*Journal of Dairy Research*

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# Bulk tank milk quality data is unlikely to give useful information about dairy cow welfare at herd level

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## Research Article

**Cite this article:** Ginestreti J *et al* (2020). Bulk tank milk quality data is unlikely to give useful information about dairy cow welfare at herd level. *Journal of Dairy Research* **87**, 208–211. https://doi.org/10.1017/S0022029920000187

Received: 30 December 2018
Revised: 2 December 2019
Accepted: 18 December 2019
First published online: 13 May 2020

**Keywords:**
Animal welfare assessment; dairy cow; indicators; milk quality

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## Abstract

This research communication explores the value of routinely collected bulk tank milk quality data for estimating dairy cattle welfare at herd level. Selected bulk tank milk quality parameters (somatic cell count, total bacterial count, urea, protein and fat contents) recorded during the years 2014–2016 in 287 Italian dairy farms were compared with the animal welfare data of each farm. The welfare assessment data were extracted from the database of the Italian Reference Centre for Animal Welfare (CReNBA), which includes the outputs of the application of the CReNBA welfare assessment protocol for dairy cows, used at national level for on-farm controls. The statistical analysis was carried out using the correlation coefficient for Kendall's Tau ranks, in order to investigate the presence of a categoric relationship between the selected bulk tank milk quality parameters and the overall animal welfare score or the scores of the single areas A (farm management and staff training), B (housing) and C (animal-based measures). Somatic cell count, total bacterial count, urea and proteins demonstrated only a few statistically significant and very weak correlations with farm animal welfare data, while no significant correlations were obtained for milk fat content. Given the weak correlations found, the selected bulk tank milk parameters seems to be able to provide only limited information about the welfare level of the herd, thus it could be difficult to use them for drawing up a pre-screening model for identifying herds at risk of poor welfare.

Several research groups have recently developed methods for the on-farm assessment of animal welfare, but unfortunately many of these have the disadvantage of being too time-consuming and expensive if routinely applied on-farm. In particular, protocols that include direct animal-based measures require a high level of training, a long execution time and they do not allow for continuous monitoring of the animal welfare conditions (de Vries *et al*., 2014). As a consequence, it has been proposed that routinely collected herd data, that relates to cow performance and production, could be used for estimating dairy cattle welfare at herd level (de Vries *et al*., 2014). Some bulk tank milk parameters, such as somatic cell count (SCC), milk fat and protein content, have been suggested as potential indicators of animal welfare (EFSA, 2012). However, to our knowledge, only a few studies have explored the association between such bulk tank milk data and specific farm aspects related to herd health and welfare, that have been validated by an audit scheme (Velthuis and van Asseldonk, 2011; Bertocchi *et al*., 2012).

In Italy, hundreds of bulk tank milk samples, collected in the Northern area of the country, are analysed each day by the laboratory of the Italian National Reference Centre for Bovine Milk Quality (CRNQLB), located at the Istituto Zooprofilattico Sperimentale della Lombardia e dell'Emilia Romagna (IZSLER), and by the milk laboratory of the Istituto Zooprofilattico Sperimentale del Piemonte, Liguria e Valle d'Aosta (IZSPLV) to check the quality of the produced milk and to verify the compliance with the hygiene law requirements (Regulation (EC) No. 853/2004).

Given this huge amount of routinely collected data, the present study aimed at investigating the possibility of using bulk tank milk quality data as indicators of dairy cow welfare at the



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herd level, in order to use them as a pre-screening tool for identifying herds at risk of poor welfare.

## Materials and methods

### On-farm welfare assessment protocol for dairy cows

The Italian National Reference Centre for Animal Welfare (CReNBA), located at IZSLER, has developed an on-farm welfare assessment protocol for dairy cows, based on the latest scientific knowledge and the current European and Italian legislations (Bertocchi *et al.*, 2018). This protocol is routinely applied by trained veterinarians throughout Italy and the collected data are submitted, daily, to the CReNBA database. The CReNBA protocol includes all of the animal categories present within a herd (calves, lactating cows, dry cows and heifers) and is divided into three thematic areas: (i) area A: farm management and staff training (which includes non-animal based measures related to animal handling, farm-managing, staff training and experience); (ii) area B: housing (in which non-animal based measures are used to verify the adequacy of the facilities that hosted the animals) and (iii) area C: animal-based measures (in which the ability of the animals to cope with their environment is assessed using indirect and direct animal-based measures). The protocol is available at Bertocchi *et al.* (2018).

