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Concentrate supplementation impact on the performances of extended transitional crossbred Zebu cow

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ABSTRACT

This research was carried out to evaluate the effect of concentrate supplementation on growth, milk yield and composition, and reproductive responses of crossbred Zebu cows for 120 days (two months pre-partum and two months post-partum). Six (06) advanced pregnant (60 days of pre-partum) crossbred Zebu cows in second parity were equally divided into two groups like control and supplemented. About 22.0 kg mixed green fodders (Para: German =2:1) and 2.0 kg concentrate mixtures (wheat bran, mustard oil cake, common salt and di-calcium phosphate were 82.28, 13.72, 3.70 and 0.30%, respectively) were offered as basal diet to each cow of both groups. Besides these, an extra amount (0.5 kg) of concentrate mixture (wheat bran- 50%, mustard oil cake- 40%, common salt- 2% and di-calcium phosphate- 8%) was supplied to each cow of supplemented group. Results revealed that pre-and post-partum dry matter intake was significantly (p=0.000) higher in the supplemented group compared to the control group but concentrate supplementation did not affect on body weight and body condition score of the zebu cows. About 19% of milk production was increased (p=0.000) due to concentrate supplementation in the diet of crossbred zebu cows but milk composition remained unchanged (p>0.05). On the other hand, the birth weight of calves was non-significantly (p=0.29) higher (24%) in additional concentrate supplementation group compared to the control group. Moreover, it was found that a limited amount of concentrate supplementation was able to reduce about 12 days of post-partum heat period (p=0.02) and days open (p=0.01) of Zebu cows which would be helpful to gear up the tropical dairy animal production. It is concluded that supplying an additional amount of concentrate to the cows before and after 2 months of freshening had a positive influence on milk production as well as reproductive performance.

Introduction

Transition period is the last three weeks of pre-partum and the first three weeks of post-partum that are to be considered very traumatic and/or critical period in the annual cycle of the dairy cow. In this period, the dairy cow must have to cope with different metabolic and hormonal changes as well as different daily routine and ration (Grummer, 1993; Drackley, 1999). Transition period is also the most physiologically and nutritionally stressful period in reproductive cycle of dairy cow (Drackley, 1999). During this period, feed intake reduced conspicuously (Murphy, 1999) while the nutrient demand for fetal growth and commencement of milk synthesis is increased (Olsson, 1996). This period is crucial for the dairy animals to augment body reserves to meet up the demands of the growing fetus as well as to avoid negative energy balance in the body.

According to Goff and Horst (1997), the majority of the health complexities occur during this transition period and some of the adverse effects of neglected last trimester feeding has been well documented, these are low productive performance (Sasser *et al.*, 1988), death of fetus or reduced viability at birth (Miller, 2012), fatty acid mobilization and loss in body condition (Grummer, 1993), prevalence of peri-parturient health problems like dystocia, retained placenta, ketosis, displaced abomasum and mastitis (Dyk *et al.*, 1995), delayed post-partum estrus and altered reproductive parameters (Das *et al.*, 2007). Randel (1990) mentioned that inadequate nutrition before and/or after calving decrease pregnancy rates, conception at first service and prolongs post-partum estrous. For overcoming these complexities, Dann *et al.* (2006) suggested that feeding management during early dry period is necessary for improving reproductive health as well as production of transition dairy cows. In another research, Mukasa-Mugerwa (1989) demonstrated that supplementation of concentrate in dairy cattle feeding enhances milk yield and fertility of the cow whereas, Keady *et al.* (2001) reported a positive response only in the milk fat content. Majority

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of the cattle of Bangladesh are Zebu cattle (80-85%) with limited crossing (15-20%) of *Taurus* cattle and found all thirty agro-ecological zones of Bangladesh (ILRI, 2004). Zebu cows are characterized by the low fertility (Chopade *et al*., 2002), less milk yield per day, slower growth rate, long post-partum estrous and minimal body weight (Bari, 1987). Such impoverished physical condition and reproductive performance of cows are commonly due to low genetics potentials and imbalanced diet consumption (Alam *et al*., 2009).

