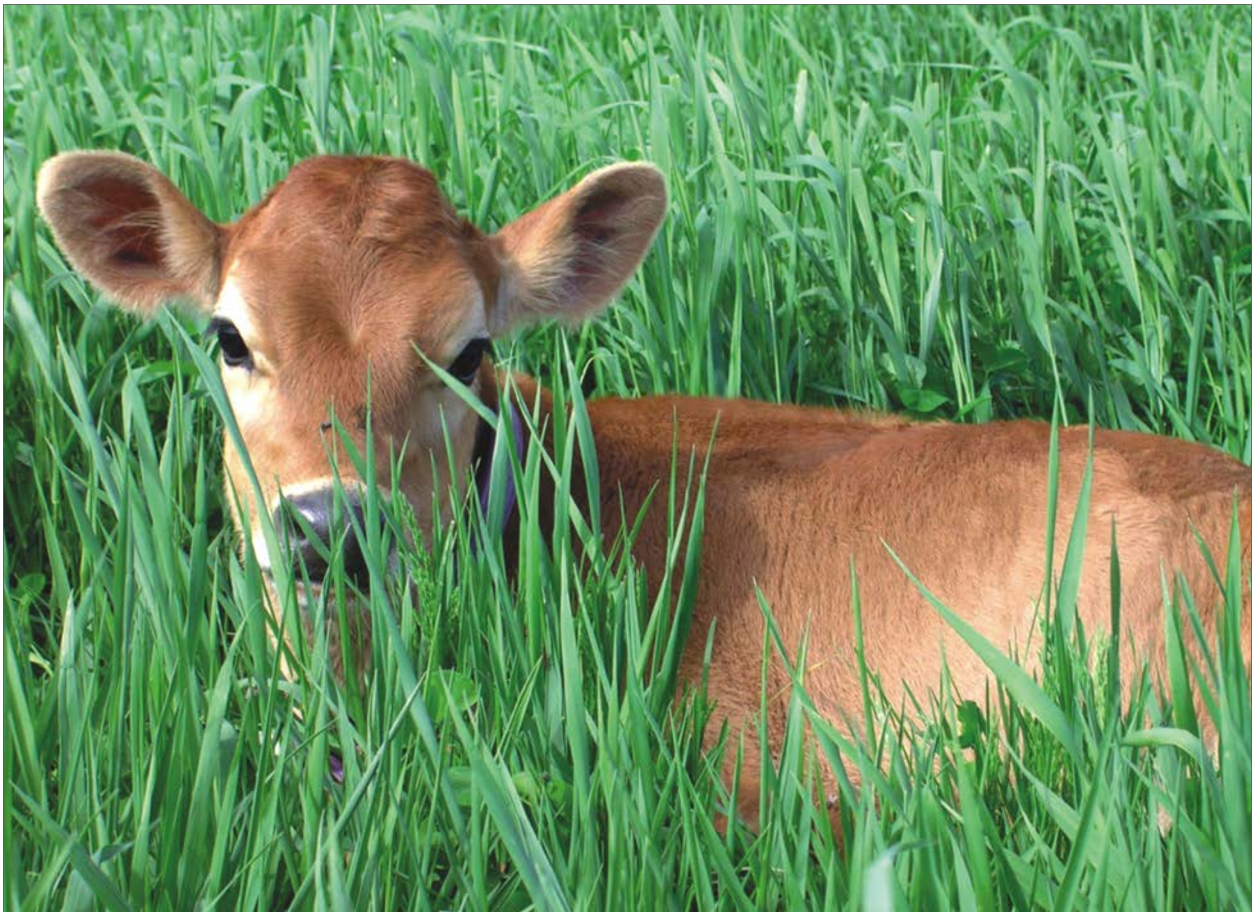

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Factors Affecting Test-Day Somatic Cell Counts and Milk Yield of Dairy Cows

