Effect of Some Environmental Factors on Colostrum Quality and Passive Immunity in Brown Swiss and Holstein Cattle

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ABSTRACT

In cattle, immunoglobulins, which provide passive immunity to the new-born calf, are transferred through the colostrum. This study was aimed to investigate the effect of some environmental factors on colostrum quality in Brown Swiss and Holstein cows and on the blood serum immunoglobulin G (IgG) levels of their calves. The study material consisted of 90 colostrum samples taken from 51 Brown Swiss and 39 Holstein cows and of 90 blood serum samples obtained from their calves. The milk colostral and serum IgG levels were measured by using electrophoresis equipment. It was determined that breed, number of lactations, milk yield and the length of the dry period had no effect on the colostral IgG levels. The lowest colostral IgG level was detected in cows which had calved during the summer season. It was determined that while the serum IgG levels of the calves were not affected by breed, sex, lactation number or the length of the dry period but rather by birth season and ambient temperature at the time of parturition. A positive and high correlation (r=0.430) was calculated between colostral and blood serum IgG levels of the calves.

Keywords: Cattle; Neonatal; Immunity; IgG; Disease.

INTRODUCTION

The success of a cattle-breeding operation depends on the majority of the cows weaning a live calf every year, and on the maintenance of the health of new-born calves from birth to weaning (1). While mortality ranges between 1 to 5% in adult cattle, it may increase up to 30% in new-born calves (2, 3). Neonatal mortality, increased production costs per unit, and reduced selection intensity decrease the profitability of production (4, 5). Inadequate passive immunity in calves, increases the incidence of diseases, including among others diarrhoea, pneumonia and septicaemia, and also causes increased mortality rates prior to weaning (6, 7).

The syndesmochorial placenta of ruminants precludes the transmission of maternal antibodies from the dam to the calf during gestation (8-10). As calves do not receive any immune substance from the dam *in utero*, they are born either hypogammaglobulinemic or agammaglobulinemic (11, 12). Therefore, the only way of establishing passive immunity is to ensure that the calf receives colostrum (12, 13).

Literature reports indicate that in order to provide calves with an adequate passive immunity, the level of IgG in the bloodstream should be at least 10 mg/ml by the end of the 48^{th} hour postpartum (7). Several factors may prevent the blood serum IgG level from reaching this concentration, including among others, poor colostral quality, the timing of the provision of colostrum to the calf, the amount of colostrum received by the calf, the feeding and management conditions of the dam throughout gestation, exposure to excessive stress and alterations in the permeability of the intestines (9).

This study was aimed at the investigation of the colostrum quality of Brown Swiss and Holstein cattle and some environmental factors influential on the blood serum immunoglobulin G (IgG) levels of calves born to these animals.

MATERIALS AND METHODS

Farm and animal selection

The present study was conducted following the births of Brown Swiss and Holstein between November 2012 and February 2014 on a farm belonging to Ataturk University, Faculty of Veterinary Medicine in Erzurum province, east of Turkey (41.17˚E and 39.55˚N).

The study was conducted in accordance with ethical rules and procedures, and was approved by the Local Ethics Board for Animal Experiments (Certificate of Authorisation to Experiment on Living Animals N˚2012/78, The Local Ethical Committee of Ataturk University).

The test material consisted of milk colostrum samples which were collected from 51 Brown Swiss and 39 Holstein cows, and blood samples which were collected from 48 male calves and 42 female calves that were born from these cows.

The cows were raised in a semi-closed barn, and were fed on silage and dry meadow grass in the morning and on a mixture of silage, roughage and feed concentrate in the afternoon. The animals were provided with water by means of automatic watering nozzles placed inside the barn. The cows were dried off two months before calving.

The barn temperature was recorded during the birth. One hour after birth, the calves were separated from their dams, and transferred to individual boxes in the calf unit. During the first three days after birth, the calves were bottle-fed with the dam's colostrum and transition milk. Colostrum was provided to the calves in amounts equalling to 10% of their body weight and was given in two portions a day. Until 3 months of age, the calves were continued to be fed on milk, in amounts calculated in the same way and as from the second week, the calves were also provided with dry meadow grass and a calf starter feed. Water was provided *ad libitum*.

