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Effect of Boron Supplementation During Peripartum Period on Colostrum Yield and Composition and Carry Over Effect on Calf Health in Crossbred Karan Fries Cows During Hot Humid Season

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ABSTRACT

The present investigation was undertaken to assess the effect of supplementation of boron on colostrum yield and composition in lactating crossbred Holstein Friesian cows and its carryover effect on health of calves during hot humid season. Eighteen prepartum healthy crossbred Karan Fries cows were selected from institutional herd and divided into three groups as B0 (control), B250 (with 250 ppm boron) and B500 (with 500 ppm boron) in addition to the basal diet (ICAR, 2013 feeding standard) from 30 days prepartum to 60 days postpartum. Boron was supplemented in the form of boric acid. Average THI during whole experimental period was 82.45. Daily colostrum yield, colostrum composition viz fat %, SNF %, total solids %, protein%, lactose % and colostrum SCC were analyzed and calf birth weight, growth rate, calf health parameters like diarrhoea, pneumonia, naval ill and mortality were also recorded. There was significant effect ($P<0.001$) reduction in colostrum SCC in accordance with both treatment groups and day of lactation and colostrum SNF was high on 4th day of lactation. The calf fed with colostrum of boron supplemented dam showed reduced rate of diarrhoea, naval ill and mortality and no significant difference on calf birth weight, growth rate and average daily gain. On conclusion, supplementing boron 250 ppm and 500 ppm in diet has reduced colostrum somatic cell count and improved calf health but no considerable improvement in colostrum yield and colostrum composition and calf growth rate.

KEYWORDS: Boron, Colostrum composition, Colostrum yield, Somatic cell count

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INTRODUCTION

According to the 20th livestock census (2019), India's bovine population is around 302.79 million, with 51.36 million crossbred animals. Exotic cattle produce an average of 8.09 kg of milk per day, accounting for 28% of all milk produced in India. Major causes of loss in dairy production associated withtwo reasons that includes diseases of newborn and postnatal mortality (Broucek et al., 2009). So, in this view, colostrum is the most important factor for betterment of calf survival and health benefits (Godden, 2008) but intra mammary infection (IMI) during dry period leads to reduction in production of colostrum (Maunsell et al., 1998). Colostrum is a mammary gland secretion that is produced and stored during the final trimester of pregnancy and the first few days following calving which has variety of qualities, including nutritious, energizing, protecting, and purgative. It stimulates peristalsis and, as a result, meconium excretion, preventing excessive densification and excretion difficulties. (Puppel et al.,2019). The temperature humidity index (THI) is a combined assessment of the effect of ambient heat and relative humidity that reflects how much heat stress dairy cows are experiencing (Berman, 2005). Segnalini et al.(2013) observed reduced dry matter intake (DMI) of about 10- 15 % in heat stressed cow in relation to cooled cows that leads to reduced production of colostrum. According to Nardone et al. (1997), during high air temperature (THI of 72-86) reduction in colostrum composition (%) like

lactose, total protein, lactalbumin, fat was observed. Negative effects also observed in daily weight gain over 30°C of environmental temperature (Nardone et al., 2006), also heat exposure for 6 hours while the environmental temperature rose from 32 to 52°C resulted in a large rise in neutrophils and a significant decrease in eosinophils (May et al., 1977) that compromises the calf health. Boron is a trace mineral that is both an emerging and an essential mineral in mammals (Nielsen, 1994; Gowda et al., 2023).

Boron supplementation enhanced lambs' cell-mediated and humoral immunity (Bhasker et al., 2017). Significant ($P<0.001$) increase in boron level in the serum and milk on supplementation with boron at the level of 5, 10, 15 g of borox per day (Basoglu et al., 2017) which is ought to have indirect effect on the calf health and growth parameters, but no experimental study has been conducted to assess the direct effect of boron on colostrum and calf health parameters. Hence, the purpose of this study was to evaluate how the supplementary boron affect the colostrum yield and quality of crossbred Karan Fries cows and its carry over effect oncalf health.

