Effect of Late Gestation and Early Postpartum Concentrate Supplementation on Milk Production, Milk Composition and Reproductive Performances of HF × Boran Dairy Cows

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Abstract
A study was carried out to evaluate the effect of late gestation and early postpartum concentrate supplementation on milk yield, milk composition and reproductive performances of HF × Boran crossbred dairy cows in randomized complete block design with three treatments. The treatments were control (hay and concentrate from agro-industrial by-products), T_2 (hay and concentrate from agro-industrial by-products plus ruminant premix) and T_3 (hay and concentrate mixture from agro-industrial by-products plus commercial dairy concentrate plus ruminant premix). As a result of variations in treatment diets, the crude protein contents of treatments during the late gestation and early postpartum periods were 26.5, 14.1, 14.3 and 26.5, 15.4, 15.6% for T_1, T_2 and T_3, respectively. The metabolizable energy contents of treatments were 11.1, 10.4, 10.7 and 11.1, 11.5 and 11.8 MJ/kg DM for T_1, T_2 and T_3, respectively. During late gestation period cows on the control diet had a higher ($P<0.001$) daily energy intake (91.0 MJ) than T_2 (88.0 MJ) and T_3 (86.2 MJ) per cow. The daily protein intake for T_1 (2699.2 g) was also higher ($P<0.0001$) than T_2 (1456.0 g) and T_3 (1430.8 g), respectively but not different ($P>0.05$) among parities. Total daily DM intake during early post-calving period for T_2 (14.5 kg) was significantly ($P<0.0001$) varied from T_1 (13.2 kg) and T_3 (13.1 kg). There was significant variation in nutrient intake among treatments and parities in the early postpartum period and daily energy intake per cow in T_2 (141.1 MJ) was higher ($P<0.0001$) than T_3 (129.3 MJ/) and T_1 (121.0 MJ). But the daily CP intake per cow was higher ($P<0.0001$) for T_1 (3499.3 g) than T_2 (2229.6g) and T_3 (2039.3 g). Daily milk yield per cow was 15.8 l, 14.2 l and 11.0 l for T2, T3 and T1, respectively. Milk composition did not vary ($P>0.05$) because of diet and parity differences. Body condition score (BCS) at calving and day 60, *calving to first heat intervals (CFHI),* calving to first service intervals (CFSI), calving to conception intervals (CCI) and calving interval (CI) was statistically different ($P<0.05$) among treatments and cows in T_2 and T_3 were better than T_1. Therefore, from the results it can be concluded that formulating ration according to the cow requirement, stage of production improves milk production and reproductive performances. Furthermore, agro-industrial by-products alone are appropriate feed sources in formulating dairy ration.
Keywords: agro-industrial by-products, hay, milk, milking cows, reproductive performances, supplementation

1. Introduction

In Ethiopia, the supply of processed animal feedstuffs is very limited, because of the fact that there are only 11 animal feed manufacturers operating in the country (CSA, 2012). Moreover, majority of them are working below their designated production capacities due to among others, low supply of raw materials, lack of commercial orientations by the farmers, poor awareness about processed feeds utilization by livestock producers, lack of tax exemptions and double taxations for individual feed ingredients in the compound feed mixtures (Adugna, 2009). In views of the emerging market-oriented livestock production (improved dairying and fattening) in the country and the corresponding supplementary feed requirement, it is obvious that the supply of processed feedstuffs in the country fall short of the anticipated demand. Fekede *et al.* (2015) reported that formulated rations were rarely accessed and used by smallholder peri-urban dairy farmers in Ejere, Sululta and GirarJarso districts of central highlands of Ethiopia.