Green grass plays a vital role in reproduction of animals and green fodder supply beta-carotene that stimulates corpus luteum to produce progesterone hormone which responsible for maintaining pregnancy in cows (Alam *et al*., 2009). But small holders' dairy production in tropical or sub-tropical countries including Bangladesh primarily rely on traditionally feeding of dry roughages, agricultural crop-residues and industrial by-products containing high level of ligno-cellulosic materials (Khan *et al*., 2009), and nutritionally poor agricultural byproducts as concentrate source (Dutta and Sharma, 2004). This often leads to feeding of a nutritionally imbalanced ration which contains proteins, energy, minerals and vitamins either in excess or shortage relative to the nutrient requirements of the animals (Khan *et al*., 2009). Productive and reproductive performances of cattle are negatively affected in tropical areas by low forage availability and quality (Hammon *et al*., 2006; McArt *et al*., 2013). Singh *et al.* (1997) identify the deficit of digestible crude protein level (50-55% of the requirement) in roughage based feeding systems of lactating cows ration. Such deficiency of crude protein in diet negatively affects the pre- and post-partum weight gains, decreased the percentage of animals showing estrus by 110 days after calving, decreased the first service conception rate, and increased the post-partum estrus interval in dairy animals (Sasser *et al*., 1988). On the other hand, concentrate supplementation to the dairy ration reflects dry matter intake (Stockdale, 2000), milk production and its quality (Higgs *et al*., 2013) as well as reproductive efficiency of cows (Mukasa-Mugerwa, 1989).

During pre-partum, high level of concentrate feeding positively influences the birth weight of calf, early resumption of ovarian cyclicity and pregnancy rates (Bellows and Short, 1978). If energy level in diet is low then follicles become unable to mature and follicular atresia occurs. Thus, animal loss their sexual desire followed by absence of estrous cycles (Alam *et al*., 2009). In addition, poorest body condition of the cows had highest subfertility rate (Morris, 1976) and lower body weight. Such tendency to body weight loss in transition period leads to reduction of fertility as well as pregnancy rate (Haresign, 2013). However, several efforts have been made by the researchers to promote the reproductive potentialities of animals through crossbreeding or upgrading program (Rutledge, 1997) and, dietary manipulation in terms of nutrients (Islam *et al*., 2019), concentrate supplementation (Prima *et al*., 2018) and roughage source feed (Habib *et al*., 2018). Recently Prima *et al*. (2018) found significant alteration in milk production and its constituents, and early resumption of post-partum ovarian activity in Holstein-Friesian crossbred cows through concentrate supplementation. Similarly, Schoonmaker (2013) evidenced that dietary management during transition period have a major impact on health and productivity of dairy cows. Concentrate supplements are used in diet as a nutrition management tool that increase DMI and milk yield of cows (Stockdale, 2000; Bargo *et al*., 2003).

However, farmers expect to produce sufficient quantities of milk and involution within shortest possible time by crossing the native cattle with exotic breed that increases their nutrient requirement as well but they don't supply extra amount of concentrate considering the physiological condition of cows. Alone such crossbreeding program is not able to bloom as desired to boost up the milk production without considering better nutrition to the animals. Even genetically best animal deteriorates soon in the absence of a sufficient and balanced ration (Shamsuddoha and Edwards, 2000). That's why designing dairy animal feeding based on their physiological status is always of prime importance and supplementation of concentrate is the core of it. Scientific literature regarding the concentrate supplementation to the crossbred Zebu cows during transition period is very limited and farmers have not any idea to evaluate the performance of that *Bos indicus* cows using such feeding strategy. That's why this research work was undertaken to investigate the impact of pre-and post-partum concentrate supplementation on dry matter intake, growth performance, milk yield and its quality, and reproductive performance of Zebu cows.