MATERIALS AND METHODS

Location of the study

The research has been carried out at the National Dairy Research Institute's (NDRI) Livestock Research Centre in Karnal, Haryana, India. The institute is situated on 29^0 43" N latitude and 76^0 58" E longitudes at an altitude of 245 metres above the mean sea level. The minimum ambient temperature of the place is near 0°C and the maximum temperature is approximately upto 34°C. The average annual rainfall is close to 700 mm per year, which is mostly received from July to September.

Experimental animals and feeding

Eighteen prepartum crossbred Karan Fries cows were selected based on expected date of calving from the Livestock Research Center of National Dairy Research Institute, Karnal and divided into three groups of each on the basis of bodyweight, parity and estimated producing ability. It was made sure that the animals included in the study were apparently healthy and devoid of any anatomical, physiological, or infectious diseases. The experiment was carried out in accordance with the Institutional Animal Ethical Committee guidelines. Three groups of animals were assigned as B0, B250 and B500. B0 was taken as control whereas B250 and B500 were supplemented with Boron. B0 was kept without any supplementation and was given with basal diet based on ICAR- 2013. B250 and B500 was supplemented with 250 ppm and 500 ppm of boron, respectively above the basal diet. The boron was given to animals by mixing with small amount of concentrate to prevent wastage of boron. Supplementation was given for a period of 90 days (30 days prepartum upto 60 days postpartum) and each animal was kept under observations. Cattle were kept under loose system of housing with enough space as per BIS requirements but were tied during the time of supplementation of boron. Animals were fed as per ICAR 2013 feeding standards. Daily concentrate supplement was fed at 5.00 AM and 2.00 PM and roughage at 10.00 AM and 3.00 PM. Water was provided *ad libitum.*

Parameters observed

Temperature Humidity Index (THI), Daily colostrum yield, colostrum composition viz fat %, SNF %, total solids %, protein%, lactose %. To evaluate the quality of colostrum, colostrum SCC was also analyzed. Calf birth weight, and fortnightly bodyweight changes were also recorded. The incidence of diseases like diarrhoea, pneumonia, naval ill and mortality were also noted.

Calculation of Temperature Humidity Index

Meteorological variables in terms of dry and wet bulb temperatures were recorded throughout the experiment during morning and evening hours and temperature humidity index was calculated by the formula.

$$THI = 0.72 (T_{db} + T_{wb}) + 40.6$$

Where, T_{db} = dry bulb temperature (^{0}C); T_{wb} = wet bulb temperature (^{0}C)

Collection and estimation of composition and Somatic Cell Count (SCC) in colostrum

Milking of colostrum was done two times a day for 5 days in calving pen and colostrum yield for 5 days was recorded and about 50 ml of colostrum samples in a sterile sample container and were analyzed for composition and SCC. Colostrum composition (%)i.e., fat, protein, lactose, total solids and SNF were estimated by lactoscan milk analyzer. Colostrum SCC were estimated by Lactoscan SCC kit X 4 (manufactured by M/s Milkotronic, Bulgaria.) consisting of Lactochip, Sofia green lyophilized dye, Automatic pipette tip. 100 µL of colostrum was mixed with dye and kept aside for 2 minutes. 8 µL of above sample was charged in lactochip and SCC counted by Lactoscan.

Statistical analysis

Two-way ANOVA was used to examine the data using the statistical programme IBM(r) SPSS(r) Statistics (version 22, IBM SPSS Inc., Chicago, USA). Duncan test was used to compare the treatments pairwise, with a significance threshold of 95 percent ($P<0.05$).