Proper nutrition in the late stage of pregnancy is very critical since nutrient demands for foetal growth, body reserve replenishment and initiation of milk synthesis are increased. However, improvement of the late pregnancy feeding is rarely practiced in most production systems in tropical Africa (Gillah *et al*., 2013). Dairy farmers hardly use plant protein sources (oil seed cakes) and energy concentrates (Gillah *et al*., 2012) because of fearing high prices of commercial dairy feeds (Urassa *et al.*, 1999). Fekede *et al.* (2015) recommended that feeding trials and animal response studies are required to generate further information on the biological and economic advantages of using rations formulated from locally available ingredients over the industrially manufactured feeds. But still information on farm feed supplementation during the late stage of pregnancy on consecutive milk yield, milk chemical composition, reproduction performance and its cost implication is scarce in Ethiopia.

Zebu (*Bos inducus*) cattle are known to be less fertile and have lower levels of milk production than *Bos taurus.* However, *Bos taurus* are not well adapted to tropical environments and cannot maximize their potential for production in the tropics as they are less tolerance to heat stress with severe reduction in feed intake, growth rate, milk yield and reproductive function in response to heat stress (Pegorer *et al*., 2007). To minimize problems related to decreased production of purebred *Bos Taurus* cattle in Ethiopia one strategy has been to produce *Bos taurus* x *Bos indicuscross* cross breed dairy cows. Therefore, knowledge concerning ration formulation, feed intake and reproductive performances at late gestation and early post-partum in crossbred dairy cows that have *Bos indicus* blood in Ethiopia (tropical Africa) is useful to develop specific protocols or strategies to maximize production of these dairy cattle in a tropical environment. Therefore, in this study home-mixed concentrate with hay; home-mixed concentrate plus ruminant premix with hay and; and home-mixed concentrate plus ruminant premix plus commercially formulated concentrate with hay were fed to *Bos Taurus* dairy cattle that have *Bos indicus* blood from late pregnancy through early post-partum to evaluate the effect of the ration differences on feed intake, milk production, milk composition and reproductive performances.

2. Materials and Methods

2.1 Study site

The feeding trail was conducted at dairy farm of Addis Ababa University, College of Veterinary Medicine and Agriculture (CVMA) located in Bishoftu town. Bishoftu is located at 45 km along South East of Addis Ababa, the capital of Ethioipia at 9°N latitude and 40°E longitude and at 1850 m.a.s.l. The annual rain fall is 866 mm of which 84% is in the long rainy season from June to September. The annual average temperature ranges from 12.3^{o}C to 27.7^{o}C with an overall average of 18.7^{o}C (NMSA, 2010).

2.2 Feed chemical analysis and ration formulation

Before the start of the actual experiment representative samples from each feed ingredients were taken for chemical composition analysis. Furthermore, feed samples from formulated treatment rations from each treatment group were collected weekly, bulked, sub-sampled in to polythene bags followed by laboratory procedures for chemical composition analysis. Feed chemical compositions were analyzed at National Veterinary Institute (NVI) and Holleta Agricultural Research Center (HARC) laboratories. Feed samples were analyzed for DM and Ash using the standard procedures of AOAC (1995). Nitrogen (N) content was determined by Kjeldahl method and crude protein (CP) was then calculated as N*6.25 (AOAC, 2005). The organic matter was calculated as difference between 100 DM and ash content. Acid Detergent Fiber (ADF) and Neutral Detergent Fiber (NDF) were analyzed following the procedures of Van Soest *et al*. (1991). Calcium (Ca) content of the feeds was analyzed using atomic absorption spectrophotometer following the procedures of Perkins (1982) and phosphorus (P) content was determined using auto analyzer according to AOAC (1995). In *vitro* organic matter digestibility 48h (IVOMD, g/kg) determination was done according to Tilley and Terry (1963). Metabolizable energy (ME) was then estimated from the IVOMD according to McDonald *et al*. (2002) as; ME (MJ/kg of DM) = 0.016 x (g/kg of IVOMD)

2.3 Experimental design and feeding

Twelve close-up dry crossbred dairy cows with about 75% of Holstein Friesian blood and 25% of local zebu (Boran) were selected from the dairy herd on the basis of parity (0 to third parties) and gestation length. The cows were then blocked by parity, and four animals from each parity group were randomly assigned to one of the three treatments making 4 animals per treatment in a Randomized Complete Block Design (RCBD) experiment. The three treatment combinations were the following;

