J Vet Clin 19(4) : 391-396(2002)

Comparison of Blood Biochemical Values between High and Low Producing Holstein Cows

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Abstract : This study investigated blood biochemical values between high and low yielding dairy cows, in order to suggest a means for the improvement of milk production. A total of 30 Holstein cows (3rd to 5th of parity) were used and assigned to two groups according to milk production levels at 15, 30, 60 and 90 days postpartum. Milk production of group A was less than an average of 27 kg/day and that of group B was an average of 30 kg/day. Blood samples were collected by jugular venipuncture from each cow six times at 15 days before the anticipated calving date, within 12 hours postpartum (0 days) and at 15, 30, 60 and 90 days after calving. In serum mineral concentrations, group B was consistently higher than group A in both Mg and Ca. Inorganic phosphorus concentrations showed a little fluctuation between the groups at antepartum and at postpartum, but group B was significantly higher than group A at 15 and 30 days after calving ($p < 0.05$). In serum biochemical values cholesterol concentrations were consistently higher in group B except at 0 days. BUN and glucose concentrations did not differ between the groups. The concentration of vitamin A of group B was significantly higher than group A at 15 days before the anticipated calving date and at 15 days postpartum ($p < 0.01$), but at 30, 60 and 90 days postpartum vitamin A concentration of both groups were similar. Vitamin E concentration did not differ between the groups during the experimental period. Results of this study suggest that raising the levels of Mg, Ca, Pi and vitamin A in serum would be effective in increasing milk production of low producing cows.

***Key words* :** Holstein cows, milk production, blood biochemical values

Introduction

Milk production is affected by hereditary factors, lactation number, season, length of the dry period, disease and nutrients[24]. Among these factors nutrient intake is closely related to the prevalence of metabolic disease in lactating and pregnant dairy cows. Nutritional status also plays an important role in mammary gland development, differentiation and subsequent lactation[27]. Nutrients are carried from the digestive tract to the tissues by blood as a transport medium. So blood biochemical values are used as an indicator of nutritional status and for the diagnosis of a disease.

Metabolic profiles reflected either dietary inadequacies or disease states. Concentrations of blood constituents in lactating dairy cattle can vary with the stage of lactation[2,8,9,18,23,28] and with milk yield[7,10].

Milk production increases gradually at postpartum and then comes to a peak point of lactation at 4-8 weeks after calving[27]. During early lactation, there is an increase in the use of nutrients because of milk production and there may also be a higher prevalence of disease during the periparturient period. Therefore nutritional control is very important in the management of dairy cows during the periparturient period.

During the 1970's greater interest was shown in the metabolic profile testing of dairy cows to identify problem of management and of health[11,15-17,21,22]. Payne *et al.*[15] had proposed for the first time a metabolic profile test suggesting a normal range of blood constituents based on tests carried out on 2,400 cows in 13 herds. In Korea, Lee *et al.*[12] reported that the metabolic profile test had something to do with milk production.

Plasma vitamin A and serum vitamin E concentrations decrease in periparturient cows[6,26] and because of this, deficiencies of these vitamins are frequently observed during the periparturient period in dairy cows. Also cows, during the periparturient period, are prone to new intramammary infection that contribute significantly to mastitis in dairy herds and reduced milk quality.

As mentioned above, blood biochemistry has been used for the screening of nutritional status. The objective of the study reported here was to investigate and compare blood biochemical values between high and low yielding cows.

Materials and Methods

Experimental animals and design

A total of 30 Holstein cows (3rd to 5th of parity) which were anticipated to calve within 3-4 months were selected from a single herd on Cheju island. The animals were healthy and had no clinical mastitis. The cows were fed 3 kg of concentrated feed twice a day, morning and evening and then were allowed to graze *ad libitum.*

Animals were assigned to two groups according to their average of milk production at 15, 30, 60 and 90 days postpartum. The average milk production of group A and group B

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were less than 27 kg/day and more than 30 kg/day, respectively.