RESULTS AND DISCUSSION

Crossbred animals are more prone to disease incidence due to stress and reduced immune response especially during transition period, hot humid climate and insufficient immune response of dams have effect on its colostrum production with less amount of Immuno globulins (Ig) secretion, which is found to be important for calf health and growth performance during early stages of growth, where the calf should get colostrum within 30 minutes to 2 hours of birth with adequate amount of immunoglobins and vitamins and minerals that are higher in quantity than milk. Normally the level of Boron (µmol/l) were significantly ($P<0.05$) high in multiparous (10.5 ± 1.58) dairy cow than primiparous cows (5.45 ± 1.63) that helps in providing passive immunity to cows in addition to other mineral components (Aydogdu and Guzelbektes, 2018). The dry matter intake of experimental animals on the day of calving was 8.34 ± 0.54, 8.58 ± 0.54 and 8.67 ± 0.59 for B0, B250 and B500 ppm, respectively. The most common method of assessment of heat stress in animals is THI. The experiment was conducted during the months of July to October with the average THI of about 82.45 which indicated that the animalswere in heat stress condition.

Effect of boron supplementation on colostrum yield

The differences in mean value of colostrum yield differ significantly ($P<0.05$) among the days. During the experimental period, the quantity of colostrum yield (litres) varies from 4.54 ± 0.54 to 9.25 ± 0.77 for control, 4.90 ± 0.62 to 9.52 ± 1.08 for B250 groups and 4.13 ± 0.71 to 9.13 ± 0.71 for B500 supplemented groups and the overall mean colostrum yield for B0, B250 and B500 groups was 7.23 ± 0.64, 7.59 ± 0.78 and 6.77 ± 0.85, respectively with no significant difference among the groups. Highly significant variation noted that increase in colostrum yield with increasing days of calving. The values of colostrum yield (in liters) throught the experimental period is presented in the Table 1.Previous studies noted that, Boron supplementation at 620 mg boron/100 kg BWT per head per day had nil effect on production performance of animals (Owen, 1994), also noted by Kabu and Uyarlar (2015) and Basoglu et al. (2017) which is similar to our result but no data on colostrum yield with respect to boron supplementation to compare our results accurately.

Table 1. Effect of boron supplementation during peripartum period on colostrum yield (litres) in Karan Fries cows

Days of lactation	B0	B250	B500	P Value
1	4.54 ± 0.54^{c}	4.90 ± 0.62^{c}	4.13 ± 0.71^{c}	0.735
2	6.38 ± 0.64^{bc}	6.54 ± 0.68^{bc}	5.74 ± 0.77^{ab}	0.737
3	7.65 ± 0.60^{b}	8.03 ± 0.68^{ab}	6.96 ± 0.81^{abc}	0.615
4	8.35 ± 0.63^{ab}	8.96 ± 0.84^{ab}	8.05 ± 0.93^{ab}	0.756
5	9.25 ± 0.77^{a}	9.52 ± 1.08^{a}	9.13 ± 0.71^{a}	0.659
P Value	<0.05	<0.05	<0.05	

Mean value with different superscripts (a, b, c) in a column differs significantly between on different days of colostrum yield

Effect of boron supplementation on colostrum SCC

The results (Means± SE) of colostrum SCC (X 10^3 cells/ml) during different days in supplemented and control crossbred cows have been presented in Table 2. The SCC average mean values (X 10^5cells/ml) were found to be 13.8 ± 0.53, 10.2 ±0.31 and 9.82 ± 0.30 in B0, B250 and B500 group respectively. Significantly reduced (P<0.05) colostrum SCC between days of milking and between treatment groups supplemented with boron. Decrease in colostrum SCC was observed with increase in days after calving.The reduction in somatic cell count of the colostrum and improvement of health status of calf may be due to immune-modulatory effect of boron which is humoral or cell mediated (Basoglu et al., 2017) and antioxidant effect of boron (Sharma et al., 2020) that helps in improvement in antioxidant status in mammary gland which may be responsible for maintaining function of alveolar epithelial cells (Arechiga et al., 1998) by reducing the somatic cell count of colostrum in treatment groups than control groups as improper dry period management may lead to mastitis problems during transition period.