$T_{1,}$ *ad libitum* hay + noug (*Guizotia abyssinica*) seed cake, wheat middling, wheat bran and salt),
$T_{2,}$ *ad libitum* hay + noug (*Guizotia abyssinica*) seed cake, wheat middling, ruminant premix and salt),
$T_{3,}$ *ad libitum* hay + noug (*Guizotia abyssinica*) seed cake, wheat middling, super dairy concentrate with 19% CP/kg, ruminant premix and salt). For all treatment groups hay was a basal diet.

In all groups, feeding was started 21 before calving and continued up to 90 days in milk (DIM) post-partum. The cows in T_1 (control) fed *ad libitum* hay and agro-industrial by-products according to the farmer feed formulation and feeding systems. Cows in T_2 fed *ad libitum* hay and agro-industrial by-products rich in energy and protein contents plus ruminant premix. Cows in T_3 fed *ad libitum* hay and agro-industrial by-products plus ruminant premix plus super commercial concentrate (complete dairy feed having energy, protein, minerals and vitamins) mixed from different ingredients which was not specified because of commercial use.

The energy and protein requirements for dairy cows with about 75% Holstein blood level was calculated based on feeding standards for farm animals and nutrition values of animal feeds (CVB, 2012). Accordingly, for 550 kg body weight dry mature cow 90 MJ ME/day and 1680 g CP per day with 14% protein content ration and 107 MJ ME/day and 2250 g CP per day with 15% CP content ration for a lactating cow with 500 kg body weight (10 liter milk production per day). Furthermore, for additional milk production 5.3 MJ energy per liter was considered. The normal daily intake of roughage varies between 8 to 10 kg for a cow of 400 kg and 10 to 12 kg for a cow of 500 kg (Hans *et al*., 2008). In the current feeding trail 8 to 13 kg hay/day/cow was offered during late pregnancy and postpartum periods depending on the daily refusals with *ad libitum* feeding. The concentrate supplementation during the late pregnancy was 3 kg/day/cow for cows in T_2 and T_3. But for cows in T_1 (control) the amount of daily concentrate offered was according the farmer feeding which was 6 kg/day/cow and was similar during the late pregnancy and postpartum periods. After calving the ration for (T_2 and T_3) was changed to milking ration and the concentrate supplementation was increased by 0.5 kg per day for two weeks (maximum 10 kg) then after two months it depends on cow's milk production (*i.e.* for 1 liter additional milk production 0.5 kg concentrate supplementation).

2.4 Animal management

Cows were individually penned and fed with native grass hay and experimental diets until the end of the trail. Feed was offered twice per day at 8:00 AM in the morning and 4:00 PM in the afternoon during late pregnancy period. Clean and fresh drinking water was offered four times daily in the morning, after-noon, late after-noon and evening to all experimental cows. During the post-partum phase, concentrate was offered three times a day in the morning (6 AM), afternoon (4 PM) and evening (7 to 8 PM) in the milking parlour and cows were hand milked twice a day at 6 to 7 AM and 4 to 5 PM starting the 5th day post-calving and daily milk yield was recorded accordingly. Any sign of estrus manifestation was visually observed and recorded three times daily, early morning, afternoon and late after-noon. Cows in heat were inseminated with natural bull after 7 to 8 hours of observed estrus.

2.5 Data collection

2.5.1 Feed and nutrient intake

Feed refusals were collected in the next morning and weighed after removing external contaminants. The amount of daily feed consumed was determined as the difference between the daily feed offered and refused on dry matter (DM) basis. The daily protein intake in gram was calculated as the daily DM intake multiplying by the protein content of the ration. Then total daily energy intake in MJ/kgDM was calculated as the sum energy intake from hay and concentrate feeds (CVB, 2012).