Sampling

Blood samples were collected by jugular venipuncture from each cow six times; at 15 days before the anticipated date of calving, within 12 hours postpartum (0 days) and at 15, 30, 60 and 90 days after calving. Two types of sample tubes were used; one contained no additive and the other contained ethylene-diamine tetracetic acid (EDTA) to examine serum biochemical values and hematological values, respectively. Serum was kept frozen at -72°C for subsequent analyses of Mg, Ca, inorganic phosphorus (Pi), cholesterol, blood urea nitrogen (BUN), glucose, vitamin A, and E.

Methods of examination

The milk production of each cow was measured four times at 15, 30, 60 and 90 days postpartum; the mean of the 4 values was used to assign cows to either one of the two groups.

Serum was analyzed for magnesium by spectrophotometry using Asan kits (Asan Co., Korea) calcium, cholesterol, BUN and glucose by spectrophotometry using Young-dong kit (Young-dong Co., Korea). Pi was measured by automatic analyzer (HITACHI 7170, HITACHI Co., Japan). Vitamin A and E were measured by HPLC using 515 pump (Waters Co, USA), 474 Fluorescence detector (Waters Co, USA) and 746 data module (Waters Co, USA).

Statistical analysis

The data were analyzed by paired-*t* test. Eight animals were excepted in the statistical analysis owing to the fact that 3 of them produced milk irregularly and 5 of them were within the middle range of milk production levels.

Results

Milk production

The differences of milk yield between the groups are shown in Figure 1. The total average of milk production between 15 and 90 days after calving was 29.2 ± 5.6 kg; 24.4± 2.2 in group A and 34.0± 3.6 kg in group B. In group A average milk production at 15, 30, 60 and 90 days after calving was 25.5 ± 3.0, 27.9 ± 2.7, 24.8 ± 3.0, 20.8 ± 3.8 kg, respectively. And in group B average milk production at 15, 30, 60 and 90 days after calving was 33.5 ± 5.8, 36.5 ± 3.9, 33.7± 3.9, 32.3± 4.5 kg respectively. At 30 days after calving both A and B groups showed peak milk production and then decreased slowly as time went on. Group A's production decreased more rapidly than Group B's at 90 days post calving.

Serum mineral concentration

The serum mineral concentrations of animals in each group are shown in Table 1. Group B was significantly higher

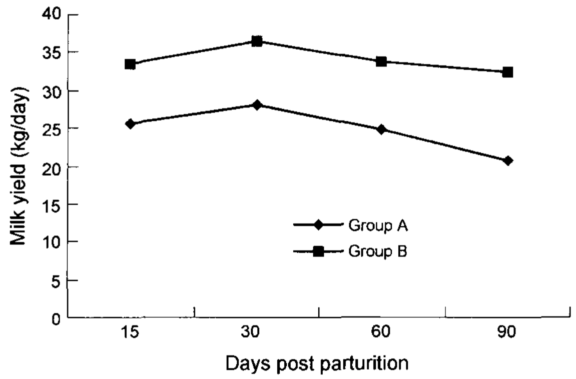

Fig 1. Milk yield of Holstein cows in early lactation periods. Group A: Low yielding cows, Group B: High yielding cows.

Table 1. Mineral concentrations of Holstein cows according to milk yield in early lactation periods. (Means ± SD)

Days	Group	N	Mg (mg/dl)	Ca (mg/dl)	Pi (mg/dl)
BP15	A	12	1.81± 0.35^{a*}	8.16± 0.36^{e**}	6.26± 0.61
	B	10	2.12± 0.13^{A*}	8.79± 0.44^{E**}	6.21± 0.71
PP0	A	12	2.05± 0.35^{b*}	7.49± 0.72^{f**}	5.73± 1.02
	B	10	2.35± 0.19^{B*}	8.42± 0.42^{F**}	5.06± 0.56
PP15	A	12	1.97± 0.23^{c*}	8.50± 0.92	4.68± 0.52^{h*}
	B	10	2.32± 0.23^{C*}	8.68± 0.24	5.44± 0.64^{H*}
PP30	A	12	1.81± 0.28	8.56± 0.38^{g**}	5.11± 0.47^{i*}
	B	10	1.83± 0.28	9.15± 0.36^{G**}	5.61± 0.61^{I*}
PP60	A	12	2.04± 0.20^{d**}	8.95± 0.24	5.34± 0.44
	B	10	2.28± 0.10^{D**}	8.97± 0.33	5.72± 0.52
PP90	A	12	2.10± 0.15	8.55± 0.19	5.48± 0.77
	B	10	2.23± 0.16	8.78± 0.59	5.48± 0.67