Table 2. Effect of boron supplementation during peripartum period on colostrum Somatic Cell Count (x 10^6 cells/ml) of Karan Fries cows

Days of lactation	B0	B250	B500	P Value (<0.05)
1	24.6^{Aw} ± 1.15	18.7^{Bw} ± 0.47	17.1^{Bw} ± 0.69	<0.001
2	15.7^{Ax} ± 0.59	12.1^{Bx} ± 0.57	11.9^{Bx} ± 0.21	<0.001
3	10.7^{Ax} ± 0.18	8.30^{Bx} ± 0.12	8.27^{Bx} ± 0.21	<0.001
4	10.4^{Ay} ± 0.39	7.66^{By} ± 0.11	7.60^{By} ± 0.21	<0.001
5	7.64^{Az} ± 0.34	4.12^{Bz} ± 0.26	4.13^{Bz} ± 0.17	<0.001
P Value	<0.001	<0.001	<0.001	

Mean value with different superscripts (A, B) differs significantly between treatment groups and superscripts (w, x, y, z) differs significantly between days.

Effect of boron supplementation on colostrum composition

Table 3 represents the effect of boron supplementation on colostrum composition. The mean ± SE of colostrum fat (%) was 5.24 ± 0.25 inB0; 5.31 ± 0.37 in B250 and 5.26 ± 0.24 in B500 groups and colostrum SNF (%) was 12.7 ± 0.51 in B0; 13.2 ± 0.64 in B250 and 13.2 ± 0.79 in B500 group. Colostrum protein (%) was 4.74 ± 0.22 in B0; 4.90 ± 0.21 in B250 and 4.91 ± 0.26 in B500 group. Colostrum lactose (%) was 6.69 ± 0.27 in B0; 6.91 ± 0.33 in B250 and 6.94 ±0.43 in B500 group. Total Solids (%) was 17.9 ± 0.51 in B0; 18.5 ± 0.58 in B250and 18.4 ± 0.85 in B500 groups. Significant increase in SNF content on 4th day of lactation in Boron supplemented groups over control. Significant difference also observed between days of lactation in protein %, lactose %, SNF % and total solids % where reduction in percentage of each composition with increase in days of lactation that facilitate turning of colostrum to milk. Basoglu et al. (2017) found no difference in milk fat percent or milk protein percent in periparturient Holstein dairy cows fed with boron (as Borax) in proportions of 567, 1134, and 1701 ppm. However, there were no research findings to back up the findings of boron supplementation on SNF and Lactose %.

Table 3. Effect of boron supplementation during peripartum period on colostrum composition (%) of Karan Fries cows

Treatment	Days of lactation					SEM	P value
	1	2	3	4	5		
			Fat (%)				
B0	4.83	5.10	5.26	5.41	5.58	0.11	0.342
B250	4.94	5.39	5.58	5.24	5.42	0.16	0.869
B500	4.92	5.72	5.54	4.96	5.18	0.11	0.220
P value	0.981	0.535	0.684	0.586	0.415		
			Protein (%)				
B0	7.25^{x}	5.38^{y}	4.07^{z}	3.50^{z}	3.51^{z}	0.28	<0.001
B250	7.75^{x}	5.22^{y}	4.14^{z}	3.78^{z}	3.62^{z}	0.30	<0.001
B500	7.54^{x}	5.40^{y}	4.20^{z}	3.75^{z}	3.70^{z}	0.30	<0.001
P value	0.847	0.922	0.772	0.092	0.367		
			Lactose (%)				
B0	11.3^{x}	7.85^{y}	5.50^{z}	5.20^{z}	5.05^{z}	0.46	<0.001
B250	11.3^{x}	7.58^{y}	5.42^{z}	5.24^{z}	5.00^{z}	0.47	<0.001
B500	11.5^{x}	7.24^{y}	5.60^{yz}	5.24^{z}	5.16^{z}	0.49	<0.001
P value	0.989	0.734	0.809	0.935	0.842		
			SNF (%)				
B0	21.0^{x}	13.6^{y}	10.3^{z}	9.50^{Bz}	8.95^{z}	0.85	<0.001
B250	21.1^{x}	14.4^{y}	10.7^{z}	10.3^{Az}	9.54^{z}	0.84	<0.001
B500	21.6^{x}	13.7^{y}	10.9^{yz}	10.2^{Ayz}	9.56^{z}	0.92	<0.001
P value	0.964	0.806	0.472	0.046	0.244		
			Total Solids (%)				
B0	25.8^{x}	18.7^{y}	15.5^{z}	14.9^{z}	14.5^{z}	0.80	<0.001
B250	26.0^{x}	19.9^{y}	16.2^{z}	15.5^{z}	14.9^{z}	0.80	<0.001
B500	26.5^{x}	19.4^{y}	16.4^{yz}	15.2^{z}	14.7^{z}	0.91	<0.001
P value	0.984	0.756	0.155	0.323	0.653		

