Factors influencing somatic cell score in Swiss dairy production systems

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Summary

The aim of this study was to analyse the influence of fixed effects on somatic cell score (SCS) in Swiss dairy production. Monthly milk recording results were investigated against the background of changing housing conditions from tie-stall barns to loose housing systems. Zone, housing system and calving age within lactation number had a significant effect on SCS, as well as the covariables milk yield per day, fat and protein percentage and days in milk. Highest SCS was observed in cows of valley situated farms. Concerning housing system, best values were recorded in tie-stall barns (2.53). SCS was 0.08 higher during the changing period (2.61), and 0.12 higher in loose housing systems (2.65). SCS increased continuously with lactation number, but the differences between the age classes within lactation number were not significant. The lactation curves for SCS resembled inverted milk yield curves and were different between the first lactation on the one hand and higher lactations on the other hand.

Keywords: Swiss Brown cattle, somatic cell score, housing systems, tie-stall barn, loose housing

Einflussfaktoren auf den somatischen Zellgehalt in Schweizer Milchproduktionssystemen

Das Ziel der vorliegenden Untersuchung war die Analyse von fixen Einflussfaktoren auf den sogenannten Linear Somatic Cell Score (SCS) in der Schweizer Milchproduktion. Die Ergebnisse der monatlichen Milchleistungskontrollen wurden vor dem Hintergrund wechselnder Haltungsbedingungen, vom Anbinde- zum Laufstall, untersucht. Die Zone, das Haltungssystem und das Kalbealter innerhalb Laktationsnummer hatten einen signifikanten Einfluss auf den SCS, gleich wie die Kovariablen Milchleistung pro Tag, Fett- und Proteingehalt sowie der Laktationstag. Der höchste SCS wurde bei Kühen in Talbetrieben beobachtet. Bezüglich des Haltungssystems wurden die besten Werte für den SCS in Laufställen (2.53) erfasst. Der SCS war 0.08 höher während der Umstellungsperiode (2.61) und 0.12 höher in Laufställen (2.65). Der SCS stieg kontinuierlich mit der Laktationsnummer an, wobei die Unterschiede zwischen den Kalbealtersklassen innerhalb der Laktationsnummer nicht signifikant waren. Die Laktationskurven für den SCS glichen umgedrehten Laktationskurven für die Milchleistung und waren unterschiedlich zwischen der ersten Laktation auf der einen und höheren Laktationen auf der anderen Seite.

Schlüsselwörter: Schweizer Braunvieh, somatischer Zellgehalt, Haltungssystem, Anbindestall, Laufstall

Introduction

Mastitis is one of the most serious disease and management problems in today's dairy production. In Swiss dairy herds, more than 13% of all cullings were due to mastitis (Aeberhard et al., 1997). High costs were associated with mastitis disease, accounting for 350 francs per each cow and year in Switzerland (Walkenhorst, 2000). These losses were due to involuntary cullings, reduced milk yield, discarded milk and veterinary treatments.

Up to now, a direct recording of mastitis was not established. Somatic cell count (SCC) is an internationally accepted parameter to describe udder health due to it's high genetic correlation of about 0.8 to the susceptibility of mastitis (Dopp et al., 1998). SCC is analysed from the results of the routine monthly milk recording.

The aim of the present study was to analyse the influence of fixed effects on SCC, with special

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consideration of typical housing systems in Switzerland.

Animals, Material and Methods

Data recording

The data was provided by the Swiss Brown Cattle Breeders' Association. The analysis was based on the results of monthly milk recording (n = 1866242). 1674 farms out of 15 cantons in eastern and central Switzerland were randomly selected for the supply of data. Three zone types (valley, middle, and higher mountain) were considered, according to site altitude, local and traffic circumstances, and topography. The recording was defined on the observation period from January, 1994 to May, 2002. Information on housing system was documented within the linear description of exterior in primiparous cows since January, 1998. Tie-stall barns (n = 1045) and loose housing systems (n = 629) were differentiated. The time interval wherein housing conditions changed from tie-stall barn to loose housing system was termed 'changing period'.

The performance parameters recorded were: milk yield, fat percentage, protein percentage, lactose percentage, milk urea content and somatic cell count.