BP: Before anticipated parturition, PP: Post parturition, A: Low yielding cows,
B: High yielding cows, N: number of heads.
A:a, B:b, C:c, D:d, E:e, F:f, G:g H:h, I:i; Significantly differential pairs (*; $p < 0.05$, **; $p < 0.01$).

than group A in concentrations of Mg and Ca. Mg showed a significant difference between the groups from 15 days before the anticipated calving time to 15 days postpartum ($p < 0.05$) and group B was very significantly higher than group A at 60 days postpartum ($p < 0.01$). In Ca, group B was very significantly higher than group A at 15 days before the anticipated calving date, 0 days and at 30 days postpartum ($p < 0.01$). Inorganic phosphorus concentrations showed a little fluctuation between the groups at antepartum and postpartum but group B is significantly higher than group A at 15 and 30 days after calving ($p < 0.05$).

Serum cholesterol, BUN and glucose

Differences of cholesterol, BUN and glucose concentrations between groups are illustrated in Table 2. With the exception of the time of calving (0 days), serum cholesterol concentrations were consistently higher in group B than in group A. At 60 days after calving, group B is significantly higher than group A in cholesterol concentration. There were no significant differences in the blood urea nitrogen and glucose concentrations between the two groups of cows, which were grouped based on their 90-days milk production levels.

Serum vitamin A and E

Group B is significantly higher than group A in vitamin A (retinol) at 15 days before the anticipated calving date and at 15 days after calving ($p < 0.01$). But there are similarity in serum vitamin A and E concentration between the groups at 30, 60 and 90 days postpartum (Fig 2).

Vitamin E (α-tocopherol) concentration was not differ between the groups (Fig 3). Vitamin A and E levels showed very low concentration from before anticipated calving to 15 days postpartum (early pasture season; March and April). Then vitamin A and E levels increased in both groups at 30

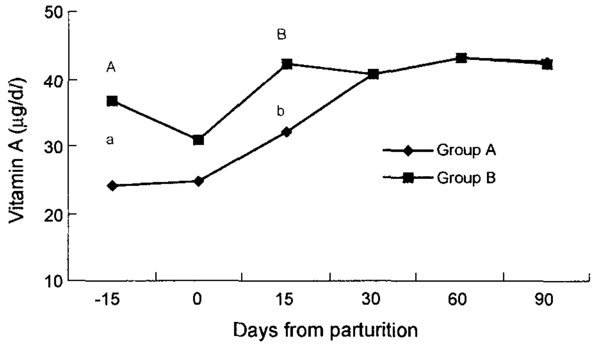

Fig 2. Differences in serum vitamin A between high and low yielding cows in early lactation. At 15 days before the anticipated calving date and at postpartum day 15, group B is significantly higher than group A in vitamin A but at postpartum days 30, 60, 90 both groups are similar. Group A: Low yielding cows, Group B: High yielding cows, A:a, B:b; Significantly differential pairs ($p < 0.01$).

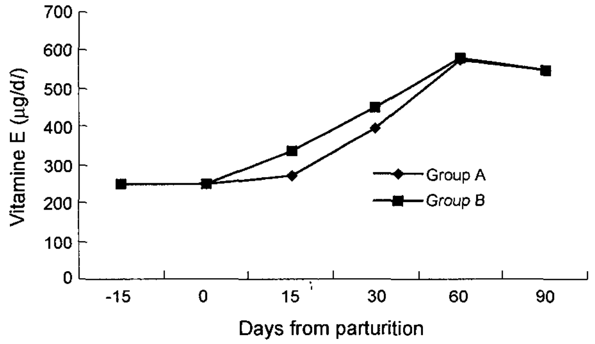

Fig 3. Differences in serum vitamin E between high and low yielding cows in early lactation. Vitamin E (α-tocopherol) concentrations in the groups were similar in early lactation. Group A: Low yielding cows, Group B: High yielding cows.