Until being weaned (within the first three months after birth), all of the calves were regularly examined on a daily basis for infections of the respiratory and digestive systems, and all morbidity and mortality cases were recorded.

Collection of Blood and Colostrum Samples

Following the cleaning and disinfection of the udders one hour after birth, colostrum samples were collected into 15 ml sterile tubes manually, milking from all the clinically healthy mammary glands and then pooled.

Twenty-four hours after birth, the neck region of the calves was cleaned and disinfected, and 10 ml blood samples were drawn from the jugular vein into sterile blood tubes, using a sterile cannula. These samples were centrifuged at 5000 rpm for 15 minutes using a centrifuge (LABOFUGE 200, Heraeus). Following centrifugation, the upper layer of blood serum was collected, transferred into Eppendorf tubes, and frozen. The colostrum and blood samples were first frozen at -20˚C, and later stored at -80˚C until being analysed.

Biochemical Analyses

The IgG levels of the colostrum and blood serum samples were determined by electrophoresis. The frozen samples were thawed at +4 ºC and then stained, and the dried gels were scanned so that their images were transferred to a computer. The images were analysed using the Image Lab. Software, Bio-Rad (Version 4.0).

Data Classification

The colostrum samples collected from the cows which had calved, were assigned to three groups on the basis of the IgG levels they contained. These groups were as follows: low quality colostrum (30 to 50 mg/ml), medium quality colostrum (50 to 70 mg/ml) and high quality colostrum (>70 mg/ml). The blood serum samples of the calves were assigned to two groups also on the basis of the IgG levels they contained. These groups were as follows: low quality blood serum (<10 mg/ml) and high quality blood serum (>10 mg/ml).

Statistical Analyses

The factors, which were considered potentially influential on the IgG levels of the colostrum and blood serum samples, were analysed using the General Linear Model (GLM) procedure. The groups were compared with Duncan's multiple comparison test. The correlation of the IgG levels of the colostrum and blood serum samples with the ambient temperature at the time of parturition, the length of the dry period, and the milk yields of the animals in the previous lactation periods was assessed by a parametric correlation method.

The effect of the colostrum quality on the incidence of respiratory and digestive system infections and mortality in calves was analysed by the non-parametric Kruskal-Wallis test. The effect of the blood serum IgG level on the incidence of respiratory and digestive system infections and mortality in calves was analysed with the Mann-Whitney U test.

All statistical analyses were performed using the SPSS programme. Data were expressed as mean ± standard error. Statistical value of *P*<0.05 was considered significant.

RESULTS

Of the colostrum samples collected, 7.78% was of low quality, 24.44% was of medium quality and 67.78% was of high quality. The mean colostrum IgG level was determined to be 79.51±4.80 mg/ml for the Holstein cows and 77.07±4.55 mg/ml for the Brown Swiss cows. The effects of breed, lactation number, milk yield and the length of the dry period on the colostrum IgG levels were found not to be significant. In contrast, cows, which had calved in summer, were found with significant lower colostral IgG levels *(P<0.05)* (Table 1).

Of the 90 blood samples collected, 17 were determined to be of low quality and 73 were determined to be of high qual-

Table 1: Analysis of Variance results, number of cows, standard errors mean, minimum and maximum values, pertaining to the milk colostrum IgG levels (mg/ml)

		n			Min	Max	*P-value*
Breed	Brown Swiss	51	77.07	4.55	68.02	86.12	ns
	Holstein	39	79.51	4.80	69.97	89.06	
Lactation Number	1	21	78.47	6.22	66.08	90.85	ns
	2	20	74.50	6.61	61.36	87.65	
	3	16	81.48	6.69	68.18	94.78	
	4	13	83.74	7.75	68.32	99.16	
	5≥	20	73.27	6.28	60.78	85.77	
Season	Spring (3.45°C[ł]/9.52°C[ɸ])	15	81.04^{b}	7.07	66.97	95.12	*
	Summer (18.08°C[ł] /21.00°C[ɸ])	5	58.85^{a}	11.82	35.33	82.37	
	Autumn (3.35°C[ł] /11.43°C[ɸ])	32	85.03^{b}	4.72	75.63	94.42	
	Winter (-10.08°C[ł] /-2.92°C[ɸ])	38	88.25^{b}	4.28	79.74	96.76	