The protocol consists of 70 observations on a multiple-choice checklist, as detailed in online Supplementary Table S1. Each question has two or three options of answer: not acceptable/acceptable or not acceptable/acceptable/excellent. Each parameter has a different weight obtained by expert opinion elicitation and contributes in varying degrees to the overall animal welfare score of the farm, which is a combination of the scores of areas A, B and C. The overall animal welfare score and the scores of each area, expressed on a scale from 0 to 100% (the higher the score, the higher the animal welfare), come from the analysis of the measures collected on farm.

### Routinely collected bulk tank milk quality data and herd selection

Among the bulk tank milk quality data available in the CRNQLB and IZSPLV databases, SCC, TBC, fat, protein and urea contents were chosen for study their potential as animal welfare screening tools, since in published work these parameters seemed to be the most affected by changes in dairy cow welfare at herd or animal-level (Velthuis and van Asseldonk, 2011; Hristov *et al.*, 2014).

For the purpose of this study, milk quality and CReNBA databases were merged: farms that appeared in both records were selected and their data, obtained during the period 1st January 2014 to 31st December 2016, were extracted. For that period, 287 herds had been assessed for both animal welfare and bulk tank milk quality, of which 237 were loose-housing farms and 50 were tie-stall systems. The selected farms were located in Lombardia, Piemonte and Emilia Romagna regions, the average herd size was 248 (range 20–2030), the average number of lactating cows was 114 (range 10–887) and the average milk yield/cow per day was 28.2 kg (range 8–39 kg).

### Data analysis

For SCC, the geometric mean of the three-month period prior to the animal welfare assessment was calculated (at least 3 analyses). For TBC, the geometric mean of the analyses carried out in the two months prior to the animal welfare evaluation was calculated (at least 4 analyses), according to Regulation (EC) No 853/2004. For fat, protein and urea content, the arithmetic mean of the analyses carried out in the three months before the animal welfare evaluation (at least 3 analyses) was calculated according to the provisions given by the Italian Ministerial Decree No 185/1991. In case a farm did not satisfy the requested minimum number of analyses for a specific parameter, it was excluded from the study only for that parameter.

Statistical analysis was carried out using Kendall's Tau coefficient, which is a non-parametric test that measures the presence of a categoric relationship between two variables. Thus, it was chosen for investigating if different values of the selected milk quality parameters could lead to a different ranking of the farms, based on the animal welfare scores. Kendall's Tau values range from −1 (highest negative association) to +1 (highest positive association). A value of 0 indicates no association. Data were processed using Microsoft Excel and R® software version 3.4.2, Package 'Kendall' (McLeod, 2011).

## Results and discussion

Based on the overall animal welfare scores, farms were divided into 3 categories: insufficient (overall animal welfare score <60%) good (overall animal welfare score between 60 and 80%) and excellent (overall animal welfare score ≥80%). The distribution of bulk tank milk parameters according to the overall animal welfare score categories is reported in online Supplementary Table S2.

Table 1 shows the results of the Kendall's Tau for milk quality parameters and the overall animal welfare score or the single area scores. SCC, TBC, urea and proteins demonstrated statistically significant, but very weak, correlations. In particular, SCC was negatively correlated with the overall animal welfare score ($T = -0.129$, $P < 0.01$), the score of area A ($T = -0.129$, $P < 0.01$) and the score of area C ($T = -0.103$, $P < 0.05$). TBC was negatively correlated with the overall animal welfare score ($T = -0.195$, $P < 0.01$), with the score of area A ($T = -0.260$, $P < 0.01$) and the score of area B ($T = -0.209$, $P < 0.01$). Urea content showed a significant and positive weak correlation with the overall animal welfare score ($T = 0.101$, $P < 0.05$) and the score of area A ($T = 0.186$, $P < 0.01$), while for protein content a weak correlation was found with the score of area B ($T = 0.108$, $P < 0.05$), but none with the overall animal welfare score. No significant correlations were found between the milk fat content and the animal welfare data.