Table 2. Concentrations of serum cholesterol, urea nitrogen and glucose of Holstein cows according to milk production in early lactation periods (Mean ± SD)

Days	Group	N	Cholesterol (mg/dl)	BUN (mg/dl)	Glucose (mg/dl)
BP15	A	12	66.8±23.0	14.5±2.01	41.4±10.0
	B	10	76.1±15.2	16.7±3.07	41.4±6.5
PP0	A	12	77.3±15.4	22.9±4.42	54.2±9.0
	B	10	75.0±10.0	26.1±5.80	56.7±8.9
PP15	A	12	72.4±22.0	16.7±3.00	49.3±5.4
	B	10	88.9±14.0	14.7±1.08	46.3±6.8
PP30	A	12	78.1±10.6	17.3±3.05	45.9±3.6
	B	10	88.7±39.0	17.3±3.20	45.4±6.9
PP60	A	12	111.2±14.7[a]	19.4±2.70	39.1±5.3
	B	10	128.9±13.5[A]	19.5±3.50	39.6±5.4
PP90	A	12	104.9±17.1	18.6±3.32	42.6±8.7
	B	10	121.5±14.2	17.8±1.94	47.2±4.2

BP: Before anticipated parturition, PP: Post parturition, A: Low yielding cows,
B: High yielding cows N: number of heads, [A:a] ;Significantly differential pair ($p < 0.05$).

and 60 days postparturition.

Discussion

Metabolic profile testing is useful to identify dietary causes of disease, or of low production in dairy cows. The test is based on the assessment of blood constituents. In previous research reports, most of the variation in blood chemical values was due to differences in herds, stage of lactation and seasonal effect[11, 16, 17].

The lower Mg concentrations which occur in nonlactating cows are related to the lower intakes of Mg [23]. Jones *et al.*[7] reported that Mg concentration of high producing herds was higher than that of low producing herds. Also in this study high yielding cows were consistently higher than low yielding cows in concentrations of Mg. And Wolff *et al.*[30] reported that Mg supply would increase milk production. It is thought that Mg is one of the nutrients most directly related with milk production during early lactation.

Concentration of calcium in blood decreases because the calcium requirement for milk synthesis exceeds availability at parturition. In this study also the tendency for calcium concentration to decrease after calving was noticed. Concentration of serum calcium tended to decrease as Mg concentration increased. This result is similar to those of the previous reports[11, 13]. When compared to the values of Ca from other studies[11, 29], the values of this research showed slightly lower levels ($7.49 \pm 0.72 \sim 9.15 \pm 0.36$ mg/dl) but none of the experimental animals suffered from milk fever. The results of this study showed that high yielding cows were higher than low yielding cows in the concentration of calcium. Shappell *et al.* [25] reported that feeding lower dietary calcium to cows in the prepartum period was effective in the prevention of severe hypocalcemia at parturition.

Deficiency of inorganic phosphorus causes depressed or poor growth rates, softening of the bones and reproductive problems[3], and low phosphorus intakes of lactating cows reduced feed intake and milk yield. In this research the concentration of inorganic phosphorus in two groups showed a little fluctuation at antepartum and postpartum but the concentration of inorganic phosphorus of high yielding cows was significantly higher than that of low yielding cows at 15 and 30 days after calving.

Cholesterol levels change over the lactation-pregnancy cycle with low content in early lactation increasing with the number of days milked[18]. And Puppione *et al.*[19] stated that this increase in cholesterol is associated with increased lipoprotein synthesis and changes among the various types of lipoproteins, which are required for lipid transport. This study also showed that cholesterol concentration increased with lactation progressing. Cows conceived with below 2 services had higher serum cholesterol values than cows requiring more services[20]. Cholesterol concentrations are reported to be directly related to milk production from 25 through 88 days postpartum[9]. Results of this study also showed that blood cholesterol levels were related to milk production.