Materials and Methods

Animals and diets

Experimental protocols of animal feeding were conducted at the Research Dairy Farm of Department of Dairy Science, Bangladesh Agricultural University, Bangladesh. The total duration of the study was 120 days and the first 10 days of which were for adjustment. Seventh month pregnant six crossbred Zebu cows (four Sahiwal × Sindhi cows and two Sahiwal × Red Chittagong cows) in second parity were selected for this experiment and were equally (with regards to genotype also) divided into two groups, namely control and supplemented (each group contains 3 cows). Initial body weight and body condition score of the control and supplemented groups were 284.11±7.28, 284.11±7.23 kg and 3.00±0.00, 3.00±0.00, respectively. Cows were housed in an individual maternity box stall for 60 days pre-partum to 4 days of post-partum period, and thereafter, shifted to the stanchion barn (double rowed, face out system). Around 22 kg mixed roughage [Para (*Brachiaria mutica*) and German grass (*Echinochloa crus-galli*)= 2:1] and 2.0 kg concentrate mixture (mix of

82.28, 13.72, 3.70 and 0.30% wheat bran, mustard oil cake, common salt and DCP, respectively) were supplied daily to each Zebu cow of both dietary groups over the experimental period as basal diet. This fixed amount of roughages and concentrate mixture were supplied to the Zebu cows based on existing farm feeding practices. In addition to this basal diet, 500 g of concentrate mixture (25% of total concentrate mixture) was supplied in supplemented/treatment group where wheat bran, mustard oil cake, common salt and di-calcium phosphate were 50.0, 40.0, 2.0 and 8%, respectively. Half of the concentrate mixture was supplied at 07:00 am and the rest at 11:30 am. Subsequently, green grasses were provided once a day at 12:00 pm. Proximate analysis of feed ingredients were assayed as described by AOAC (2005). Ingredients and chemical constituents of the diets are presented in Table 1.

Measurement of cow and calf performance

Individual daily dry matter intake (DMI) was recorded from the supplied feed and feeding orts. Body weight of the cow was estimated at 15 days intervals using Shaffer's formula: Body weight (pound) = (G^2 × L)/300). The factor 0.4536 was used to convert pound into kg and body condition score (BCS) was estimated at every successive 15 days by the same person using a scale from 1 (emaciated) to 5 (heavy deposited fat) as described by Edmonson *et al.* (1989). Calf birth weight was recorded within half an hour of calving through digital weighing balance. Milk yield per day of each cow was calculated by summing up the yield obtained by hand milking from two shifts (morning and afternoon) and recorded from 5 to 60 days of post-partum. Individual milk samples were collected once weekly from two successive milking for analyzing milk constituents (total solids, solids-not-fat, fat, protein, lactose and ash content). Milk compositional parameters were analyzed by automated milk analyzer (Lactoscan SLP, MILKOTONIC Ltd., Bulgaria) at Dairy Chemistry Laboratory, Department of Dairy Science, Bangladesh Agricultural University. Post-partum heat period (interval between parturition and first sign of heat) of each cow was calculated through frequent observation of external sign of heat after the freshening. In addition, the interval from the date of calving to conception was considered as days open.

Table 1. Ingredient and chemical composition of dietary groups during pre- and post-partum period

	Control	Supplemented
Ingredient composition (g kg^{-1} DM)		
Para grass	612.50	579.15
German grass	160.00	151.0
Wheat bran	186.23	203.00
Mustard oil cake	31.00	51.00
Common salt	9.50	10.25
Di-calcium Phosphate (DCP)	0.77	5.60
Chemical composition (g kg^{-1} DM)		
Dry matter	416.33	436.34
Crude protein	92.20	98.89
Crude fiber	272.26	262.55
Ether extract	35.00	36.74
Nitrogen-free-extract	494.24	491.65
Ash	95.96	94.29
ME (MJ kg^{-1} DM)‡	8.78	8.90
NE (Mcal kg^{-1} DM)‡‡	1.91	1.94