SE: Standard Error; Min: Minimum; Max: Maximum; ns: Non-Significant; *: *P*<0.05
a, b: Differences between the mean values with different superscripts in the same column are statistically significant.
ł: Outdoor temperature mean at the calving time
ɸ: Indoor temperature mean at the calving time

Table 2: Analysis of variance results, mean values, standard errors, minimum and maximum values, pertaining to the blood serum IgG levels of the calves (mg/ml)

		n			Min	Max	*P-value*
Breed	Brown Swiss	51	11.75	0.53	10.70	12.80	ns
	Holstein	39	11.87	0.55	10.77	12.98	
Gender	Female calf	48	11.94	0.50	10.94	12.94	ns
	Male calf	42	11.68	0.56	10.58	12.79	
Lactation Number	1	21	11.87	0.72	10.44	13.31	ns
	2	20	11.71	0.76	10.19	13.22	
	3	16	12.19	0.77	10.66	13.73	
	4	13	11.12	0.89	9.35	12.90	
	5≥	20	12.16	0.73	10.72	13.60	
Season	Spring (3.45°C[ł] /9.52°C[ɸ])	15	12.60^{ab}	0.83	10.95	14.25	*
	Summer (18.08°C[ł] /21.00°C[ɸ])	5	9.87^{b}	1.36	7.15	12.58	
	Autumn (3.35°C[ł] /11.43°C[ɸ])	32	11.97^{ab}	0.54	10.89	13.05	
	Winter (-10.08°C[ł] /-2.92°C[ɸ])	38	12.81^{a}	0.49	11.83	13.79	

SE: Standart Error; Min: Minimum; Max: Maximum; ns: Non-Significant; *: *P*<0.05
a,b: Differences between the mean values with different superscripts in the same column are statistically significant.
ł: Outdoor temperature mean at the calving time
ɸ: Indoor temperature mean at the calving time

ity for colostral antibodies. The mean blood serum IgG level was determined as 11.87±0.55 mg/ml for the Holstein cows and 11.75±0.53 mg/ml for the Brown Swiss cows (Table 2).

While breed, sex, lactation number and the length of the dry period were determined to have no effect on the serum IgG levels of the calves (*P>0.05*), it was determined that the calving season and the ambient temperature (outdoor temperature: min -25.0°C / max 24.5°C; indoor temperature: min -19.0°C / max 27.0°C) at the time of parturition both affected the serum IgG levels (*P<0.05*), (Table 2 and Table 3).

The dry period length was determined as 64 days. The correlation coefficients (r) between the colostral IgG level and the length of the dry period, adjustment milk yield (2x305 days), the actual milk yield and the ambient temperature were found to be low and not significant whereas the correlation coefficients between the colostral IgG and blood serum IgG levels were statistically significant (r=0.430) (*P<0.01*) (Table 3).

It was determined that the blood serum IgG levels of the calves decreased with increased ambient (barn) temperature (r=-0.179) (*P<0.05*) (Table 3).

It was determined that no statistically significant correlation existed between colostrum quality and the incidence of respiratory and digestive system infections in calves (*P>0.05*) (Table 4).

The incidence of respiratory system infections was found to be 11.76% in the calves with low blood serum IgG levels, and 1.37% in the calves with a strong immunity (*P<0.05*). Furthermore, it ascertained that the incidence of digestive system infections in calves did not alter with blood serum IgG levels (Table 5).

The mortality rates of the calves, resulting from infections, were not correlated with colostrum quality or blood serum IgG level (Table 6).

DISCUSSION

In the present study, the mean colostral IgG level was determined as 78.23 mg/ml. This level was found to be above the minimum immunoglobulin level of colostrum for the establishment of an adequate passive immunity (50 mg/ml) (14).