2.5.2 Milk yield

The average daily milk yield of the individual lactating cow was determined by dividing the total milk yield of each experimental cow by the number of milking days.

2.5.3 Milk composition analysis

Lactation stage is one of the major factors influencing yield and composition of milk in cattle Ibeawuchi and Dangut (1996) and milk samples were collected in mid-early lactation of the experiment on day 56 after calving for physicochemical qualities analysis. Composite of 100 ml raw milk samples from morning and afternoon milking were made from each cow into sterile bottles, kept on an ice box and transported to Ethiopian Meat and Dairy Industry Development Institute (EMDIDI) laboratory for analysis.

Physical examination of milk samples: The temperature of the milk samples was determined immediately after milking at each collection time using thermometer. The pH of the milk samples was determined in the laboratory using a digital pH-meter based on the procedure described by O'Connor (1995). Specific gravity (density) of milk was calculated according (O'Connor, 1995) as Specific gravity = (L/1000) +1 Where, L = corrected lactometer reading at a given temperature. Titratable acidity (TA) of the milk samples was determined according to the method of the (AOAC, 1990) following the formula;

$$TA\% = \frac{N/10\ NaOH\ (ml) \times 0.009}{\text{weight of milk sample}} \times 100$$

Chemical composition of milk samples: Milk total solids (TS) were calculated according to Richardson (1985) by the formula;

$$TS = \frac{(Cwt + \text{Oven dry sample weight}) - Cwt}{\text{Sample weight}} \times 100$$

Where, Cwt = crucible weight

Total protein content of the milk samples was determined by Kjeldahl method (AOAC, 1990). The Gerber method was used to determine the milk fat content and fat percentage was read from the butyrometer scale (O'Connor, 1995). Total ash content was determined according to the procedures of Richardson (1985) by igniting the dried milk samples used for determination of total solid content in a muffle furnace in which the temperature was slowly raised to 550°C. The sample was ignited until carbon disappears and a white ash remains. Total ash was then calculated as;

$$Ash = \frac{\text{Residue weight}}{\text{Sample weight}} \times 100$$

Solids-not-fat (SNF %) content of milk samples was determined by subtracting percent milk fat content from milk total solids (TS) present O'Mahony (1988) as;

% Solids-not-fat = %Total solids – %fat

The lactose percentage was determined by subtracting the milk fat, protein and total ash percentages from the

percentage of the milk total solids O'Mahony (1988) as;
% Lactose = % total solids – (% fat + % protein + % ash)
2.5.4 Reproductive parameters
Body condition score (BCS), calving to first heat interval (CFHI), calving to first service interval (CFSI), calving to conception interval (CCI), calving interval (CI) and services per conception (S/C) were measured as indicators for reproductive performances of crossbred dairy cows. BCS of cows was measured at the start of the experiment, 5 to 12 days postpartum and 60 days after calving. Body condition score of cows was recorded by visual observation and manual assessment to score the dairy cows on a 1 to 5 scale (where 1 = emaciated, 5 = fat) following the procedures of (Edmonson *et al*., 1989). CFHI was determined by calculating the number of days from calving to first heat sign observed. CFSI was determined as the number of days from the time a cow calved until her first service. CCI was determined as the interval between calving and the next successful conception. The CI was estimated from CCI and the gestation length in cattle (*i.e.* CCI = CI-280).

