THE PHENOTYPIC RELATIONS BETWEEN SOMATIC CELL COUNTS AND MILK CONSTITUENTS OF CLINICAL AND NON-CLINICAL MASTITIS MILK OF DAIRY COWS

S. Kobayashi[1] and T. Ohtani[2]

Faculty of Agriculture, Meiji University, Kawasaki 214, Japan

Summary

Pathogen infections or mastitis inflammations usually develop differently on each udder of lactating cow. Although healthy udders will be attacked by the mastitis pathogens or the pathogens from blood in a long term, they would not be always inflamed. Somatic cell counts (SCC) in milk, which is utilized as an index of mastitis diagnosis, and the relation among SCC and milk constituents will have to be examined on each udder individually. Twelve cows of a Holstein cow herd in Nasu Research Station, which were suffering clinical or non-clinical mastitis, were selected, and SCC and milk constituents on each udder milk were measured. The effects of mastitis infection on udder milk components were relatively small except lactose content on udder milks of non-clinical mastitis (SCC $< 10.0 \times 10^5$ per ml milk). On udder milks of clinical mastitis, however, high negative correlations were recognized between SCC and milk components. On different sampling days, high contents of fat and protein corresponded to that of total solids.

(Key Words: Somatic Cell Counts, Milk Constituents, Non-Clinical Mastitis, Dairy Cow)

Introduction

Milk leukocytes increase together with infection to or outbreak of infectious deseases, and so the somatic cell counts (SCC) of milk have been generally utilized for detection of chronic or non-clinical mastitis (Jones et al., 1984; Nakano, 1987). SCC vary resulting from not only pathogenic infections (Dabdoub et al., 1984; Niemialtowski et al., 1988) but also from drug administrations (Nickerson et al., 1986), intakes of decomposed feed (Nakano, 1987), and other factors.

Bulk milk from each dairy farm usually contains 2.0-3.0 x 10^5/ml of somatic cells (Nakano, 1987; Vines, et al., 1986). The bulk milk is composed of a lot of cow milk, parts of which would be suffering attacks of infectious deseases, because a high quality milk from a healthy cow usually contains less than 1.0 x 10^5/ml cells.

The importance of SCC of milk from a point of clinical diagnosis is emphasized by the fact of relation between SCC and milk composition (Michael et al., 1987). It has been investigated in detail especially concerning protein. By injections of *Escherichia coli* endotoxin, a concentration of α-lactalbumin in blood possitively correlated with SCC in milk (Mcfadden et al., 1988), and they reflected the competency of blood-milk barrier (Capuco et al., 1986). In a field of survey, casein as a percent of true protein was lower for high somatic groups, and an increase in tyrosine value for incubated preserved milk indicated higher proteolytic activity in high somatic cell milk (Verdi et al., 1986)

The increase in permiating and sifting out competency of lobule cell membrane of udder, which had been infected with mastitis bacteria, had also affected the concentrations of milk fat and milk solids not-fat (Dabdoub et al., 1984; Jones et al., 1984).

In outbreaks of non-clinical or clinical mastitis, the inflammations are usually revealed only in parts (one or two) of four udders. In views of a preventive veterinary management, variations of extent in infection or inflammation of each udder have to be inspected. The competency of udder lobule cells being infected with mastitis pathogens will be naturally reduced. But, sound udders will be also, in a long term, infected by the pathogens

[1] Address reprint requests to Dr. S. Kobayashi, Laboratory of Animal Management, Faculty of Agriculture, Meiji University, Kawasaki 214, Japan

[2] Present address: Fuji Experimental Station of Animal Production, Tokyo University of Agriculture, Fumoto 156, Fujinomiya 418-02, Japan

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from neighboring inflammatory udders, which are suffering mastitis. During the procedure, the constituents of udder milk will differently change individually.

In this study, SCC and milk components of the udders of all the cows with clinical or non-clinical mastitis were examined. The changes in the extent of inflammation shown as SCC were also observed.

Materials and Methods

Twelve cows of a Holstein cow herd in Nasu Research Station, Tokyo University of Agriculture, were selected for the experiment. Their udder milks contained relatively high SCC, and only a part of the udders of some cows were diagnosed as clinical mastitis. A lot of cows which were at the first lactation secreted low SCC milks.