Statistical analysis

Somatic cell count (SCC) is not normally distributed. Therefore, linear somatic cell score (SCS) was computed to achieve a normal distribution of the data, specified by the international standard (Reents et al., 1995):

$$\mathbf{SCS = log_2(SCC/100{,}000) + 3.}$$

According to the requirements stated by Dopp et al. (1998), the following plausibility criterions for the final data set were specified:

- Calving age (months): 17–41 (lactation no. 1); 28–68 (lactation no. 2); 41–85 (lactation no. 3); >68 (lactation no. >3)
- Days in milk: 5–375
- Milk yield (kg/day): 1.0–90.0
- Fat content (%): 1.5–8.5
- Protein content (%): 1.5–8.5
- Lactose content (%): 1.0–8.0
- Milk urea content (mg/dl): 1.0–60.0
- Somatic cell count (cells/ml): 5000–10000000

After the plausibility check, 1866242 records from 82775 cows remained for the statistical processing.

Data analysis was performed applying the MIXED procedure of the SAS statistical package (SAS, 2002). A mixed model, based on restricted maximum-likelihood techniques, was used to evaluate the influence of fixed and random effects on SCS.

An F-test was conducted to obtain an indication about the importance (level of significance, p) of the fixed effects. The housing system was considered as fixed effect with 3 levels (tie-stall barn, 'changing period', loose housing). The fixed effect of the zone was subdivided in 3 classes (valley, middle, and higher mountain). The fixed effect of the calving age within lactation number was grouped as following: First lactation in 3 classes (<31, 31–34, >34 months), second lactation in 3 classes (<43, 43–47, >47 months), third lactation in 2 classes (<58, >=58 months), and greater third lactation in 1 class (>68 months). Milk yield, fat percentage, and protein percentage were considered as covariables. Four regression coefficients on the various functions of days in milk were computed to account for the shape of the lactation curve (Ali and Schaeffer, 1987). The animal effect was treated as random variable, because the monthly milk recording results were repeated measurements of a cow. The farm, combined with year and season, was also treated as random due to the high number of herds involved in the study.

Results

During the period of data collection, 517 farms changed their housing system to cubicles. The median herd size in farms with tie-stall barns was 17.4 and 26.8 in farms with cubicles. An overview about the descriptive statistics of the data set is given in Table 1.

All analysed effects were significant on SCS at a level of $p < 0.001$. The regression coefficients on the covariables were $b_0 = -0.058$ (milk yield), $b_1 = -0.031$ (fat percentage), and $b_2 = 0.329$ (protein percentage).

Table 1. Means ($\bar{x}$), standard deviations (sd), minima (min), and maxima (max) of the milk recording results. (n = 1866242)

Trait	$\bar{x}$	sd	min	max
Age at first calving (mo.)	32.3	3.5	17.0	41.0
Lactation number	2.9	1.7	1.0	7.0
Milk yield (kg)	19.92	6.57	1.0	78.0
Fat percentage (%)	4.07	0.55	1.5	8.5
Protein percentage (%)	3.44	0.37	1.5	7.7
Lactose percentage (%)	4.97	0.23	1.4	7.7
Milk urea content (mg/dl)	26.71	8.21	2.0	60.0
Somatic cell count (SCC) (cells/ml in 1000)	171.2	354.2	5.0	9977
Somatic cell score (SCS)1	2.69	1.67	–1.3	9.6

[1] calculated with the international formula [SCS = $\log_2$ (SCC/100000) + 3]