2.6 Statistical analysis
The data collected were managed and organized in Excel and analyzed using General Linear Model (GLM) of Statistical Packages for Social Sciences (SPSS, 2011) version 20. The mean comparison was done using the least significant difference (LSD) for parameters with significant differences. Preliminary analysis showed that interaction effects of the fixed factors were not significant and thus not included in the model. The model used for data analysis was:
$Y_{ij} = \mu + T_i + P_j + e_{ij}$
Where;
Y_{ij} = the response variable such as feed intake, milk yield, milk composition and reproductive parameters
μ = the overall mean
T_i = effect of i^{th} treatment/diet (Ti = 1, 2, 3)
Pj = effect of the j^{th} parity (Pj = 0, 1, 2, 3)
e_{ij} = random error

3. Results and Discussion
3.1 Chemical composition of the experimental feeds
The chemical composition of feed ingredients and the experimental rations are given in Table 1 and 2, respectively. The CP content of NSC was higher than that of 31.26% and 28.2% reported by Abebaw and Solomon (2008) and Wondimagegne *et al*. (2016), respectively. This indicated that NSC is a good source of protein that could be used to supplement native grass hay utilized in livestock feeding. The CP content of grass hay in the current study was in agreement with Aschalew and Malede (2013) who reported 6.7%. The NDF content of grass hay in the current study was nearly equivalent with 74.4% NDF reported by Gezu *et al*. (2017). The CP content of wheat middling was within the CP range of wheat bran of 16 to 21% (McDonald, 2002) and similar with the CP contents of wheat middling 17.8% (Adugna, 2008).

The CP content in T_1 was similar with Mesfin *et al*. (2013) who investigated 26% of CP from farmers' home-mixed concentrate for lactating crossbred dairy cows in peri-urban dairy production system of central Ethiopia. The CP values for T_2 and T_3 during the post calving period was comparable with 15% CP for concentrate mixture recommended by Delgado and Randel (1989) for cows grazing tropical grass swards. The difference in CP values maybe attributed to ration differences as dairy farmers have no standards to blend individual feed ingredients in formulating concentrate mixtures.

Table 1. Chemical composition of feed ingredients (% DM)

Chemical composition	Hay	Wheat middling	Super concentrate (19% CP)	Noug seed cake (NSC)
DM%	90.7	90.0	91.6	93.10
Ash%	9.2	4.5	8.7	10.10
EE%	0.7	3.5	3.3	7.40
CP%	6.8	17.8	31.0	39.9
Ca%	1.8	1.9	2.4	1.10
P%	0.15	1.1	0.38	0.46
OM%	90.8	95.5	91.3	89.90
ADF%	39.5	10.0	10.3	31.70
NDF%	73.1	42.2	48.5	54.55
IVOMD%	48.7	70.4	75.0	70.11
g IVOMD/kg	486.8	704.0	750.0	701.10
ME (MJ/kg)	7.8	11.3	12.0	11.20

DM= Dry matter; EE= Ether Extract; CP= Crude protein; Ca= calcium; P= Phosphorus; OM= Organic Matter; ADF= Acid Detergent Fiber; NDF= Neutral Detergent Fiber; IVOMD = *In vitro* Organic Matter Digestibility; ME= Metabolizable Energy; MJ= *Megajoule*

Table 2. Chemical composition of experimental rations (%DM)

	DM%	Ash	CP	ADF	NDF	Ca	P	OM%	g IVOMD/kg	ME (MJ/kg)
Treatments										
Pregnant diet										
T_1	91.0	6.1	26.5	10.3	50.5	1.1	0.4	93.9	695.0	11.10
T_2	93.1	13.5	14.1	20.1	43.4	1.7	1.9	86.5	650.0	10.40
T_3	92.1	12.6	14.3	18.7	44.2	1.8	2.4	87.4	670.0	10.70
Milking diet										
T_1	91.0	6.1	26.5	10.3	50.5	1.1	0.4	93.9	695.0	11.10
T_2	91.8	12.7	15.4	19.1	39.7	1.5	1.7	87.3	720.0	11.50
T_3	92.2	11.6	15.6	17.0	33.1	1.7	2.1	88.4	740.0	11.80

DM= Dry matter; EE= Ether Extract; CP= Crude protein; Ca= calcium; P= Phosphorus; OM= Organic Matter; ADF= Acid Detergent Fiber; NDF= Neutral Detergent Fiber; IVOMD = *In vitro* Organic Matter Digestibility; ME= Metabolizable Energy; MJ= *Megajoule*; T_1= treatment one (control, farm concentrate); T_2= Treatment two; T_3= Treatment three

