Note

Study of relationships between blood concentration in raw milk and milk quality and herd performance measures

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Abstract Previous methods for detecting blood in milk, including visual inspection and high-speed centrifugation, can only determine the presence or absence of blood in milk. However, inspection using a simple measurement device developed by Tokachi Zaidan enables quantification of blood in raw milk even at concentrations below the visual detection limit (0.01%). In this study, we used this device to determine the frequency of blood in the ordinary milk of individual cows and, based on herd performance, we investigated the relationships between blood concentration in milk and physiological factors such as month-age and breeding performance as well as the quantity and quality of milk. In total, 197 milk samples from individual cows were provided by two dairy farms (A and B) and analyzed in this study. Mean blood concentrations in milk (± standard deviation) were 0.0017±0.0009% (n=57) for Farm A and 0.0026±0.0008% (n=140) for Farm B. In both cases, the concentrations were substantially below the visual detection limit (0.01%). For both dairy farms (A and B), the blood concentration in milk tended to be higher for individuals with higher month-ages and calving numbers. On Farm B, the blood concentration in milk tended to be higher for individuals with a greater number of days after calving (i.e., individuals with lower breeding performance) and higher somatic cell counts in milk resulting from longer lactation periods. Nevertheless, in all cases, mean blood concentrations in ordinary milk were on the order of one-fifth the visual detection limit (0.01%) and were in a range that was not considered problematic.

Key word: blood in milk, milk quality, herd performance, somatic cell, dairy farm
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Introduction

In response to growing consumer concerns regarding food safety in recent years, the dairy industry has begun to increase the stringency of milk testing [4]. As a result, there are now regions that do not permit the sale of milk containing even low concentrations of blood that is not visible to the naked eye but can be detected through rigorous inspection.

Bloody milk (red or pinkish raw milk that contains blood [2,6]) can be caused by physical factors such as kicks or other trauma to the udder, pathological factors such as mastitis or other inflammatory conditions, and

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physiological factors such as infiltration of blood due to sudden swelling of the udder [1,8]. Cases have been reported in which blood in milk was not detected during pre-milking stimulation (manual stimulation of the teats prior to cup attachment), which is typically the stage at which blood in milk is detected, resulting in the need to dispose of several tons of milk after shipping [5]. Furthermore, because bloody milk is discarded as soon as it is discovered, the causes of blood in milk and the frequency at which it occurs are not clearly understood.

Previous methods for detecting blood in milk, including visual inspection and high-speed centrifugation, can only determine the presence or absence of blood in milk. However, inspection using a simple measurement device developed by Tokachi Zaidan can quantify blood in raw milk even at concentrations below the visual detection limit (0.01% [3]) [7]. Use of this new device has greatly increased the ability to clarify the conditions and physiological factors that increase the likelihood of bloody milk.

In this study, we used this device to determine the frequency of blood in the ordinary milk of individual cows. Based on head performance, we investigated the relationships between blood concentration in milk and physiological factors such as month-age and breeding performance as well as milk yield and milk quality.

Materials and methods

1. Simple measurement device for determining blood concentration in milk

The external appearance of the simple measurement device for determining the blood concentration in milk is shown in Fig. 1. The operation of the device and the measurement procedure have been reported previously [7].

2. Milk samples

The milk samples used in this study were provided by two dairy farms: 57 samples from individual cows provided by Farm A on December 2, 2020 and cumulative total of 140 samples from individual cows provided by Farm B on September 4 and December 4, 2020. The samples consisted of unused portions of raw milk samples collected for monthly evaluations of dairy herd performance.