While Heinrichs and Jones reported the mean colostral IgG level of Holstein cattle as 46.94 mg/ml (15), Chavatte *et al.* (16) reported the mean colostral IgG level of the same breed as 70.6 mg/ml. In general, the colostrum samples

Table 3: The correlation coefficients between ambient temperature, blood serum IgG level, colostrum IgG level, length of dry period, adjustment milk yield (2x305 days) and actual milk yield, and the statistical significance of these correlation coefficients

	Temp	B IgG	Col lgG	DPL	Adj Milk Yield	Act Milk Yield
Temp	1					
B IgG	-0.179*	1				
Col lgG	-0.127	0.430**	1			
DPL	0.132	-0.109	-0.065	1		
Adj Milk Yield	-0.140	0.036	-0.002	-0.116	1	
Act Milk Yield	-0.132	0.086	-0.054	-0.215	0.845**	1

Temp: Barn temperature; B lgG: Blood serum IgG levels; Col lgG: Colostrum IgG levels; DPL: Dry Period Length (minimum 47 days, maximum 103 days, mean 64 days); Adj Milk Yield: Adjusted Milk Yield (2x305 days); Act Milk Yield: Actual Milk Yield; *: *P*<0.05; **: *P*<0.01

Table 4: The effect of milk colostrum IgG levels on the incidence of respiratory and digestive system infections

Health Situation		Colostrum Quality			*P-value*
		Low	Middle	High	
Respiratory Infection	Healthy	7 (100%)	21 (95.45%)	59 (96.72%)	ns
	Diseased	0 (0%)	1 (4.55%)	2 (3.28%)	
	Total	7 (100%)	22 (100%)	61 (100%)	
Gastrointestinal Infection	Healthy	6 (85.71%)	18 (81.82%)	58 (95.08%)	ns
	Diseased	1 (14.29%)	4 (18.18%)	3 (4.92%)	
	Total	7 (100%)	22 (100%)	61 (100%)	

ns: Non-Significant

analysed in the present study were determined to be of good quality.

No difference was detected between the Holstein and Brown Swiss cows for colostral IgG levels. On the other hand, Godden suggested that colostrum quality varied among different breeds (17). In some other studies, Brown Swiss cows were shown to have lower colostral IgG levels than Holstein cows (18). The result obtained in the present study, suggesting colostral IgG levels do not vary with the two breeds studied, differs from the results of previous publications.

It was ascertained that the lactation number had no effect on the colostral IgG levels. Similar results have also been reported in previous research (18). On the other hand, Quintero *et al*. suggested that the colostral IgG levels of young animals are higher than the levels of older animals (19). On the contrary, some other researches have suggested that IgG levels increase with advanced age (7, 17, 18, 21-23).

Morin *et al.* (24) reported that the colostral IgG levels of cows, which calve during the winter season, are higher than the colostral IgG levels of cows which calve in other seasons. Godden (17) indicated that the IgG levels of cows that calve during summer are lower. Furthermore, Gulliksen *et al.* (25) suggested that the colostral IgG levels of cows that calve in winter are lower than those calving during other seasons.

The present study demonstrated that the IgG levels of the cows, which had calved in summer, were lower than the IgG levels of the cows, which had calved in the other seasons. It is considered that the exposure of cows to heat stress during late gestation may reduce colostrum quality. The difference among the studies can be related to temperature, i.e., hot in summer in one area and cold in winter in another; besides, conflicting results may be attributed to the limited numbers in the current study of calving of the cows in summer,.

The mean blood serum IgG level of the calves was determined as 11.81 mg/ml. This value was found to be above the minimum blood serum immunoglobulin level required for the establishment of an adequate passive immunity (10 mg/ml) (23). In the present study, the blood serum IgG levels of the calves of the Brown Swiss and Holstein breeds were observed not to differ from each other. Furthermore, a positive correlation was determined between colostrum quality of cows and level of IgG in the blood serum. In other words, the passive immunity was observed in calves which were fed with colostrum containing high levels of IgG. A previous study relating with this issue was performed by Jozica *et al.* (26) showing that colostrum of good quality should be given to calves in order to obtain a strong passive immunity.