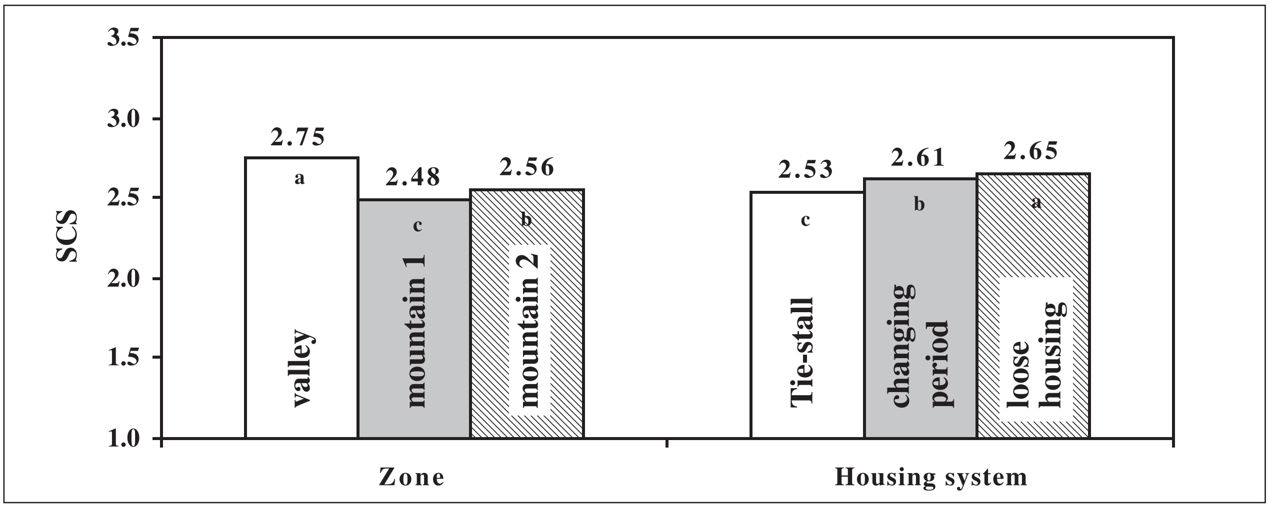

Figure 1: Least-square-means for somatic cell score (SCS) of the fixed effects of zone and housing system (n = 1866242). Standard errors were at a level of 0.02. Different letters symbolise significant differences at a level of p = 0.05 (F–test)

Least-square-means (LSM) of SCS for the fixed effects of zone and housing system are presented in Figure 1. Highest level of SCS was observed in valley situated farms (2.75), whereas in both, mountain zone 1 (2.48) and 2 (2.56), SCS was at a lower level. The differences between housing systems were comparatively low. Best results were recorded in tie-stall barns (2.53), indicated by a SCS 0.08 lower than in the changing period, and 0.12 lower than in loose housing systems. An overview about the LSM for SCS for calving ages within lactation number is demonstrated graphically in Figure 2. First and second lactation were subdivided in three age classes each, third lactation was classified in two groups, lactations greater than 3 were no more subdivided. By far, lowest level of SCS was observed in primiparous cows, increasing continuously to the animals with lactation number greater than 3 (3.31). Between the calving age classes within lactation number, the differences in SCS were not significant. There was only a slight tendency towards higher SCS in each group of older animals. The effect of the lactation day on SCS is presented in Figure 3. Exemplary, 4 lactation curves for SCS of different calving age classes and lactation numbers are shown. Two results were obvious: First, the run of the curve of lactation number 1 differed from that of higher lactations, and second the level of SCS increased with lactation number. Lactation number 1 started with its maximum value (SCS = 2.76) at lactation day 10 and declined rapidly to its minimum at day 60 (2.11). After this, SCS rose continuously until the end of lactation (day 330: 2.64). In the higher lactations, SCS also decreased strongly, but the minimum values were already achieved at lactation day 30. The following increase of SCS was stronger than in the first lactation, and the maximum value was higher by far compared to the initial value at lactation day 10.