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Abstract: This study evaluates the correlations between the management practices, Somatic Cell Counts (SCC) and milk yield in dairy farms of Thuringia, Germany. Milk performance data were collected from the national milk-recording database (VIT), Verden. Determination of the somatic cells was done at the milk laboratory of the TVL-Thuringia by means of Fossomatic device (Fossomatic-5000®, Fa. Foss. Electric., Denmark). Lactation records of 10742 dairy cows were included. Traits studied were test-day milk yield and SCC (log) with respect to health status of the udder. Results indicated that test-day milk yield as well as SCC was higher in multiparous cows and lower in primiparous cows. Somatic Cell Counts (SCC) was lower early in the lactation (4.85) and increased thereafter to reach 4.96 in the late stage of lactation. Daily milk yield reached the peak in the early stage of lactation (28.41 kg) and was lower in the late stage of lactation (19.52 kg). The study also found that test-day milk yield and SCC (log) were significantly ($p<0.001$) affected by season of the year, housing and milking systems. Hygienic measures practiced in the studied farms were found to be affecting the mean test-day milk yield and SCC (log) significantly.

Key words: Mastitis, management factors, SCC, test-day milk yield, hygienic measures

INTRODUCTION

Mastitis, a disease leads to tremendous reduction in milk yield, increase in number of clinical treatments and early cow culling rate (Shook, 1989; Gill *et al*., 1990; Beaudeau *et al*., 1993; Lescourret and Coulon, 1994; Schukken *et al*., 1997). Cerón-Muñoz *et al.* (2002) stated that mastitis occurs as a response to invasive agents, can be characterized by an increase in SCC or logarithmic transformation in Somatic Cell Score (SCS). It has been claimed earlier that SCC higher than 283×10^3 cells mL^{-1} indicate the presence of mastitis (Guidry, 1985; Reneau, 1986). Bartlett *et al.* (1990) stated that the established association between milk production and SCC in dairy cattle is increasingly used to estimate the loss of production due to mastitis. Important management decisions regarding the effective cost of prevention and control of mastitis are based on this relationship. Jones (1986) found that SCC of 0.6×10^6-1×10^6 cells mL^{-1} were associated with 8-12% reduction in herd milk production. The estimated correlation between SCC and total production of milk was ranged between -0.15 to -0.01 (Welper and Freeman, 1992). De Graaf and Dwinger (1996) estimated the crude milk production losses per cow with sub-clinical mastitis as 1.56 kg day^{-1} whereas the milk production loss per quarter affected with sub-clinical mastitis was estimated to 17.6% on an average. Shook and Schultz (1994)

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and Rupp and Boichard (1999) indicated that the lactation average SCC does not use all the information and mask short-term variation in SCS and the SCC in uninfected cows is high at freshening, lowest from peak to mid-lactation and highest at drying off. Milk yield and SCC were found to be significantly affected by season in the study of Corbett (1998), Kelly *et al.* (2000) and Rodriguez *et al.* (2000). Several studies revealed a significant effect of lactation number and stage of lactation on the level of milk yield and milk SCC (Seker *et al.*, 2000; Kiiman and Savlei, 2000; Godollo and Tanszek, 2000; Haile-Mariam *et al.*, 2001). However, a decrease in bulk milk SCC is an indicator of the success of management and hygienic control program (Suriyasathaporn *et al.*, 2000). Thus, a high somatic cell count means a loss of milk production, hence, a loss of revenue.

The ultimate objective of the present study was to investigate the influence of some management and hygienic factors on the test-day milk SCC and its relations with the production of milk in dairy cows.

MATERIALS AND METHODS

The studied Farms structure, description and general management practices were previously described (Fadlelmoula, 2002). Recorded test-day milk yield and SCC of 10742 dairy cows calving between June 1998 and April 2000 were utilized in the study in addition to farm number, animal herd-book number, sire herd-book number, dam herd-book number, date of calving and lactation number. A questionnaire for the collection of management data was prepared which include origin of the cow, housing system, milking system, udder cleaning methods, inter-milking sanitation of the milking units and post-milking teat dipping. Performance and questionnaire data were merged into one data set by means of a statistical program using the SAS package (SAS, 1996). To achieve the normal distribution of SCC, it was transformed into logarithmic form. Analysis of the factors affecting SCC (log) and test-day milk yield were performed using the procedure MIXED of SAS on the basis of Restricted Maximum Likelihood method (REML). This procedure included both fixed and random effects of the studied factors in accordance with the following regression model.