TABLE 1. CALVING CAREERS AND MILK PRODUCTIONS OF EXPERIMENTAL COWS

Cow no.	Calving sequence	Days after parturition	Milk yield (kg/day)	Somatic cell count ($\times 10^5$/ml)	Remarks
1	1st	198	10.4	1.4	
2	1	247	16.7	3.9	
3	2nd	171	27.2	14.5	under admin. antibiotics
4	3rd	37	35.5	3.5	
5	3	108	28.4	2.6	
6	3	144	19.2	0.3	healthy cond.
7	3	165	13.0	1.9	
8	3	174	12.0	1.3	
9	3	181	17.3	4.2	
10	4th	41	39.4	1.7	
11	4	107	16.1	0.8	healthy cond.
12	4	267	14.5	0.4	early dried up

The calving numbers, the days after parturition, milk yields and average SCCs of 4 udders at the beginning of the experiment were showed in table 1.

Udder milks from 48 teats were sampled by hand-milking before routine milking at evening three times during the experimental period. SCCs were measured by the Breed Method (Kato, 1963). Contents of fat, protein, lactose and total solids were measured by Milko-scan 203 (Foss Electric Co., Denmark). Diet fed to the cow herd during 10 days preliminary and through the experimental period was described in table 2.

Based on SCC level at the beginning of the experiment, each udder was divided to 4 groups as follows; Group A: 0.0–1.0x10^5/ml cells, Group B: 1.1–3.0x10^5/ml cells, Group C: 3.1–10.0x10^5/ml cells, and Group D: more than 10.0x10^5/ml cells. Popular analytical methods (Yokouchi, 1982) were referenced for a statistical analysis of the results.

Results and Discussion

SCC and milk components on different sampling days

Average SCCs and milk components of udder milk at the beginning, on the 21st day, and on the 42nd day were showed in table 3. Through the period, both the SCC and the milk components closely resembled each another, and their differences between sampling days were not recognized. Milk fats were lower than usual values. They might have been caused by the sampling prior to the routine milking.

SCC and milk components on each cow

SCCs and milk components on each cow were showed in table 4. Cow no. 3, which was under antibiotics administration because of clinical mastitis, a little recovered during the period, and the SCC of an inflammatory udder milk remarkably decreased. Cow no. 6 was under healthy con-

TABLE 2. COMPOSITION OF THE FEED GIVEN (PER HEAD, DAY)

Feedstuff	Daily provision per head			
	Weight kg	TDN* kg	CP* kg	V_A* 10^3IU
Wheat bran	2.0	1.20	0.31	2
Corn grain (rolled)	2.0	1.36	0.17	2
Rye grain (rolled)	3.0	2.04	0.35	0
Soybean seeds (parched)	1.2	0.97	0.43	0
Cotton seeds	1.8	1.50	0.38	0
Beet pulp (dehydrated)	2.2	1.42	0.15	0
Alfalfa (pellet)	1.5	0.77	0.21	34
Alfalfa (cube)	1.8	0.82	0.23	15
Brewers grain (wet)	2.0	0.40	0.16	0
Silage (mixed grass)	10.5	1.67	0.40	34
Fish meal	0.15	0.07	0.06	0
Pre-mix	0.35	–	–	30
Table salt	0.10		–	–
Total	28.60	12.22	2.85	117

*Contents were calculated based on "Composition of feeds commonly used in dairy cattle ratios" (National Research Council, 1978).

dition through the period, which was selected for comparison. Cow no. 11 was attacked by mastitis pathogens, and the udder milk SCC remarkably increased. Cow no. 12 was dried up too early during the period because of low milk yield. SCCs of the other cows showed relatively small changes.

SCC and milk components on udder groups classified based on SCC level

Average SCCs of Group A, B, C and D were (0.4±0.2) x 10^5/ml, (1.6±0.7) x 10^5/ml, (5.3±2.7) x 10^5/ml, and (44.5±29.4) x 10^5/ml through the period, respectively. Fat contents significantly differed between the groups. The difference might have originated in the genetic characteristics of the cows which belonged frequently to each group. Concentrations of milk components except milk fat did'nt indicate significant differences.