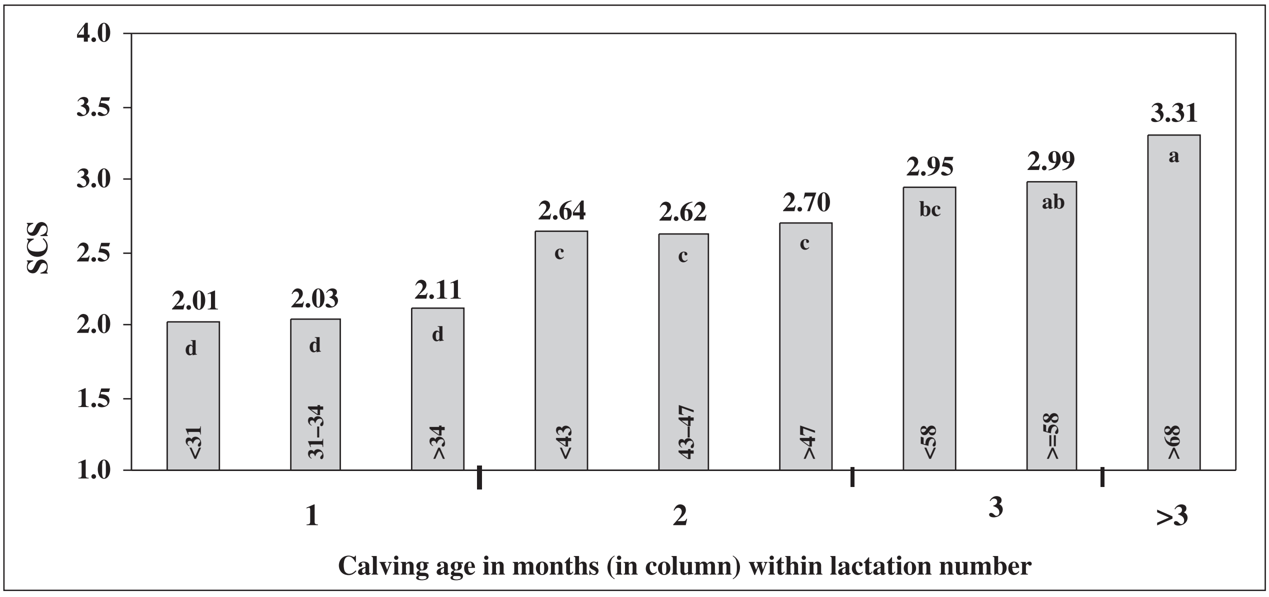

Figure 2: Least-square-means for somatic cell score (SCS) for calving age within lactation number (n = 1866242). Standard errors were at a level of 0.02. Different letters symbolise significant differences at a level of p = 0.05 (F–test)

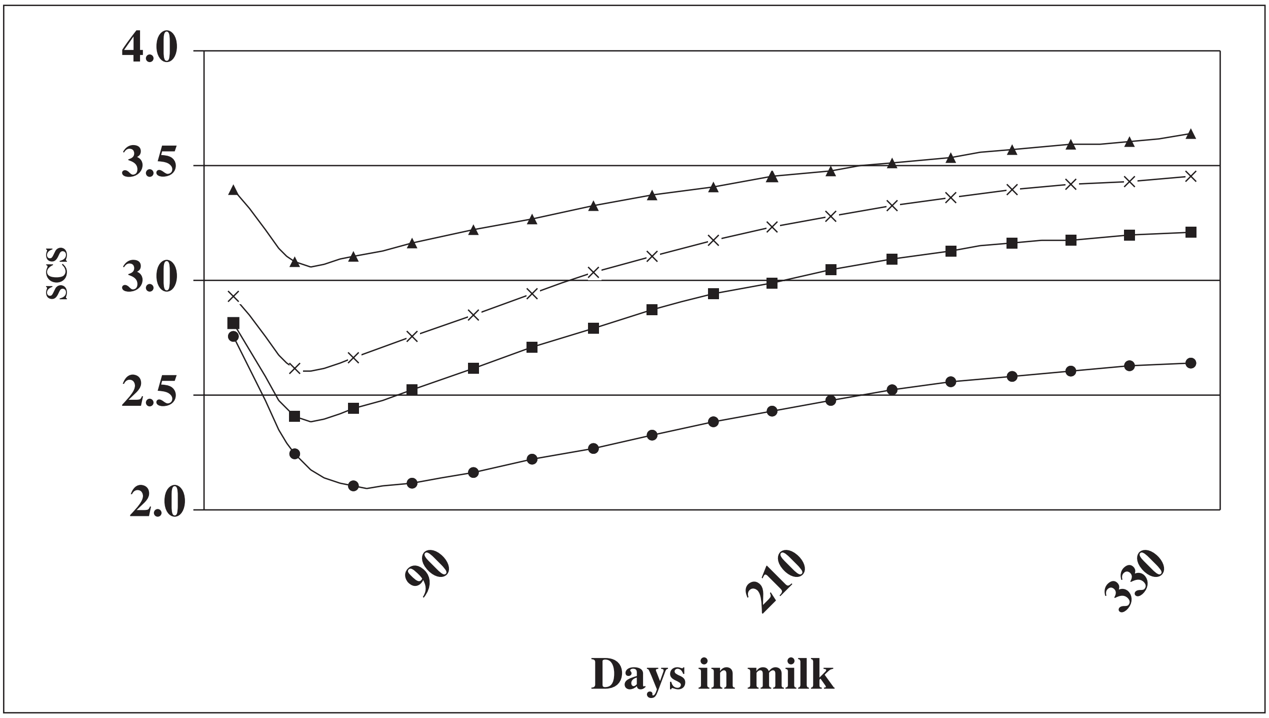

Figure 3: Lactation curves for SCS of lactation number 1 (●), 2 (■), 3 (x), and >3 (▲), standardised for cows in loose housing systems and valley situated farms with the following correction factors for calving age (months), milk yield (kg), fat (%), and protein percentage (%): Lactation 1 (31–34, 17.4, 4.06, 3.40), lactation 2 (43–47, 19.9, 4.08, 3.46), lactation 3 (<58, 21.4, 4.07, 3.43) and lactation >3 (>68, 22.3, 4.01, 3.38)