When the milk of a single cow and its level of animal welfare are directly compared, relationships between milk composition and dairy cow welfare are reported in literature (Sant'Anna and Paranhos da Costa, 2011; Arnould *et al.*, 2013). However, based on the results obtained in the present study, this relationship does not seem so clear when analysis is done at herd level. The absence of good significant correlations between the selected bulk tank milk quality parameters and the dairy cow welfare at herd level could be explained by a possible loss of the information due to the dilution of the individual cow milk with the milk of all the other cows. The same could be stated for the animal welfare data, since the CReNBA protocol measures not only the welfare of the lactating cows but also the welfare of the dry cows and of the young stock (heifers and calves), thus, the data from the non-productive animals may have affected the obtained results. Lastly, the milk industry has become more uniform, thus it is difficult to

https://doi.org/10.1017/S0022029920000187 Published online by Cambridge University Press

**Table 1.** Kendall's Tau for milk quality parameters and animal welfare scores

| Milk quality parameter | Farms (*n*) | Overall animal welfare score | Score of area A | Score of area B | Score of area C |
|---|---|---|---|---|---|
| SCC | 270 | −0.129** | −0.129** | −0.036 | −0.103* |
| TBC | 254 | −0.195** | −0.260** | −0.209** | −0.069 |
| Fat | 271 | 0.055 | −0.007 | 0.002 | 0.069 |
| Protein | 235 | 0.05 | −0.013 | 0.108** | 0.025 |
| Urea | 271 | 0.101* | 0.186** | 0.077 | 0.017 |

*$P < 0.05$; **$P < 0.01$.

find wide farm to farm variations of certain bulk tank milk parameters, such as fat and protein contents, despite the possible variations of the animal welfare score at herd level.

Based on the obtained results, the selected bulk tank milk parameters seem to give only limited information about the welfare level of the herd. SCC in milk is commonly used as the main tool for udder health monitoring, especially for mastitis problems, which are one of the major welfare issues for dairy cows. Some research groups found that several common management practices in dairy cow farming had consistent associations with bulk tank SCC (Dufour *et al*., 2011; Velthuis and van Asseldonk, 2011), however, despite the fact that these management activities are among those measured in area A of the CReNBA welfare assessment protocol (Supplementary Table S1), the obtained Kendall's Tau was very low ($T = -0.129$). Also, the correlation with area C (animal-based measures) was very low ($T = -0.103$), even if a poor cleanliness of the animals was demonstrated to increase the SCC level (Velthuis and van Asseldonk, 2011) and the presence of lesions and lameness can affect the ability of the cow to defend and free itself from pathologies (Bertocchi *et al*., 2012).

TBC is usually a good indicator of milk hygiene and its increase is generally related to a careless milking, inadequate cleanliness of the milking groups, absence of pre or post dipping or to cows with udder problems (Velthuis and van Asseldonk, 2011). A possible link between TBC and the farm management and structures has been reported by previous studies, which demonstrated correlations between TBC and animal cleanliness and milking hygiene, together with a good management of the herd (Velthuis and van Asseldonk, 2011; Zucali *et al*., 2011). It might be supposed that farmers who pay more attention to environmental, udder and milking hygiene are more likely to be sensitive with respect to the animal welfare conditions (Múnera-Bedoya *et al*., 2017). These relationships were only partially confirmed by the present study. Although TBC was the parameter showing the highest Kendall's Tau values, the found correlations were nevertheless still very weak (Table 1).

The urea content in milk depends mainly on the feeding strategy, which, if not adequate, could be a potential risk for dairy cow welfare, especially in intensive farming (EFSA, 2012). In the CReNBA animal welfare assessment protocol for dairy cows, nutrition is measured using several indicators: feed composition and administration (area A), number, dimension and accessibility of the feeding places (area B) and body condition score (area C) (Supplementary Table S1). However, urea showed only very weak positive correlations with the overall animal welfare score ($T = 0.101$) and the score of area A ($T = 0.186$).

Compared to what has been suggested by EFSA (2012), in this study, no association was found between the animal welfare scores (both overall and single area scores) and fat content in bulk tank milk, whilst in the case of protein content we observed only a positive weak correlation with the score of area B ($T = 0.108$) (Table 1). Hristov *et al*.(2014) highlighted a significantly higher fat and protein content in loose-housed herds instead of tied ones. They suggested that this was due to the fact that the welfare of dairy cows in loose-housing systems is better than in the tied-stall. Based on the present study, neither fat nor protein content can be used as a good indicator of dairy cow welfare at herd level.

In conclusion, only very weak associations were found between the selected bulk tank milk quality parameters and animal welfare at herd level, as regards those aspects relating to farm management practices, housing conditions or animal-based measures included in the CReNBA protocol. These extremely weak correlations may have been affected by the complexity of the animal and the environmental factors that can influence bulk milk parameters, thus, it would be very difficult to use routinely collected bulk tank milk quality data as a pre-screening tool for estimating dairy cattle welfare at the herd level.

**Supplementary material.** The supplementary material for this article can be found at https://doi.org/10.1017/S0022029920000187.

**Acknowledgements.** This work was supported by the Italian Ministry of Health grant PRC 2014002 – Benelatte.

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