Correlation cofficients between SCC and milk components

1) Correlation coefficients on different sampling days: Correlation coefficients between SCC and milk components at the beginning day and on the 21st day were showed in table 6, and those on

TABLE 3. MEANS AND STANDARD DEVIATIONS OF UDDER MILK SAMPLED BEFORE ROUTINE MILKING ON DIFFERENT EXPERIMENTAL DAYS (N = 11x4 - 44)

Duration of experiment	Fat (%)	Protein (%)	Lactose (%)	Total solids (%)	SCC (x10^5)
0	2.54±0.70	3.50±0.37	4.60±0.37	11.49±0.84	5.6±10.0
21	2.53±0.71	3.37±0.33	4.59±0.37	11.37±0.94	7.0±14.3
42	2.72±0.59	3.38±0.31	4.55±0.37	11.53±0.81	6.6±1.46

TABLE 4. MEANS AND STANDARD DEVIATIONS OF UDDER MILK SAMPLED BEFORE ROUTINE MILKING ON EACH COW

Cow No.	Fat (%)	Protein(%)	Lactose(%)	Total solids(%)	SCC(x10^5)
1	2.28±0.57	3.65±0.16	4.82±0.11	11.63±0.54	1.3± 2.4
2	3.68±0.27	4.06±0.13	4.59±0.21	13.20±0.30	12.5±16.6
3	2.63±0.30	3.24±0.11	4.57±0.20	11.32±0.26	6.9±15.7
4	1.98±0.40	3.44±0.15	4.76±0.38	11.05±0.37	14.4±20.9
5	3.02±0.32	3.24±0.12	4.78±0.14	11.92±0.31	6.3± 8.6
6	2.37±0.28	3.79±0.08	4.79±0.21	11.83±0.43	0.5± 0.3
7	3.36±0.38	3.24±0.12	4.53±0.30	12.01±0.38	11.0±19.5
8	2.95±0.29	3.17±0.17	3.95±0.58	10.94±0.73	1.7± 0.9
9	2.29±0.46	3.31±0.15	4.34±0.22	10.82±0.48	12.4±20.4
10	1.98±0.41	3.00±0.23	4.80±0.25	10.65±0.51	3.9± 6.2
11	2.99±1.13	3.34±0.20	4.27±0.78	11.48±1.27	14.9±33.0

TABLE 5. MEANS AND STANDARD DEVIATIONS OF UDDER MILK SAMPLED BEFORE ROUTINE MILKING IN FOUR UDDER GROUPS CLASSIFIED BY CELL COUNTS

Group*	Fat (%)	Protein (%)	Latose (%)	Total solids (%)	SCC ($x10^5$)
A (Excellent)	2.23±0.61	3.47±0.38	4.78±0.18	11.36±0.75	0.4± 0.2
B (Good)	2.93±0.78	3.41±0.37	4.33±0.53	11.56±1.05	1.6± 0.7
C (Nonclinical mastitis)	2.56±0.63	3.30±0.27	4.46±0.52	11.20±0.95	5.3± 2.7
D (Clinical mastitis)	3.05±0.62	3.57±0.34	4.00±0.70	11.50±1.05	44.5±29.4

*Divided according to the following SCC at the beginning of the experiment, A: $0.0-1.0x10^5$ SCC per ml milk, B: $1.1-3.0x10^5$ SCC per ml milk, C: $3.1-10.0x10^5$ SCC per ml milk, and D: more than $10.0x10^5$ SCC per ml milk.

TABLE 6. CORRELATION COEFFICIENTS BETWEEN MILK COMPONENTS AND SOMATIC CELL COUNTS OF UNDER MILK ON THE DAY OF START AND ON THE 21ST DAY

On the start	Fat (v)	Protein (w)	Lactose (x)	T. solids (y)	SCC (z)	Factor
SCC (z)	0.315*	0.124	-0.339*	0.182	–	z
T. solids (y)	0.807**	0.636**	0.039		0.024	y
Lactose (x)	-0.428**	-0.081	–	0.359*	-0.203	x
Protein (w)	0.316*	–	0.136	0.665**	0.197	w
Fat (v)	–	0.351*	-0.129	0.831**	0.047	v
Factor	v	w	x	y	z	On 21st

*Significant at p = 0.05.
**Significant at p = 0.01.