Discussion

In this study, slightly higher SCS were observed in loose housing systems. Valde et al. (1997) did not find any significant difference in mean SCS between free-stall and tie-stall herds. In the investigation of Matzke et al. (1992) less cases of mastitis were identified in loose housing compared to tie-stall barns. Six clusters of risk factors (production indexes, housing, hygiene, health disorders, milking management, and milking machine) to have a potential relationship with the incidence of mastitis were characterised by Elbers et al. (1998). Within the data recording period many farmers changed their housing system from tie-stall barns to loose housing systems. A new housing system means for both, the farmer and the animal, to adapt to a new environment, i.e., new lying, moving, feeding, and milking area. The process of acclimatising may contribute in problems, disorders, and diseases, what means predisposing factors for higher SCS. This fact is confirmed by the increased SCS in the 'changing period'. The highest SCS in loose housing has mainly two reasons: The 'changing period' does not completely contain the real process of adapting to the new environment. Presumably, problems may have been appeared temporally delayed. Further on, it must be considered that conventional tie-stall barns, potentially in combination with regular outdoor exercise, represent a well adapted environment for producing milk with healthy cows.

According to the present results, Mrode et al. (1998) and Haile-Mariam et al. (2001) found SCS increasing with parity. The calving age within parity also influenced SCS. Mostly, the differences between the classes were not significant, but there was a general tendency towards higher SCS in older animals. This trend was also investigated by Schutz et al. (1990). The main reason for these observations was that the more a milk gland produced milk the higher was the opportunity for exposure to mastitis-causing pathogens. In this context, errors in the milking technique were a predisposing factor for defects in the teat canal. The investigated influence of stage of lactation on SCS was similar to the studies of Zhang et al. (1994), Reents et al. (1995), and Haile-Mariam et al. (2001). All curves for SCS resembled inverted milk yield curves. The run of the curve of SCS in lactation number 1 differed significantly from that of the following parities, which increased more rapidly after the minimum around lactation day 30. Schutz et al. (1990) confirmed that elevated SCS in first lactating cows at the beginning of the lactation were a consequence of oedema and physiological changes from origination of milk secretion rather than mastitis infection. Further on, lactation curves for SCS were closely related to a dilution effect by the milk volume. When milk declined in later lactation, somatic cells were concentrated in a smaller volume, and therefore SCS increased (Schutz et al., 1990). Further on, the proportion of healthy compared to infected udders changes in the run of the lactation. The percentage of infected udders rises by the end of lactation. The risk of being infected by pathogens increases with lactation day because of the rising strain to the udder of being milked twice a day. Consequently, the percentage of infected udders increases what is tantamount to an increasing SCS.

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Facteurs influençant la quantité de cellules somatiques dans la production laitières suisse

L'analyse des facteurs fixes influençant le taux linéaire de cellules somatiques (Linear Somatic Cell Score, SCS) dans la production laitière en Suisse, a été analysé dans le cadre de la présente étude. On a examiné les résultats des contrôles laitiers mensuels en tenant compte des diverses conditions de détentions en stabulation entravée ou libre. La zone, le système de détention et l'âge au vêlage dans la période de lactation avait un effet significatif sur le SCS, de même que les variables productions laitières journalière, taux de matière grasse et de protéines ou jours de lactation. Le SCS le plus élevé a été observé chez les vaches issues d'exploitation de plaine. Pour ce qui est des symptômes de détentions, les meilleures valeurs de SCS ont été constatées dans les stabulations libres. Le SCS était de 0.08 plus élevé durant la période de transition (2.61) et de 0.12 plus élevé dans les stabulations libres (2.65). Le SCS s'élève de façon continuelle avec le nombre de lactation, alors que les différences entre les classes d'âge de vêlage à l'intérieur d'une lactation n'étaient pas significatives. Les courbes de lactation en terme de SCS étaient inversement symétriques aux courbes de lactation pour la production et étaient différentes entre les premières lactations d'un côté et les lactations plus élevées d'un autre côté.