Serum urea nitrogen concentration in dairy cows has been described as a sensitive indicator of protein intake and solubility. Concentration of serum urea nitrogen is higher in summer and lower in winter because of higher protein intake during the grazing season[11]. Usually the increase in serum urea concentrations after calving is attributed to a higher dietary supply of nitrogen[31]. In this study BUN also increased after calving. But there was no difference in BUN when cows were compared by groups according to milk yield in early lactation.

Concentrations of glucose in blood is related to supply of energy. The decrease in the concentration of glucose at the end of pregnancy may be due to a relatively poor diet and/or a higher energy requirement for fetal anabolism[28]. Erfle *et al.*[1] and Jenny *et al.*[4]. reported that blood glucose appeared to be a poor indicator of either energy balance or dietary intake of energy, particularly in early lactation. In this study, there was no difference in the concentration of glucose between the two groups during early lactation.

Vitamin A and E are important nutrients, for maintaining health in dairy cattle. While most of the vitamins are synthesized in the body, vitamins A and E are not synthesized and therefore vitamin A and E need to be supplemented in feed. Jo[5] reported that serum vitamin A is lower in winter than in summer. And Jonhston and Chew[6] reported that plasma vitamin A concentrations decreased in periparturient cows. In this study the concentration of vitamin A of low yielding cows was significantly lower than that of high yielding cows at 15 days before calving (in early spring). And low yielding cows had very lowered concentration of vitamin A in the early grazing season (before calving). These facts indicate that the prevalence of vitamin A deficiency may be higher in low yielding cows which are due to calve before the grazing season. Miller *et al.*[14] reported that dairy cows had lower serum vitamin E concentrations in winter and early spring. In this study also vitamin E concentration was lower before calving (in early spring), but vitamin E concentration did not differ between two groups. In this study vitamin A and E concentration were increased as time went on (from March to July). These results are due to the fact the experimental dairy cows were grazing at pasture during the later period of research. Due to the low levels of vitamin A and E in cattle before the grazing season there may be a need to supplement feed with vitamin A and E at this time to avoid deficiency.

The present work has indicated the existence of differences between milk yield and certain blood chemical values during early lactation (from 15 days before anticipated calving time to 90 days postpartum). And milk production declined more rapidly in low yielding cow after the peak production (at 30 lays post calving). So it is thought that proper management needs to try to keep up milk yield in low yielding cows during early lactation.

In conclusion, these results were suggests that if the levels of Mg, Ca, Pi and vitamin A in serum were raised, milk production would be increased in low producing cows during early lactation.

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젖소에서 고능력우와 저능력우의 혈액화학치의 비교

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요 약 : 젖소에서 우유생산량의 증가시키기 위한 방안을 제시하기 위하여, 고능력우와 저능력우의 혈액화학치를 조사 연구하였다. 젖소 30두(3산에서 5산 사이)를 분만후 15, 30, 60, 90일의 착유량을 기준으로 두 군으로 나누었다. 착유량이 27 kg/day 이하인 군을 A(group A)군으로 하고, 30 kg/day 이상인 군을 B(group B)군으로 하였다. 혈액 샘플은 경정맥을 통하여, 분만전 15일, 분만후 12시간 이내(0 days), 분만후 15, 30, 60, 90일에 채혈하였다. 혈액 광물질 중 Mg과 Ca 농도는 B군이 A군보다 지속적으로 높았다. 무기인 농도는 두 군간에 분만전후에 변동이 있었으나, 분만후 15일과 30일에는 B군이 A군보다 유의성있게 높았다 ($p<0.05$). 혈액화학치 중에 cholesterol 농도는 분만당일을 제외하고는 B군이 지속적으로 높았고, BUN 농도와 glucose 농도는 두 군간에 차이가 없었다. 비타민 A 농도는 분만전 15일과 분만후 15일에 B군이 A군보다 유의성있게 높았고 ($p<0.01$), 비타민 E 농도는 실험기간 동안에 두 군 사이에 차이가 없었다. 결과적으로 우유 생산량을 증가시키기 위해서 저능력우에 분만 전후에 사료 중에 Mg, Ca, Pi 과 비타민 A를 첨가하여주는 것이 효과가 있을 것이다.

주요어 : Holstein 젖소, 우유 생산량, 혈액 화학치