‡Metabolizable energy (ME) values were estimated according to the equation of Kearl (1982), ME (MJ kg^{-1} DM) = [− 0.45 + (0.04453 × %TDN)] × 4.184; TDN is estimated according to the following equations: TDN for roughages (% of DM) = − 17.2649 + (1.2120 × %CP) + (0.8352 × %NFE) + (2.4637 × %EE) + (0.4475 × %CF); TDN for concentrate (% of DM) = 40.3227 + (0.5398 × %CP) + (0.4448 × %NFE) + (1.4218 × %EE) − (0.7007 × %CF).
‡‡ Net energy (NE) = ME x 0.93 and, 1 MJ = 0.234 Mcal.

Statistical analysis

Repeated Measures Analysis of Variance (RMANOVA) in Completely Randomized Design was performed to investigate the concentrate supplementation effect on DMI, body weight, BCS, milk yield and its composition in Zebu cows. The time period was treated as the within-subjects factor for measuring the parameters repeatedly on Zebu cows and the diet (independent variable) was considered as the between-subjects factor. In this, antecedent lactation milk yield was deliberated as a covariate for assaying alteration in the current milk yield of cows. Moreover, independent sample t-test was done to find out the concentrate supplementation impact on calf birth weight and their percentages of dam body weight, post-partum heat period and days open of Zebu cows.

Results and Discussion

Dry matter intake and growth measurements

The data on dry matter intake (DMI) and body growth parameters of cow and calves are presented in Table 2. It was obtained 7% higher pre-partum DMI and 5% post-partum DMI in concentrate supplemented group compared to the control group of Zebu cows. On a percentage of BW basis, average DMI was significantly greater for cows fed supplemented diet than those fed control diet during pre-partum (3.11% *vs.* 2.94%; p=0.000) and post-partum period (3.26% *vs.* 3.17%; p=0.000). Such progressive trend of DMI by the cow might be due to additional amount (500 g) of concentrate supplementation in diet. This finding is similar to Guo *et al*. (2007) who reported that higher concentrate feeding regime during pre-and post-partum period increases DMI by the cows. Dietary energy influences to the DMI of cows and it was found from this study that supplemented cows received more energy (1.94 Mcal NE/kg DM) from their diet compared to the control cows (1.91 Mcal NE/kg DM). Hence, DMI of supplemented cows were higher in current study than the control cows. These are consistent with the findings of Rabelo *et al*. (2005) who reported that high energy density diet fed cows (1.63 Mcal NEL/kg, 25% NDF and 47% NFC) had more DMI compared to the cows fed low energy density diet (1.57 Mcal NEL/kg, 30% NDF and 41% NFC). Within-subjects test indicated that time ($p<0.01$) and their interaction with diet ($p<0.05$) showed significant effect on pre-partum DMI but post-partum DMI was found statistically similar ($p>0.05$) in case of time and diet interaction (Table 3).

Table 2. Effect of diets on DMI, body weight, BCS, milk yield, milk composition and reproductive performance of Zebu cows

Parameters	Dietary groups (Mean ± SE)		p-value
	Control (n=3)	Supplemented (n=3)	
Dry matter intake (DMI) and growth parameters			
Pre-partum DMI (kg/day)	8.66 ±0.04	9.23±0.04	0.000
Post-partum DMI (kg/day)	8.49 ±0.03	8.91±0.03	0.000
Pre-partum body weight (kg)	293.75±7.19	296.37±7.19	0.82
Post-partum body weight (kg)	267.13±7.06	273.25±7.06	0.60
Overall body weight (kg)	279.14 ± 16.40	283.37±15.67	0.52
Pre-partum BCS (5.0)	3.00±0.19	3.25±0.19	0.47
Post-partum BCS (5.0)	2.58±0.36	2.83±0.36	0.67
Overall BCS (5.0)	2.78±0.17	3.00±0.17	0.40
Calf birth weight (kg)	15.68±0.33	19.44±2.68	0.29
% of dam body weight	5.87±0.08	7.21±0.99	0.31
Milk yield and its constituents			
Milk yield (kg d^{-1})	4.55±0.04	5.41±0.04	0.000
Milk composition (g kg^{-1})			
Total solids	130.26±1.55	130.04±1.55	0.92
Fat	42.70±1.02	42.41±1.02	0.85
Solids-not-fat	87.56±0.84	87.63±0.84	0.96
Protein	34.49±1.25	35.83±1.25	0.49
Lactose	46.07±0.58	45.08±0.58	0.29
Ash	6.64 ±0.09	6.61±0.09	0.83
Reproductive parameters			
Post-partum heat period (d)	98.00±2.08	86.33±2.33	0.02
Days open (d)	121.67±2.03	109.67±2.05	0.01