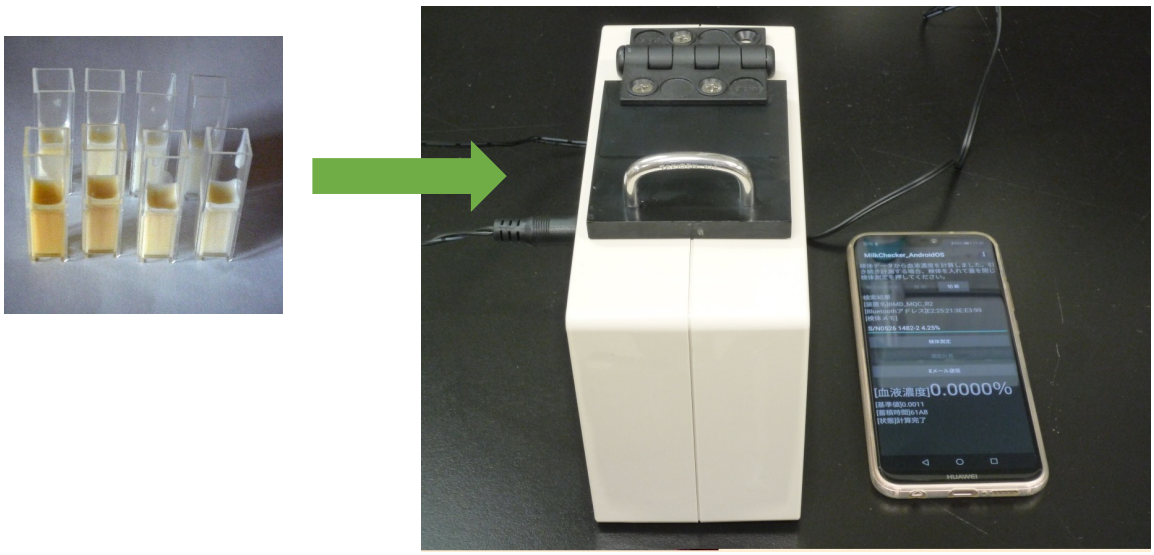

Fig. 1 Simple measurement device for determining blood concentration in milk.

Tie- stall dairy barns

Tie- stall dairy barns

Grazing cows

Grazing cows

Fig.2 Photos of dairy farms (left, Farm A; right, Farm B).

Both dairy farms (Fig. 2) were located in the grassland dairy farming area of east Hokkaido and used tie-stall dairy barns with grazing management. At the time of the study, the number of milking cows was 57 and 95 on Farms A and B, respectively. Mean 305-day milk yield was 8,700 and 7,900 kg and mean calving number was 2.7 and 2.8 on the respective farms.

3. Comparison of herd performance results and blood concentration in milk

Using dairy herd performance results for Farms A and B, we analyzed the relationships between blood concentration in milk and days after calving, milk quality, and other dairy cow characteristics. The herd performance measures analyzed were month-age, calving number, days after calving (excluding cases where this was 500 d or greater), somatic cell count in milk, milk yield, and milk composition (fat content, protein content). Somatic cell count was converted to a linear score using the following equation:

SCC (linear score) = log2 (SCC×10^3 [unit/mL]/100) + 3 [9]

Results and Discussion

1. Blood concentration in milk

Dairy herd performance results, mean values for milk quality, and mean blood concentrations in milk from individual cows on Farms A and B are presented in Table 1. Mean blood concentrations in milk (± standard deviation) were 0.0017±0.0009% (n=57) for Farm A and 0.0026±0.0008% (n=140) for Farm B. In both cases, the concentrations were substantially below the visual detection limit (0.01%) and were not considered problematic.

2. Relationships between blood concentration in milk and herd performance measures

Correlations between blood concentration in milk and herd performance measures (month-age, calving

Table 1 Dairy herd performance measures, milk qualities, and blood concentration in milk at each farm (Mean±SD)

		Farm A (n=57)	Farm B (n=140)
Month-age		52 ± 20	61 ± 26
Calving number		2.7 ± 1.5	2.7 ± 1.6
Days after calving		179 ± 94	286 ± 193
Milk yield	[L/(day・cow)]	24 ± 6.5	23 ± 7.4
Milk qualities			
Somatic cell count	[$\times 10^3$cells/ml]	32 ± 34	109 ± 51
Fat	[%]	4.6 ± 0.83	4.1 ± 0.67
Protein	[%]	3.4 ± 0.43	3.6 ± 0.43
Blood contamination in milk	[%]	0.0017 ± 0.0009	0.0026 ± 0.0008

Table 2 Correlations between blood concentration in milk and herd performance measures, milk yield, and milk quality

	Farm A	Farm B
Month-age	0.528 **	0.272 **
Calving number	0.528 **	0.255 **
Days after calving	0.221	0.189 *
Milk yield	− 0.027	− 0.024
Milk qualities		
Somatic cell count	0.133	0.222 **
Fat	− 0.043	0.054
Protein	− 0.048	0.107

*P<0.05, **P<0.01

number, days after calving (excluding cases in which this was 500 d or greater), milk yield, as well as milk quality (somatic cell count, fat content, protein content) for Farms A and B are shown in Table 2.