$$Y_{ijkmno} = \mu + Lacn_i + Lacs_j + Yeas_k + Mang_m + Anim_n + e_{ijkmno}$$

Where:

Y_{ijkmno} = Mean test-day milk yield or SCC (log) of nth animal

μ = Over all mean

$Lacn_i$ = Fixed effect of the i^{th} lactation number

$Lacs_j$ = Fixed effect of the j^{th} stage of lactation

$Yeas_k$ = Fixed effect of the k^{th} season of the year

$Mang_m$ = Fixed effect of the m^{th} management and hygienic factors

$Anim_n$ = Random effect of n^{th} animal

e_{ijkmno} = Residual effect

m = Housing system, milking system, udder cleaning methods, inter-milking sanitation of the milking units and post-milking teat dipping

Means were tested for significance with the aid of F-test.

RESULTS AND DISCUSSION

Several factors were found to be affecting the dairy cow udder health, the frequency of the causing pathogen and infection rate, which would be reflected in an increased SCC. However, high milk yield

Table 1: Arithmetic means, SD and CV of test day SCC and milk yield

Trait	n	Mean±SD	CV (%)
SCC ($\times 10^3$)/test day	7829	317.00±231	73.03
SCC (log)	7829	5.39±0.30	11.97
Milk yield/test day	9496	23.82±7.16	34.26

Table 2: LS-means and SE of SCC (log) and test-day milk yield as influenced by lactation number ($p<0.001$)

Lactation No.	SCC (log)	Test-day milk yield
First	4.48±0.02	21.12±0.14
Second	4.79±0.03	24.33±0.16
Third	5.04±0.03	25.70±0.17
>Third	5.27±0.03	25.80±0.20

Table 3: LS-means and SE of SCC (log) and test-day milk yield as influenced by stage of lactation ($p<0.001$)

Stage of lactation	SCC (log)	Test-day milk yield
Early	4.85±0.02	28.41±0.14
Middle	4.87±0.03	24.79±0.15
Late	4.96±0.03	19.52±0.18

Table 4: LS-means and SE of SCC (log) and test-day milk yield as influenced by season of year ($p<0.001$)

Season of year	SCC (log)	Test-day milk yield
Summer	5.73±0.04	23.22±0.08
Autumn	5.11±0.04	23.73±0.12
Winter	3.85±0.03	23.78±0.15
Spring	3.22±0.02	24.52±0.18

is claimed to be a predisposing factor to intra-mammary infection. The arithmetical mean (±SD) of test-day SCC (absolute and logarithmic) and milk yield were $317\times10^3\pm231$ cells mL^{-1}, 5.39±0.30 and 23.82±7.16 kg, respectively (Table 1). The mean value was high compared to that obtained by Cerón-Muñoz *et al.* (2002). But lower than the result of Dang and Anand (2007). SCC values lower than 283×10^3 cells mL^{-1} do not reflect the health of the udder, but rather are associated with milk yield (Guidry, 1985; Hortet *et al.*, 1999; Dang and Singh, 2006).

Results in Table 2 showed the significant ($p<0.001$) effect of lactation number on SCC and milk yield. Which were found to increase in an increasing rate as the age of the cow advances that indicate the increase of the chance of the cow to be susceptible to intra-mammary infection. Closely Similar findings were reported by Labohm *et al.* (1998), Koldeweij *et al.* (1999) and Kiiman and Savlei (2000). However, different results for milk yield were stated by Hortet and Seegers (1998) and Hortet *et al.* (1999).

Within lactation SCC and milk yield were found to be significantly ($p<0.001$) inversely related (Table 3). As lactation advances, the level of SCC increases and consequently decreases the daily milk yield. With two folds increase in SCC, there was more than 3.5 kg decrease in milk yield. Comparable results were published by Kelly *et al.* (2000), Rupp *et al.* (2000), Haile-Mariam *et al.* (2001) and Juozaitiene *et al.* (2004).

