of Dairy Science 81, 1917-1927.

Barkema HW, Schukken YH, Lam TJGM et al. (1999) Management practices associated with the incidence rate of clinical mastitis. Journal of Dairy Science 82, 1643-1654.

Barkema HW, Schukken YH and Zadoks RN (2006) Invited review: The role of cow, pathogen, and treatment regimen in the therapeutic success of bovine *Staphylococcus aureus* mastitis. Journal of Dairy Science 89, 1877-1895.

Berry DP, O'Brien B, O'Callaghan EJ et al. (2006) Temporal trends in bulk tank somatic cell count and total bacterial count in Irish dairy herds during the past decade. Journal of Dairy Science 89, 4083-4093.

Chassagne M, Barnouin J and Le Guenic M (2005) Expert assessment study of milking and hygiene practices characterising very low somatic cell score herds in France. Journal of Dairy Science 88, 1909-1916.

CSO [Central Statistics Office] (2008) Statistical Product-Agriculture Milk Production. Agriculture Releases. Central Statistics Office. Cork. [Online] Available from: www.cso.ie/px/pxeirestat/database/eirestat/Agriculture%20Milk%20Production/Agriculture%20Milk%20Production.asp [Accessed 1 December 2008].

European Economic Community (1992) Council Directive 92/46/EEC. Commission Document 39L0046. June 1992. EEC, Brussels, Belgium.

Galton DM, Peterson LG and Merrill WG (1988) Evaluation of udder preparations on intramammary infections. Journal of Dairy Science 71, 1417-1421.

Goldberg JJ, Wildman EE, Pankey JW et al. (1992) The influence of intensively managed rotational grazing, traditional continuous grazing, and confinement housing on bulk tank milk quality and udder health. Journal of Dairy Science 75, 96-104.

Goodger WJ, Farver T, Pelletier J et al. (1993) The association of milking management practices with bulk tank somatic cell counts. Preventive Veterinary Medicine 15, 235–251.

Hutton CT, Fox LK and Hancock DD (1990) Mastitis control practices: differences between herds with high and low milk somatic cell counts. Journal of Dairy Science 73, 1135-1143.

Kiiman H, Pärna E and Kaart T (2006) Factors affecting milk somatic cell count. Proceedings of 8th World Congress on Genetics Applied to Liverstock Production, August 13-18, 2006, Belo Horizonte, MG, Brasil.

Klei L, Yun J, Sapru A et al. (1998) Effects of milk somatic cell count on cottage cheese yield and quality. Journal of Dairy Science 81, 1205-1213.

Macmillan KL, Duirs GF and Duganzich DM (1983) Associations between dry cow therapy, clinical mastitis, and somatic cell count score with milk and fat production in ten New Zealand dairy herds. Journal of Dairy Science 66, 259–65.

Natzke RP, Everett RW and Bray DR (1982) Effect of overmilking on udder health. Journal of Dairy Science 65, 117-125.

Neave FK, Dodd FH, Kingwill RG et al. (1969). Symposium: mastitis control: control of mastitis in the dairy herd by hygiene and management. Journal of Dairy Science 52, 696-707.

Pankey JW (1989) Premilking udder hygiene. Journal of Dairy Science 72, 1308-1312.

Pitkälä A, Haveri M, Pyörälä S et al. (2004) Bovine Mastitis in Finland 2001 –Prevalence, Distribution of Bacteria, and Antimicrobial Resistance. Journal of Dairy Science 87, 2433-2441.

Reneau JK, Seykora AJ, Heins BJ et al. (2003) Relationship of cow hygiene scores and SCC. Proc. Natl. Coun., Madison, WI. pp 362-363.

Rodrigues ACO, Caraviello DZ and Ruegg PL (2005) Management of Wisconsin dairy herds enrolled in milk quality teams. Journal of Dairy Science 88, 2660-2671.

Schreiner DA, Ruegg PL (2003) Relationship between udder and leg hygiene scores and subclinical mastitis. Journal of Dairy Science 86, 3460-3465.

Smith KL, Todhunter DA and Schoenberger PS (1985) Environmental mastitis: cause, prevalence, prevention. Journal of Dairy Science 68, 1531-1553.

Wenz JR, Jensen SM, Lombard JE et al. (2007) Herd management practices and their association with bulk tank somatic cell count on United States dairy operations. Journal of Dairy Science 90, 3652-3659.