Body weight of the cows did not varied significantly by the concentrate supplementation in both pre-partum (p=0.82) and post-partum period (p=0.60) (Table 2). It might be due to reaching maximum growing stage of cows and literally proved that growth of the animals did not increase in significant trend after reaching certain age (Wiltbank *et al*., 1966). The within-subjects test indicated that time and, interaction of diet and time has significant ($p<0.01$) effects on both pre- and post-partum body weight of cows. Like body weight, body condition score of cows at pre-partum (p=0.47) and post-partum (p=0.67) period remains statistically similar but numerical value was found higher in supplemented group compared to the control group. Overall BCS of cows increased significantly (p=0.01) with the advancement of time but time and diet interaction was insignificant (Table 3). Though cows in supplemented group had received extra amount of concentrate mixture compared to the control group but BCS was not increased significantly that might be due to pregnancy stress at pre-partum and body tissue losses through milk production at post-partum period. This statement is supported by Khan *et al*. (2004) who reported that BCS of post-partum cow didn't improve after allowing concentrate supplementation during late pregnancy.

In addition to the above mentioned variables, Table 2 contains result on calf birth weight and the result exposed that calf birth weight was non-significantly (p=0.29) influenced by the concentrate supplementation. Again, it was noticeable that additional amount of concentrate mixture supplementation to the cows gave 24% higher newborn calves body weight compared to the control group calves. Similarly, Prima *et al*. (2018)

found 11% higher Holstein-Friesian crossbred calf birth weight in concentrate supplemented (0.5 kg/h/d) group than the control group. Similarly, average calf birth weight of control and supplemented group was 6 and 7% of the dam's body weight, respectively but remain statistically similar (p=0.31). On the contrary, supplementation during pre-partum period aids in growth of fetus as over one-half of the fetal growth ensues in the course of last trimester of gestation which augments calves birth weight (Prior and Laster, 1979). Similarly, Das *et al*. (2007) and Bayemi *et al*. (2014) reported that birth weight of calves will be higher when the cows supplied additional quantity of concentrate feed at earlier stage of calving. This evidence is highly corroborated with the findings of Sihag and Yadav (2007) in crossbred cattle, and Mahiyuddin and Praharani (2010) in Murrah buffalo and they stated that if dam's fed better nutrition at early stages of pregnancy then the born calves had greater birth weight than the calves born from usual dietary dams.

Yield of milk and its composition

Effect of concentrate supplementation on milk yield is presented in Table 2 and it implies that daily milk yield was significantly (p=0.000) affected by the pre-and post-partum diets. It could be inferred from the test of within-subjects effects that time and their interaction with diet both has significant (p<0.01) influence on milk yield of cows. Results indicated that those cow fed 25% more concentrate that produce 19% more (p=0.000) milk than the cows of control group. This significant increase of milk yield in supplemented group may be due to extra amount of concentrate supplementation during dry period to early stage of lactation. This finding is strongly agreed with Singh *et al*. (2003) and Das *et al*. (2007) who stated that extra feeding influences the development of secretory tissues in mammary gland which helpful for increasing the milk yield. Table 2 had the findings of milk compositional parameters and it was noticed that pre-and post-partum diet didn't alter any milk constituents of Zebu cows.