Season of year was significantly ($p<0.001$) affecting the level of test-day SCC and milk yield (Table 4). Close to the result of Corbett (1998) and Rodriguez *et al.* (2000). However different finding was that of Liebe *et al.* (1996). SCC was high in summer and autumn and lower in winter and spring, the difference was highly significant ($p<0.001$) as shown in Table 4. The daily milk yield showed the reverse trend of SCC. Similar findings were reported by Rhone *et al.* (2007).

Data in Table 5 showed a high significant ($p<0.001$) variation of SCC and milk yield in the cows housed in different barns. Loose housing with slat floor reduced the LS-mean SCC to a lower level (4.77); however, barns other than loose housing elevated the LS-mean SCC to a higher level (5.05). But not very high than the level obtained in with plan floor loose housing system (4.95). Test-day milk yield showed the reverse trend to SCC. This result could be attributed to bedding type and condition,

Table 5: LS-means and SE of SCC (log) and test-day milk yield as influenced by housing system (p<0.001)

Housing system	SCC (log)	Test-day milk yield
Loose housing with slat floor	4.77±0.02	23.16±0.08
Loose housing with plan floor	4.95±0.02	23.21±0.10
Other	5.05±0.04	21.76±0.23

Table 6: LS-means and SE of SCC (log) and test-day milk yield as influenced by milking system (p<0.001)

Milking system	SCC (log)	Test-day milk yield
Pipe system	4.84±0.08	19.84±0.46
Carrousel	4.89±0.02	24.49±0.10
Milking parlor	4.93±0.01	22.98±0.07

Table 7: LS-means and SE of SCC (log) and test-day milk yield as influenced by method of udder cleaning (p<0.001)

Method of udder cleaning	SCC (log)	Test-day milk yield
Moist	5.10±0.02	22.67±0.07
Dry	4.80±0.02	24.87±0.09

Table 8: LS-means and SE of SCC (log) and test-day milk yield as influenced by inter-milking sanitation of the milking units (p<0.001)

Inter-milking sanitation	SCC (log)	Test-day milk yield
Used	4.75±0.04	25.55±0.14
Not used	5.11±0.02	23.06±0.21

Table 9: LS-means and SE of SCC (log) and test-day milk yield as influenced by post-milking teat dipping (p<0.001)

Post-milking teat dipping	SCC (log)	Test-day milk yield
Yes	4.88±0.01	25.04±0.14
No	5.08±0.02	23.18±0.06

in agree with Wicks and Leaver (2003). However, different implication was presented earlier by Smith and Ely (1997) who reported that free-stall bedding did not significantly affect milk quality, with no difference in linear SCS among the herds studied. As indicated before, milk yield decrease as the level of SCC increased. It was agreed that the implementation of mastitis control programs were the most suitable means of lowering the SCC level and resulted in an optimum performance. A similar finding was reported by Gröhn (2000).

The milking techniques that were implemented in farms investigated exerted a significant ($p<0.001$) variation on the mean logarithmic SCC and milk yield (Table 6). High LS-mean SCC and low milk yield were obtained for milking parlor than for carrousel and pipe system. Whereas, the use of the carrousel unit was found to be effective in reducing the mean SCC and increased daily milk yield compared to the other milking units. And that could be attributed to the methods used for cleaning and disinfections of this unit. The pipe systems controls great number of the environmental pathogens and resulted in a low mean SCC than in other systems. This variation could be of management nature. A recent study specified that milking equipment was not statistically significant to the milk SCC (Kiiman, 2001). However, consistent findings were reported by Geishauser *et al.* (1999) and Mazzucchelli *et al.* (2000). Table 7 revealed that udder cleaning before milking found to have a significant ($p<0.001$) effect on SCC and milk yield. Indicating that udder preparation involving washing was associated with higher SCC. The result also pointed out that the use of dry means of udder cleaning was approved well than moist cleaning methods. This outcome result is supported by Boddie *et al.* (1993), Radostits *et al.* (1994), Yalcin *et al.* (1999), Malinowski (2000), Vorst *et al.* (2003) and Tangorra *et al.* (2004).

