Bulk tank milk quality data: can they give some information about dairy cow welfare at herd level?

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Short title: **Exploring the association between milk quality and dairy cow welfare at herd level**

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Table S1: Measures included in the protocol of the Italian National Reference Centre for Animal Welfare (CReNBA) for the on-farm assessment of dairy cow welfare (Bertocchi *et al.*, 2018).

	Area A - Farm management and staff training
1	Number of stockpersons
2	Experience and training of stockpersons
3	Animal grouping strategy
4	Inspections of the animals
5	Type of handling
6	Milking parlour access and exit
7	Feeding strategy
8	Use of concentrate feeds (daily dose)
9	Water provision
10, 11, 12	Cleanliness of water points (lactating cows, dry cows, heifers)
13, 14, 15	Cleanliness of floors in walking areas (lactating cows, dry cows, heifers)
16, 17, 18	Bedding material management (lactating cows, dry cows, heifers)
19	Use and management of calving pens
20	Foot inspection and foot bathing
21	Hygiene of the milking parlour or milking robot
22	Milking routine
23	Biosecurity measures
	Area B - Housing
24	Housing of animals older than 6 months of age
25, 26, 27	Space availability in the lying area (m²/cow or number of cubicles per animal) (lactating cows, dry cows, heifers)
28	Calving pen presence and size
29	Design of the lying area
30, 31, 32	Type of bedding material (lactating cows, dry cows, heifers)
33, 34, 35	Type of floor in walking areas (lactating cows, dry cows, heifers)
36, 37, 38	Available space at feed bunk (lactating cows, dry cows, heifers)
39	Feeding place dimension and accessibility
40, 41, 42	Functioning and number of water points (lactating cows, dry cows, heifers)
43	Bedding material for new-born calves (less than 2 weeks of age) in single pens
44	Space availability for calves up to 8 weeks of age (in single pen)
45	Possibility for calves to see and touch each other (in single pen)
46	Space availability for calves in group pens
47	Facilities for sick animals
48	Waiting room and milking parlour design
49	Milking machine or milking robot maintenance
50	Temperature, humidity and ventilation
51	Gas (NH_3, H_2S, CO_2) concentration
52	Use of artificial lighting
	Area C – Animal based measures
53, 54, 55	Avoidance distance test (lactating cows, dry cows, heifers)
56, 57, 58	Body condition score (lactating cows, dry cows, heifers)
59, 60, 61	Cleanliness of flank, upper leg, lower leg and udder (lactating cows, dry cows, heifers)
62, 63, 64	Integument alterations (lactating cows, dry cows, heifers)
65	Lameness (lactating cows, dry cows)
66	Bulk Tank Milk somatic cell count
67	Number of antibiotic treatments for clinical mastitis in 1 year
68	Annual mortality rate of adult cows (cows died on-farm, euthanized or emergency slaughtered)
69	Annual mortality rate of calves from 2 to 30 days old
70	Mutilations (disbudding, dehorning, tail docking)

Table S2: Distribution of bulk tank milk parameters [somatic cells count (SCC), total bacterial count (TBC), fat, protein, urea] according to the overall animal welfare score categories (insufficient: Overall animal welfare score <60%; good: Overall animal welfare score between 60% and 80%, excellent: Overall animal welfare score ≥ 80%).

Overall animal welfare score category	N. of farms	Bulk tank milk quality parameter	Minimum	25° perc.	Median	75° perc.	Maximum
Insufficient	54		77,572.94	198,855.90	240,549.60	315,290.80	412,329.60
Good	192	SCC	77,910.61	178,787.40	231,333.50	279,878.80	506,781.90
Excellent	24	(cell/ml)	94,631.05	154,255.10	198,274.60	240,866.30	325,746.50
All	270		77,572.94	178,577.86	230,883.69	283,107.54	506,781.87
Insufficient	43		4,842.53	9,741.88	20,749.28	34,565.25	118,644.50
Good	183	TBC	2,710.81	8,035.16	11,799.12	20,762.15	217,012.40
Excellent	28	(CFU/ml)	3,833.66	7,885.87	1,153.10	12,720.70	404,29.49
All	254		2,710.81	8,300.86	12,006.54	2,222.39	217,012.42
Insufficient	46		3.40	3.81	3.92	4.05	4.24
Good	197	Fat	3.06	3.77	3.90	4.05	4.67
Excellent	28	(g/100ml)	3.33	3.80	3.95	4.09	4.46
All	271		3.06	3.77	3.91	4.05	4.67
Insufficient	46		3.13	3.33	3.39	3.48	3.70
Good	197	Protein	2.94	3.31	3.39	3.46	4.03
Excellent	28	(g/100ml)	3.21	3.38	3.46	3.51	3.90
All	271		2.94	3.32	3.40	3.48	4.03
Insufficient	43		12.65	20.21	21.64	24.16	30.18
Good	189	Urea	11.23	20.80	23.28	26.27	35.60
Excellent	27	(mg/100ml)	17.62	21.86	22.29	27.44	31.06
All	259		11.23	20.70	23.03	26.03	35.60

Reference

Bertocchi L, Fusi F, Angelucci A, Bolzoni L, Pongolini S, Strano RM, Ginestreti J, Riuzzi G, Moroni P & Lorenzi V 2018 Characterization of hazards, welfare promoters and animal-based measures for the welfare assessment of dairy cows: Elicitation of expert opinion. Preventive Veterinary Medicine 150 8-18.