Mean value with different superscripts (A, B) differs significantly between treatment groups and superscripts (x, y, z) differs significantly between days

Effect of feeding colostrum from boron supplemented cows on bodyweight and health parameters

Effect of feeding colostrum produced from boron supplemented cows on calf birth weight, body weight changes fortnightly intervals are given in the Table 4 and Figure 1. The birth weight, growth rate and average daily gain showed no significant changes but were numerically high in B500 group than B0 and B250.

Table 4. Effect of boron supplementation to cows during peripartum period on birth weight and average daily gain of calves

Age (Days)	B0	B250	B500	P Value
Birth weight (0 day)	23.2 ± 3.24	24.2 ± 1.49	27.4 ± 1.02	0.557
15	30.2 ± 1.43	27.7 ± 1.43	32.0 ± 3.18	0.463
30	34.7 ± 2.75	33.2 ± 1.43	36.7 ± 4.00	0.707
45	40.7 ± 2.46	38.5 ± 1.32	42.5 ± 3.61	0.581
60	46.2 ± 3.03	43.7 ± 1.10	47.2 ± 3.72	0.681
Average daily gain	584 ± 12.08	558 ± 2.28	619 ± 3.59	0.583

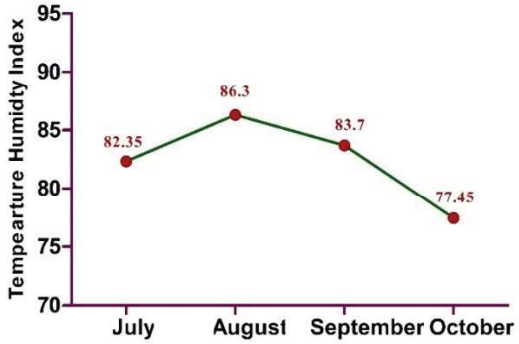

Fig 1. Average temperature humidity index of experimental sheds during study period

The percentage incidence of diarrhea in B0, B250 and B500 groups was 66.6% (4 out of 6) , 50% (3 out of 6)and 50% (3 out of 6)respectively, similarly for naval ill 33.3% (2 out of 6), 33.3%(2 out of 6) and 0% and mortality percentage (33.3%(2 out of 6), 16.6%(1 out of 6) and 16.6% (1 out of 6)for B0, B250 and B500 groups, respectively. No incidence of pneumonia was observed in all the three groups of animals. Borate has been found to be anti-inflammatory, antioxidant, disease control, wound healing source (Henderson et al., 2009; Sogut et al., 2015). Reduced level of blood boron has been related to poor immune response, high rate of mortality, cognitive deterioration (Khaliq et al., 2018). It is found to be essential for growth and reduced boron concentration decreases growth rate (Fort, 2002). Armstrong et al. (2000) observed that boron supplementation to boron deficient diet of pigs improved feed intake and growth rate. Wiley (1907) after feeding boric acids to humans, boron was identified in urine, perspiration, faeces, and milk and another report observe10-fold increase of milk boron concentration in the first 24 hours after feeding of 13 grams of boric acid to the cows (Hove et al., 1939) and on addition of boron to milk of rats found better ability to survive during the nursing period (Hove et al., 1939). Our results are in accordance with the findings that improvement in health status of animal in terms of reduction in incidence of diarrhoea, naval ill and mortality was observed but the growth rate was contrary to other findings, with boron supplementation to cows.

CONCLUSION

It is inferred that boron supplementation could maintain quality of colostrum with reduced Somatic Cell Count and no significant effect on yield and composition.The Boron supplementation could improve the calf survivability as well.

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