Of the hygienic measures studied is the inter-milking sanitation of the milking units and post milking teat dipping. Which explored a highly significant ($p<0.001$) variations in mean SCC and daily milk yield (Table 8, 9, respectively). LS-mean SCC was pronounced in farms practicing no inter-milking sanitation and teat dipping (5.11 and 5.08, respectively) and daily milk yield was lower (23.06 and 23.18 kg, respectively) compared to those using inter-milking sanitization and post milking teat dipping (4.75 and 4.88, respectively) with a high daily milk yield (25.55 and 25.04 kg, respectively). This could be a reflection of the reduction of the pathogens by the act of the sanitizer preparations. Nonetheless and due to the effect of intra-mammary infection causing pathogens and nonspecific pathogens, LS-mean SCC was significantly varied. Different studies handled this task of which Barkema *et al.* (1998) who reported about post-milking teat disinfections as an important factors for the prevention of high bulk milk SCC like Natzke (1981), Pankey (1989), Boddie *et al.* (1993), Radostits *et al.* (1994), Malinowski (2000), Oliver *et al.* (2001) and Saloniemi and Kulkas (2001). They concluded that inter milking sanitation and teat dipping is aimed at reducing infections mainly caused by contagious pathogens and preventing new infections and to a less extent preventing infections might be caused by environmental pathogens.

CONCLUSION

The study concluded that proper management strategy is most important to reduce the new intra-mammary infection rate in dairy cows and to maintain a low level of SCC and hence high milk yield. This practice, along with use of proper milking technique, adequately functioning milking equipment, dry cow therapy, prompt antibiotic treatment of clinical cases and culling of chronically infected cows will help keep SCC at allowable limit.

REFERENCES

Barkema, H.W., Y.H. Schukken, T.J.G.M. Lam, M.L. Beiboer, G. Benedictus and A. Brand, 1998. Management practices associated with low, mid and high bulk milk somatic cell count. J. Dairy Sci., 81 (7): 1917-1927.

Bartlett, P.C., G.Y. Miller, C.R. Anderson and J.H. Kirk, 1990. Milk production and somatic cell count in Michigan Dairy Herds. J. Dairy Sci., 73 (10): 2794-2800.

Beaudeau, F., A. Henken, C. Fourichon, K. Frankena and H. Seegers, 1993. Associations between health disorders and culling of dairy cows: A review. Livest. Prod. Sci., 35: 213-236.

Boddie, R.L., S.C. Nickerson and R.W. Adkinson, 1993. Evaluation of teat germicides of low iodine concentration for prevention of bovine mastitis by *S. aureus* and *St. agalactiae*. Prev. Vet. Med., 16: 111-117.

Cerón-Muñoz, M., H. Tonhati, J. Duarte, J. Oliveira, M. Muñoz-Berrocal and H. Jurado-Gámez, 2002. Factors affecting somatic cell counts and their relations with milk and milk constituent yield in buffaloes. J. Dairy Sci., 85 (11): 2885-2889.

Corbett, R.B., 1998. The use of somatic cell counts in mastitis management. Proc. 37th Annu. Mtg., Natl. Mastitis Counc., National Mastitis Council, Inc., Madison, WI, pp: 51-55.

Dang, A.K. and M. Singh, 2006. Udder the most important asset of dairy industry, its care and management. Indian Dairyman, 58 (8): 57-63.

Dang, A.K. and S.K. Anand, 2007. Effect of milking systems on the milk somatic cell counts and composition. Livestock Research for Rural Development, 19 (6): http://www.cipav.org.co/lrrd/lrrd19/6/dang19074.htm.

De Graaf, T. and R.H. Dwinger, 1996. Estimation of milk production losses due to sub-clinical mastitis in dairy cattle in Costa Rica. Prev. Vet. Med., 26 (3-4): 215-222.

Fadlelmoula, A.A., 2002. Investigations of factors affecting the udder health status of dairy cows in Thuringia. Dissertation, Martin-Luther University, Halle-Wittenberg. http://deposit.ddb.de/cgi-bin/dokserv?idn=96731819x&dok_var=d1&dok_ext=pdf&filename=96731819x.pdf.

Geishauser, T., K. Querengasser, M. Nitschke and A. Sorbiraj, 1999. Milk yield, somatic cell counts and risk of removal from the herd for dairy cows after covered teat canal injury. J. Dairy Sci., 82 (7): 1482-1488.