Items found to be correlated with blood concentration in milk at the p<0.01 level included month-age and calving number for both Farms A and B and somatic cell count for Farm B. Days after calving was correlated with blood concentration in milk at the p<0.05 level for Farm B.

(1) Month-age

The relationship between month-age and blood concentration in milk is shown in Fig. 3. Month-age and blood concentration in milk were correlated (p<0.01) for both dairy farms (r=0.528** for Farm A and r=0.272** for Farm B), indicating a tendency toward higher blood concentrations in milk with increasing month-age.

(2) Calving number

The relationship between calving number and blood concentration in milk is shown in Fig. 4. Calving number and blood concentration in milk were correlated (p<0.01) for both dairy farms (r=0.528** for Farm A and r=0.255** for Farm B), indicating a tendency toward higher blood concentrations in milk with increasing calving number.

(3) Days after calving

The relationship between days after calving and blood concentration in milk is shown in Fig. 5. Days after calving and blood concentration in milk were not correlated for Farm A (r=0.221) but were correlated at the p<0.05 level for Farm B (r=0.189*). The

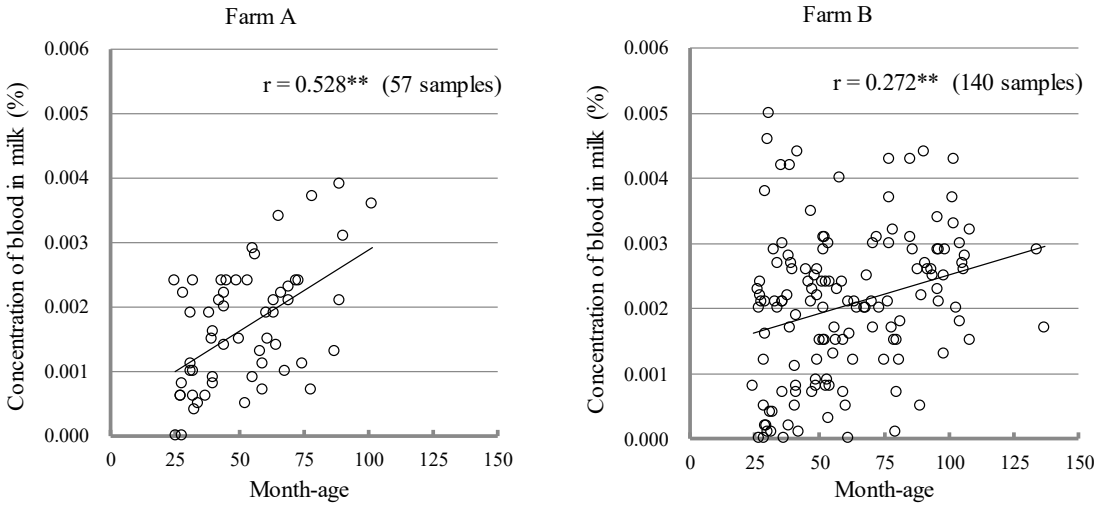

Fig. 3 Relationship between month-age and concentration of blood in milk