Table 3. Tests of within-subjects effect on DMI, growth, milk yield and its compositional parameters

Parameters	Source	F-value
DMI and growth parameters		
Pre-partum DMI	Time	1066.46**
	Time × diet	4.92*
Post-partum DMI	Time	969.55**
	Time × diet	2.37^{NS}
Pre-partum body weight	Time	1834.45**
	Time × diet	19.909**
Post-partum body weight	Time	3417**
	Time × diet	123.66**
Pre-partum BCS	Time	0.93^{NS}
	Time × diet	0.93^{NS}
Post-partum BCS	Time	1.34^{NS}
	Time × diet	0.15^{NS}
Overall BCS	Time	6.37**
	Time × diet	0.37^{NS}
Milk yield and its constituents		
Milk yield	Time	242.45**
	Time × diet	23.99**
Total solids	Time	56.35**
	Time × diet	9.72**
Fat	Time	64.86**
	Time × diet	5.87**
Solids-not-fat	Time	11.47**
	Time × diet	7.46**
Protein	Time	3.41**
	Time × diet	10.25**
Lactose	Time	18.88**
	Time × diet	6.75**
Ash	Time	2.02^{NS}
	Time × diet	0.45^{NS}

**Significant at p<0.01, *significant at p<0.05 and NS, non-significant.

Milk protein content of Holstein-Friesian crossbred cow was increased significantly through supplying extra amount (0.5 kg/h/d) of concentrate mixture (Prima *et al*., 2018), but did not happened so through feeding supplemented diet in this study. With the advancement of time and, interaction of time and diet indicated that significant (p<0.01) impact exists among all the constituents of milk except mineral content (Table 3). This finding is supported by Mac Rae *et al*. (1988) who opined that pre- and post-partum diets have very minute effect on milk composition especially on mineral and carbohydrate fractions. Similarly, Murphy (1999) observed that feeding cows more than normal before calving produces milk with negligible change in milk constituents. Furthermore, supplementation of concentrate to the graze dairy cows increases protein, fat and carbohydrate content in milk (Hills *et al*., 2015). The variation in the different report is may be due to the variation of experimental units and basal diet that's used in different study.

Reproductive performance of Zebu cows

Through supplying extra amount of concentrate (500 g) to the crossbred zebu cows brings remarkable changes in post-partum heat period (p=0.02) and days open (p=0.01) than cows fed control diet (Table 2). Results also delineated that both post-partum heat period and days open of crossbred zebu cows reduced by 12 days in concentrate supplemented group than the control group. This finding is in agreement with Prima *et al*. (2018) and Singh *et al*. (2003) who found similar results through providing of a higher plane of nutrition during the pre- and post-partum periods. This result is supported by Cavestany *et al*. (2003) who showed in dairy cattle that extending pre-partum nutrition reduces the length of post-partum heat period (49.9±7.1 days) in Holstein cows. Negative energy balance and rate of mobilization of body reserve appeared to be directly related to the post-partum interval to the first ovulation and lowered the conception rate (Butler and Smith, 1989). On the contrary, sometimes better nutrition and feeding level to the cows at transition stage didn't reduce post-partum heat and days open because these reproductive characteristics are controlled by genotype, environment and their joint interaction (Bayemi *et al*., 2014). According to Montiel and Ahuja (2005), malnutrition is responsible for prolonged post-partum anestrus and this is severe in those cows depend on forages only to meet their nutrient requirements. Beside this feeding management, heredity, environmental and overall management factors influenced the duration of anestrus in cows.

Conclusions

This study demonstrated that additional concentrate mixture supplementation with existing feeding (concentrate + green grass) to the crossbred Zebu cows had significantly increased dry matter intake, higher milk yield, early resumption of ovarian cyclicity and reduced days open. However, body condition score, calf birth weight and milk constituents were not affected by the concentrate supplemented diet. For improving the ration quality of advanced pregnant and early lactating cows, this study could provide guidelines for the tropical or sub-tropical countries like Bangladesh where cows are frequently fed an inadequate amount of concentrate.

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