Gill, R., W. Howard, K. Leslie and K. Lissemore, 1990. Economics of mastitis control. J. Dairy Sci., 73 (11): 3340-3348.

Godollo, S.I.E. and S.J. Tanszek, 2000. Factors influencing somatic cell count in milk. 2-physiological and environmental factors. Tejgazdasag, 60: 16-25.

Gröhn, Y.T., 2000. Milk yield and disease: Towards optimizing dairy health and management decisions. Bovine-Practitioner, 34 (1): 32-40.

Guidry, A.J., 1985. Mastitis and the Immune System of the Mammary Gland. In: The Iowa State University Press, Lactation, B.L. and Larson (Ed.). Ames, IA., pp: 262-299.

Haile-Mariam, M., P.J. Bowman and M.E. Goddard, 2001. Genetic and environmental correlations between test-day somatic cell count and milk yield traits. Lives. Prod. Sci., 73: 1-13.

Hortet, P. and H. Seegers, 1998. Calculated milk production losses associated with elevated somatic cell counts in dairy cows: Review and critical discussion. Vet. Res., 29 (6): 497-510.

Hortet, P., F. Beaudeau, H. Seegers and C. Fourichon, 1999. Reduction in milk yield associated with somatic cell counts up to 600×10^3 cells mL^{-1} in French Holstein cows without clinical mastitis. Lives. Prod. Sci., 61: 33-42.

Jones, G.M., 1986. Symposium: Reducing somatic cell counts: Meeting the challenge-Impact on producer and processor. J. Dairy Sci., 69 (6): 1699-1707.

Juozaitiene, V., A. Zakas and A. Juozaitis, 2004. Relationship of somatic cell count with milk yield and composition in the herds of Black and White cattle. Medycyna Weterynaryjna, 60 (7): 701-704.

Kelly, A.L., C.O`.S. Tiernan and P. Joyce, 2000. Correlation between bovine milk somatic cell count and polymorphnuclear leukocyte level for samples of bulk milk and milk from individual cows. J. Dairy Sci., 83: 300-304.

Kiiman, H. and O. Savlei, 2000. On the factors affecting somatic cell count in milk. Agraarteadus, 11 (3): 152-168.

Kiiman, H., 2001. The analysis of the milk somatic cell count reducing possibilities. J. Agric. Sci., 12 (3): 162-174.

Koldeweij, E., U. Emanuelson and L. Janson, 1999. Relation of milk production loss to milk somatic cell count. Acta Vet. Scand., 40 (1): 47-56.

Labohm, R., E. Götz, G. Luhofer, R.G. Hess and H. Bostedt, 1998. Factors influencing the somatic milk-cell count in dairy cows. 1-Influence of bacteriological findings, stage and number of lactation. Milchwissenschaft, 53 (2): 63-69.

Lescourret, F. and J. Coulon, 1994. Modeling the impact of mastitis on milk production by dairy cows. J. Dairy Sci., 77 (8): 2289-2301.

Liebe, A., H. Worstorff and D. Schams, 1996. Changes in somatic cell count and plasma cortisol concentration during three relocation trials in German Brown cows. Milchwissenschaft, 51 (8): 423-426.

Malinowski, E., 2000. The role of udder disinfection and sanitizer types. Medycyna Weterynaryjna, 56 (11): 709-714.

Mazzucchelli, F., G. Parrilla, F.J. Blanco, J.V. Martin and M. Gonzalez, 2000. Bovine mastitis. An evaluation of problems on the farm. Mundo-Ganadero, 11 (118): 44-46.

Natzke, R.P., 1981. Elements of mastitis control. J. Dairy Sci., 64: 1431-1442.

Oliver, S.P., B.E. Gillespie, M.J. Lewis, S.J. Ivey, R.A. Almeida, D.A. Luther, D.L. Johnson, K.C. Lamar, H.D. Moorehead and H.H. Dowlen, 2001. Efficacy of a new premilking teat disinfectant containing phenolic combination for the prevention of mastitis. J. Dairy Sci., 84 (6): 1545-1549.

Pankey, J.W., 1989. Pre-milking udder hygiene. J. Dairy Sci., 72 (5): 1308-1312.