TABLE 7. CORRELATION COEFFICIENTS BETWEEN MILK COMPONENTS AND SOMATIC CELL COUNTS OF UDDER MILK ON THE 42ND DAY

On 42nd	Fat (v)	Protein (w)	Lactose (x)	T. solids (y)	SCC (z)
SCC (z)	0.069	0.106	-0.298	-0.466**	–
T. solids (y)	0.724**	0.600**	0.511**	–	
Lactose (x)	-0.114	0.301	–		
Protein (w)	0.097				
Fat (v)	–				

**Significant at p = 0.01.

the 42nd day in table 7. On either day, high contents of fat and protein corresponded to that of total solids. Lactose contents also corresponded to the total solids. Significant correlations were also recognized between fat and protein. High SCCs had a tendency to lower the lactose contents on either day. A significant negative correlation was recognized between SCC and total solids only on the 42nd day.

2) Correlation coefficients on 4 groups classi-

fied based on SCC: Correlation coefficients between SCC and milk components on Group A and B were showed in table 8, and those on Group C and D in table 9. It would be concluded that high contents of fat, protein and lactose corresponded to that of total solids. The relations between each milk component were not clear. High negative correlations were recognized between SCC and lactose content, especially on Group A and D, and also on Group B. A high positive correlation between SCC and fat content on Group B might be regarded as a specific case, because negative correlations were showed between them on Group A and D.

When a consideration is limited to a non-clinical mastitis, the results on Group B and C would be most appropriate for estimation, that is the effects of mastitis infection on udder milk constituents are relatively small except lactose content. In Group D, which is regarded as a group of clinical mastitis udder, however, the effects of mastitis inflammations on all the milk components are noticeable. The permiating and sifting out ability of lobule cell membrane might be maintained still at the stage of non-clinical mastitis (SCC $< 10.0 \times 10^5$ per ml).

TABLE 8. CORRELATION COEFFICIENTS BETWEEN MILK COMPONENTS AND SOMATIC CELL COUNTS OF UDDER MILK OF GROUP A[1] AND B[2]

Group A	Fat (v)	Protein (w)	Lactose (x)	T.solids (y)	SCC (z)	Factor
SCC (z)	-0.175	0.228	-0.574**	-0.163	–	z
T. solids (y)	0.855**	0.650**	-0.137	–	0.273	y
Lactose (x)	−0.156	-0.192	–	0.634**	-0.330	x
Protein (w)	0.227	–	0.520*	0.518*	0.089	w
Fat (v)		-0.130	-0.110	0.663**	0.549*	v
Factor	v	w	x	y	z	Group B

*Significant at p = 0.05.
**Significant at p = 0.01.
[1] Cow udders, milk of which contains $0.0-1.0 \times 10^5$ SCC per ml milk.
[2] Cow udders, milk of which contains $1.1-3.0 \times 10^5$ SCC per ml milk.

TABLE 9. CORRELATION COEFFICIENTS BETWEEN MILK COMPONENTS AND SOMATIC CELL COUNTS OF UDDER MILK ON GROUP C[1] AND D[2]

Group C	Fat (v)	Protein (w)	Lactose (x)	T. solids (y)	SCC (z)	Factor
SCC (z)	0.374	0.274	0.040	0.347	–	z
T. solids (y)	0.689**	0.731**	0.620**	–	-0.673**	y
Lactose (x)	-0.184	0.495*	–	0.645**	-0.590**	x
Protein (w)	0.273	–	-0.182	0.400	-0.164	w
Fat (v)	–	0.330	0.136	0.744**	-0.383	v
Factor	v	w	x	y	z	Group D

**Significant at p = 0.05.
*Significant at p = 0.01.
[1] Cow udders, milk of which contains $3.1-10.0 \times 10^5$ SCC per ml milk.
[2] Cow udders, milk of which contains more than 10.0×10^5 SCC per ml milk.

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