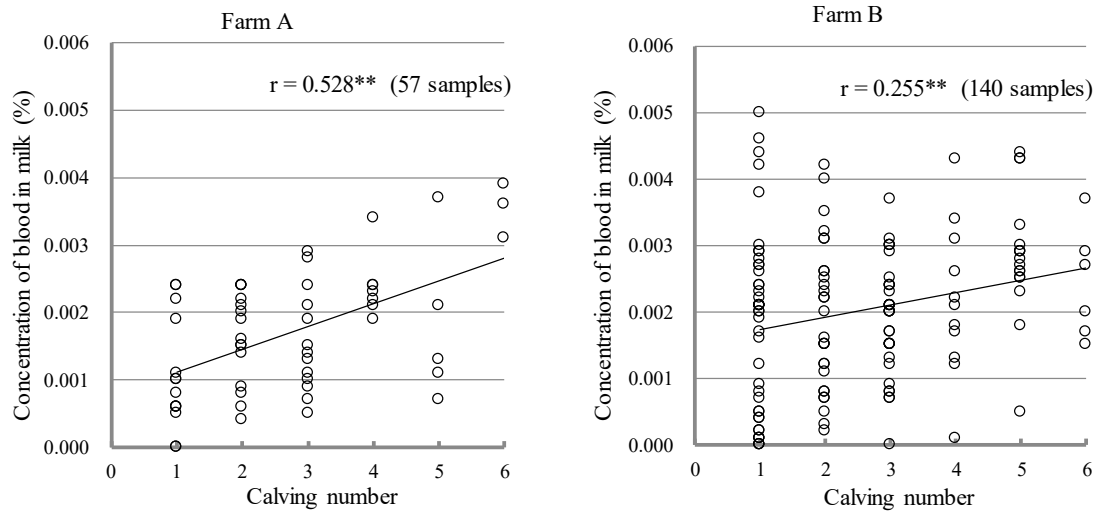

Fig. 4 Relationship between calving number and concentration of blood in milk.

difference in the observed trends between the farms may be related to the smaller number of individuals on Farm A showing poor reproductive performance, as indicated by the greater number of days after calving for Farm A compared with Farm B.

(4) Somatic cell count

The relationship between somatic cell count and blood concentration in milk is shown in Fig. 6. Somatic cell count and concentration of blood in milk were not correlated for Farm A (r=0.133) but were correlated at the $p<0.01$ level for Farm B (r=0.222**). This suggests that the blood concentration in milk also tends to be higher for individuals with a higher somatic cell count, which is a sign of inflammatory conditions. The lack of correlation between somatic cell count and blood concentration in milk for Farm A may be due to the fact that none of the individuals on Farm A had linear scores over 4 (somatic cell counts were 200,000 cells/mL or less in all cases).

The current our results suggest that, except for unusual circumstances such as inflammation or injury, there is little chance of blood occurring in ordinary

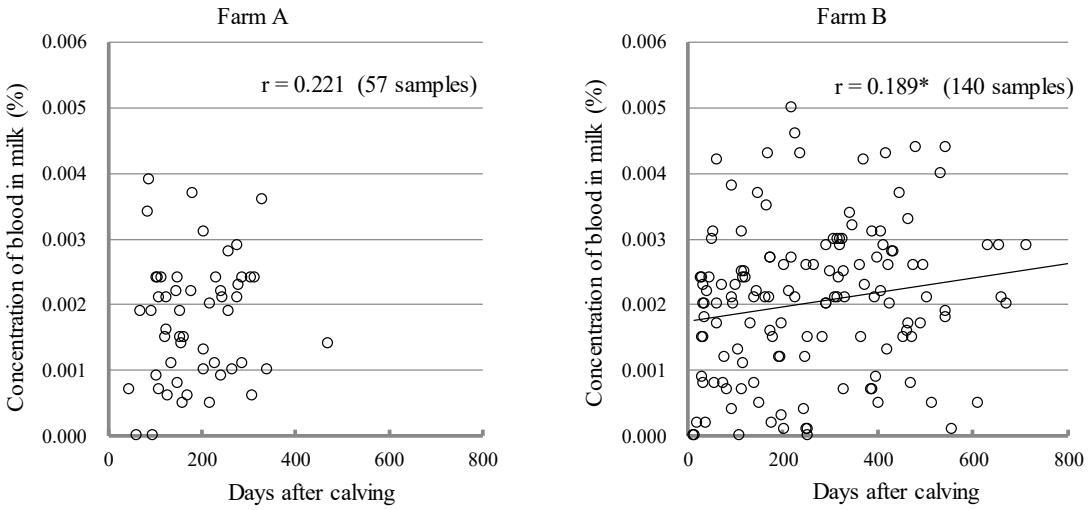

Fig. 5 Relationship between days after calving and concentration of blood in milk.