Radostits, O.M., K.E. Leslie and J. Fetrow, 1994. Herd Health: Food Animal Production Medicine. 2nd Edn. W.B. Saunders Co., Philadephia, PA., pp: 229-279.

Reneau, J.K., 1986. Effective use of dairy herd improvement somatic cell counts in mastitis control. J. Dairy Sci., 69 (6): 1708-1720.

Rhone, J.A., S. Koonawootrittriron and M.A. Elzo, 2007. Factors affecting milk yield, milk fat, bacterial score and bulk tank somatic cell count of dairy farms in the central region of Thailand. Trop. Anim. Health Prod., (Abstract). http://www.springerlink.com/content/184847m444115172/.

Rodriguez, Z.S., D. Gianola and G.E. Shook, 2000. An approximate Bayesian analysis of somatic cell score curves in Holsteins. Acta Agriculturae Scandinavica.-Section-A. Anim. Sci., 50 (4): 291-299.

Rupp, R. and D. Boichard, 1999. Genetic parameters for clinical mastitis, somatic cell score, production, udder type traits and milking ease in first lactation Holsteins. J. Dairy Sci., 82 (10): 2198-2204.

Rupp, R., C. Bertrand and S. Bazin, 2000. Overview of milk somatic cell counts in french dairy cattle breeds. Prod. Anim., 13 (4): 257-267.

Saloniemi, H. and L. Kulkas, 2001. Mastitis control in Finland. Int. Dairy Fed. Bullet. No. 367/2001:13-17.

SAS, 1996. SAS User's Guide: Statistics (Version 6.12). SAS Inst. Inc., Cary, NC. USA.

Schukken, Y.H., T.J.G.M. Lam and H.W. Barkema, 1997. Biological basis for selection on udder health traits. INTERBULL Bull. No. 15. Int. Bull. Eval. Serv., Uppsala, Sweden, pp: 27-33.

Seker, I., A. Risvanli, S. Kul, M. Bayraktar and E. Kaygusuzoglu, 2000. Relationship between California mastitis test (CMT) scores and udder traits and milk yield in Brown-Swiss cows. Lalahan Hayvancilik Arastirma Enstitusu Dergisi, 40 (1): 29-38.

Shook, G.E., 1989. Selection for disease resistance. J. Dairy Sci., 72 (5): 1349-1362.

Shook, G.E. and M. Schultz, 1994. Selection on somatic cell score to improve resistance to mastitis in the United States. J. Dairy Sci., 77 (2): 648-658.

Smith, J.W. and L.O. Ely, 1997. The influence of feeding and housing systems on production, reproduction and somatic cell count scores of Southern Holstein herds. Prof. Anim. Sci., 13 (3): 155-161.

Suriyasathaporn, W., Y.H. Schukken, M. Nielen and A. Brand, 2000. Low somatic cell count: A risk for subsequent clinical mastitis in a dairy herd. J. Dairy Sci., 83 (6): 1248-1255.

Tangorra, F.M., V. Bronzo, A. Casula, M. Cattaneo, C. Martinazzi, P. Moroni, M. Zaninelli and A.G. Cavalchini, 2004. Assessment of Teats Cleaning System Efficiency of a Milking Robot. Automatic Milking- A Better Understanding, Wageningen, The Netherlands: Wageningen Academic Publishers, pp: 121-122.

Vorst, V.D., Y.K. Bos, W. Ouweltjes and J. Poelarends. 2003. Farm and management factors affecting milk quality. EU Project Automatic Milking. http://www.automaticmilking.nl/.

Welper, R.D. and A. Freeman, 1992. Genetic parameters for yield traits of Holsteins, including lactose and somatic cell score. J. Dairy Sci., 75 (5): 1342-1348.

Wicks, H.C.F. and J.D. Leaver, 2003. The influence of housing system on somatic cell counts. Proceedings of the British Mastitis Conference. Garstang, pp: 105-107.

Yalcin, C., A.W. Stott, D.N. Logue and J. Gunn, 1999. The economic impact of mastitis-control procedures used in Scottish dairy herds with high bulk-tank somatic-cell counts. Prev. Vet. Med., 41 (2-3): 135-149.