The effect of the sex of the calves on the blood serum IgG levels was found to be statistically insignificant. Some researchers have suggested that the serum IgG levels is high in the female calf compare to the male calf since male calves

Table 5: The effect of blood serum IgG levels in the calves on the incidence of respiratory and digestive system infections

Health Situation		Immune Level		*P-value*
		Low	High	
Respiratory Infection	Healthy	15 (88.24%)	72 (98.63%)	*
	Diseased	2 (11.76%)	1 (1.37%)	
	Total	17 (100%)	73 (100%)	
Gastrointestinal Infection	Healthy	14 (82.35%)	68 (93.15%)	ns
	Diseased	3 (17.65%)	5 (6.85%)	
	Total	17 (100%)	73 (100%)	

ns: Non-Significant
*: $P<0.05$

Table 6: The effect of milk colostral and blood serum IgG levels on the mortality rate of calves

	Colostrum Quality				Immune Level		
Status	**Low**	**Middle**	**High**	***P-value***	**Low**	**High**	***P-value***
Alive	6 (85.71%)	21 (95.45%)	60 (98.36%)	ns	17(100%)	70 (95.89%)	ns
Mortality	1 (14.29%)	1 (4.55%)	1 (1.64%)		0 (0%)	3 (4.11%)	
Total	7 (100%)	22 (100%)	61 (100%)		17 (100%)	73 (100%)	

ns: Non-Significant

consume more colostrum than female calves due to their greater body weight (27). In the current study, the reason of alteration of passive immunity in relation on gender was not considered relevant as equal amount of colostrum were given both to males and females.

In the present study, the highest blood serum IgG levels were detected in the calves, which were born in winter. On the other hand, Yuceer *et al.* (28) suggested that calves born in autumn have a lower level of passive immunity. The lowest colostral IgG levels were detected in the cows, which had calved in summer. Similarly, the blood serum levels of the calves, which were born in summer, were found to be lower.

While the ambient temperature was determined to be negatively and insignificantly correlated with the colostrum IgG level, it was ascertained to be negatively and significantly correlated with the blood serum IgG level of the calves. These findings suggest that, apart from the reduction of the colostrum quality of the dams during the summer season, exposure to heat stress also affects IgG absorption in calves. Further findings in support of this conclusion include the colostrum IgG levels of the dams being similar during the winter, spring and autumn seasons, and the blood serum IgG levels of the calves being lowest in the calves born in summer, followed by those born in autumn and spring, and the blood serum IgG levels being highest in the calves born in winter. Similar to previous studies (29, 30) the present results showed that, the cows calved in summer had lower colostral IgG levels than those calved at other seasons.

No correlation was determined to exist between the length of the dry period and the colostral IgG level. However, Kaygisiz *et al.* (20) report suggest that, in the event of the dry period lasting less than one month, colostral IgG levels decrease. In the present study, no correlation was found to exist between the length of the dry period and the colostral IgG level, and therefore the blood serum IgG level of the calves, was attributed to the length of the dry period being approximately two months (64 days) in all of the animals included in the herd.

The incidence of infectious diseases in calves with blood serum IgG levels below 10 mg/ml has been reported to be higher (7, 23). The results of the present study demonstrated that the level of immunity had no statistically significant effect on the incidence of digestive system infections in calves. On the other hand, the blood serum IgG levels were found to be significantly correlated with the incidence of respiratory system infections. The results obtained in the present study, which suggested that the incidence of respiratory system infections was higher in calves with low blood serum IgG levels, were in agreement with literature reports.

Dardillat *et al.* (21) reported that colostrum quality is strongly correlated with calf mortality. Furthermore, Kuralkar and Kuralkar (8) demonstrated that serum IgG levels were directly correlated with calf mortality. Similarly, Tyler *et al.* (31) indicated that 39% of calf mortalities were caused by inadequate passive immunity. However, in the present study, it was observed that all of the calves that died belonged to the group with a high level of immunity, which suggested that the level of immunity had no significant correlation with the mortality rate of calves caused by respiratory and digestive system infections.

CONCLUSIONS

In order to establish an adequate passive immunity in calves, it should be ensured that new-born calves receive an adequate amount of good quality colostrum from their dams. Reports indicate that while exposure to heat stress reduces the colostrum quality of pregnant cows, it also reduces blood serum IgG levels in calves. In view of the summer season being cooler than tropical and many subtropical region climates, in the location of the present study, it is considered that the exposure of the calves to heat stress may have increased losses due to infections and deaths resulting from an inadequate level of immunity. Therefore, we conclude that it is of utmost importance that cows in late gestation and new-born animals are protected from exposure to heat stress, while housed in the barn.

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