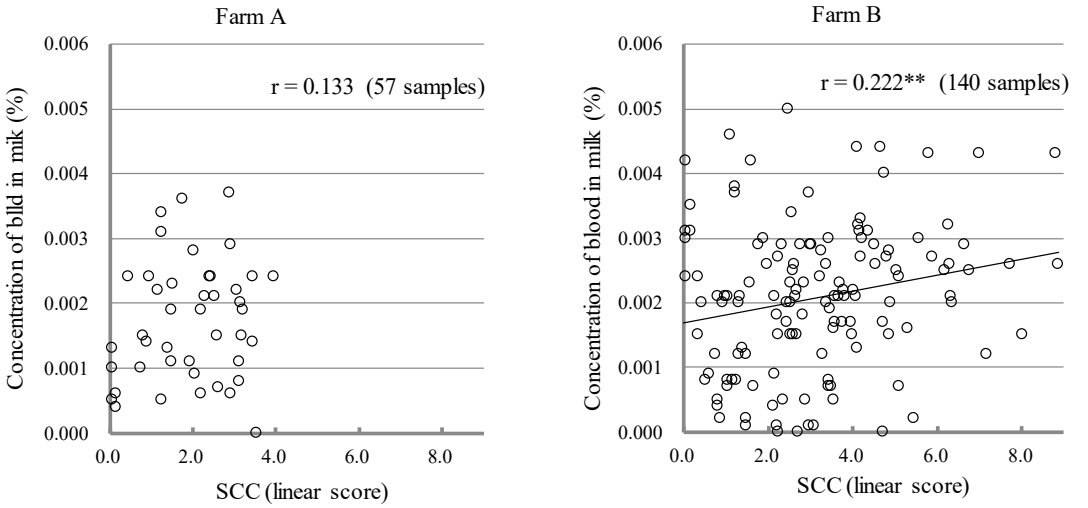

Fig. 6 Relationship between somatic cell count (linear score) and blood concentration in milk.

milk at high enough concentrations to give the milk a pink color. Furthermore, because no correlation was observed between milk yield and the blood concentration in milk, there is little risk of blood occurring in milk even for productive individuals with large udders under normal milking conditions.

In the future, we plan to investigate the relationship between mastitis and blood concentration in milk under different environmental conditions such as different seasons.

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研究ノート

乳牛の生乳中に潜在する血液量と乳質や牛群成績との関係に関する検討

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今まで行われてきた血乳検査方法である目視検査や高速遠心分離では、血液混入の有無のみの判断しかできなかった。しかし、とかち財団が開発した簡易型血液混入検査装置を用いることによって、目視の検出限界(0.01%)以下であっても、生乳中の血液濃度を定量することが可能となった。そこで本研究では、同装置を用いて通常の個体乳に含まれる血液濃度を検査するとともに、牛群検定成績を用いて、乳牛の年齢や繁殖、乳成分や乳量などの生理的条件と、生乳中の血液濃度との関係を検討することを目的とした。本試験に用いた生乳は、2酪農場(A・B)から提供を受けた、計197検体の個体乳とした。個体乳の血液濃度と標準偏差は、A酪農場が0.0017±0.0009(n=57)［%］、B酪農場は0.0026±0.0008［%］(n=140)であった。いずれも、目視で検出できる限界の血液濃度（0.01%）よりもはるかに低い値であった。A・B両酪農場で月齢が長く産次数が多い、高齢な個体であるほど生乳中の血液濃度が高まる傾向がみられた。また、B酪農場では分娩後日数が長く（すなわち繁殖成績が良くなく）、搾乳日数が延びることで体細胞数が増えている個体乳の血液濃度が高まる傾向であった。いずれもごく微量で問題がないと考えられる値であり、通常乳に含まれる血液量の平均値は、目視で確認できる限界濃度（0.01%）の1/5程度であった。

キーワード：血乳、乳質、牛群検定、体細胞数、酪農場

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