Fattori d'influenza sul contenuto delle cellule somatiche nei sistemi di produzione lattiera svizzeri

Scopo del seguente studio è era l'analisi dei fattori d'influenza costanti sulle cosiddette Linear Somatic Cell Score (SCS) nella produzione lattiera svizzera. I risultati dei controlli mensili sulla produttività lattiera sono stati analizzati considerando condizioni di tenuta differenti, comprendendo mucche legate e mucche con possibilità di movimento nella stalla. La zona, il sistema di tenuta e l'età dei vitelli all'interno del numero di lattazione hanno avuto un effetto significante avevano un influsso determinante sul SCS, equivalente alla covariabile produzione di latte giornaliera, al contenuto di grassi e proteine e al giorno di lattazione. Il più alto valore di SCS è stato riscontrato nelle mucche in aziende delle valli. Per quel che riguarda i sistemi di tenuta i migliori valori per l'SCS sono stati osservati nelle stalle con possibilità di movimento (2.53). L'SCS era di 0.08 maggiore durante il periodo di transizione (2.61) e di 0.12 maggiore nelle stalle libere (2.65). L'SCS è aumenta in modo continuo con il numero delle lattazioni, da notare che le differenze tra le classi di età dei vitelli all'interno del numero di lattazione non erano significative. Le curve di lattazione per l'SCS equiparavano girate le curve di lattazione per la produttività lattiera ed erano diverse tra la prima lattazione da una parte, e dall'altra parte, per le lattazioni successive.

References

Aeberhard K., Bruckmaier R., Blum J.: Hochleistungskühe in der Schweiz. Agrarforschung 1997, 4: 277–280.

Ali T.E., Schaeffer L.R.: Accounting for covariances among test day milk yields in dairy cows. Can. J. Anim. Sci. 1987, 67: 637–644.

Danuser J.: Individuelle Zellzahl und Eutergesundheit. Ph. D. thesis, ETH Zurich 1992.

Dopp L., Reents R., Reinhardt F., Schmutz M.: Beschreibung des Zuchtwertschätzverfahrens für Eutergesundheit. DGfZ-Schriftenreihe 1998, 11: 34–40.

Elbers A.R.W., Miltenburg J.D., De Lange D., Crauwels A.P.P., Barkema H.W., Schukken Y.H.: Risk factors for clinical mastitis in a random sample of dairy herds from southern part of the Netherlands. J. Dairy Sci. 1998, 81: 420–426.

Haile-Mariam M., Goddard M.E., Bowman P.J.: Estimates of genetic parameters for daily somatic cell count in Australian dairy cattle. J. Dairy Sci. 2001, 84: 1255–1264.

Matzke P., Holzer A., Deneke J.: Ein Beitrag zum Einfluss von Umweltfaktoren auf das Vorkommen von Eutererkrankungen. Tierärztl. Prax. 1992, 20: 21–32.

Mrode R.A., Swanson G.J.T., Winters M.S.: Genetic parameters and evaluation for somatic cell counts and its relationship with production and type traits in some dairy breeds in the United Kingdom. Anim. Sci. 1998, 569–576.

Reents R., Jamrozik J., Schaeffer L.R., Dekkers J.C.M.: Estimation of genetic parameters for test day records of somatic cell score. J. Dairy Sci. 1995, 78: 2847–2857.

SAS. SAS/STAT User's Guide, Version 8, first edition, Cary, NC, USA, 2002.

Schutz M.M., Hansen L.B., Steuernagel G.R., Kuck A.L.: Variation of milk, fat, protein, and somatic cells for dairy cattle. J. Dairy Sci. 1990, 73: 484–493.

Valde J.P., Hird D.W., Thurmond M.C., Østerås O.: Comparison of ketosis, clinical mastitis, somatic cell count, and reproductive performance between free stall and tie stall barns in Norwegian dairy herds with automatic feeding. Acta Vet. Scand. 1997, 38:181–192.

Walkenhorst M.: Mastitis: Kein Wundermittel gegen die Kuhkrankheit Nummer 1. Bio aktuell 2000, 9: 4–7.

Zhang W.C., Dekkers J.C.M., Banos G., Burnside E.B.: Adjustment factors and genetic evaluation for somatic cell score and relationships with other traits of Canadian Holsteins. J. Dairy Sci. 1994, 77: 659–665.

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