3.2 Dry matter and nutrient intake of experimental cows

Daily dry matter and nutrient intakes during late pregnancy: The overall mean feed and nutrient intakes of cows during late pregnancy and post partum periods are presented in Table 3. The daily total dry matter intake during the late pregnancy period was not significantly varied (p>0.05) among treatments. But daily DMI was significantly varied (P<0.0001), (p<0.01) among parities with higher intake by heifers than first, second and third parties which could be related to separate feeding and heifers need more feed for growth than others. But cows in the first, second and third parties were not statistically different (p>0.05) in their daily hay, concentrate and DM intakes. Total ME intake of cows in first and second parities were significantly (p<0.05) lower than heifers. But the CP intake of cows with different parities was not significantly varied (p>0.05). The variation in daily CP, ME and DM intakes of different parities during the late pregnancy period could be attributed to the differences in ration formulation and amount of feed supplementation. Hayirli *et al.* (2002) reported that transition from gestation to lactation is characterized by a dramatic decrease in DM intake and the average decrease in DM intake of heifers was less than cows during the final 3 wk of gestation.

Daily dry matter and nutrient intakes during post-calving: During the early post-calving period total daily concentrate intake of cows in T_1 was significantly lower (p<0.0001) than T_2 and T_3. Daily concentrate intake of cows in T_2 was also significantly higher (p<0.001) than T_3. Total daily DM intake of T_2 was higher (p<0.0001) than T_1 and T_3. Total daily ME intake in T_2 was statistically higher (p<0.0001) than T_1 and T_3. The ME intake of T_1 was also lower (p<0.001) than that of T_3. Total daily CP intake was significantly varied (p<0.0001) among treatments in which T_1 was significantly higher (p<0.0001) than T_2 and T_3. CP intake in T_2 was also higher (p<0.001) than T_3. The lower daily ME intake in T_1 from T_2 and T_3 could be due to the high protein intake in T1 (table 3). Increasing dietary protein concentration above the requirement reduced the daily and cumulative energy balance (Law *et al*., 2009). Assaminew and Ashenafi (2015) also reported that agro-industrial by-products used to feed lactating crossbred cows were commonly mixed in similar mixtures regardless of milk yields. The daily ME intake in T_3 was comparable with the daily ME intake of 133 MJ for milking crossbred cows in hay based diets reported by (Rehrahie and Getu, 2010). But the daily CP intake in the current study was higher than 1508 g/day reported by the same authors which could be resulted to the daily intake and ration differences.

The daily concentrate intake was also varied (p<0.0001) with third parity cows having higher intake than others. Furthermore, heifers was with significantly lower (p<0.0001) concentrate intake than other parity groups. Daily DM intake was higher (p<0.0001) for third and second parties than other groups. The ME intake of cows in third parity was higher (p<0.001) than other groups. Heifers ME intake was significantly (p<0.05) lower than second parity cows but similar with first parity cows. CP intake of second and third parity cows was higher (p<0.0001) than other groups. The differences in DM and nutrients intakes could be due to the differences in ration, milk yield and way of feeding. After parturition, dairy cattle are faced with a sudden and marked increase of nutrient requirements to support milk production (Drackley, 1999). Improving energy balance in the postpartum period can reduce the incidence of periparturient diseases Duffield *et al*. (2009).

3.3 Milk yield

The mean milk yield showed significant differences (p<0.0001) between treatment groups with higher daily yield in T_2 followed by T_3 and T_1 (table 4) for the three months milking periods. The difference could be due to the higher protein supply and relatively lower energy supply through home-mixed concentrate in T_1 compared to T_2 and T3 (table 3). Studies by Steinshamn (2010) also indicated that the differences in milk yield among treatment groups could be accredited to the differences in crude protein and energy contents in the feeds. The ADMY in T_2 was consistent with 15.5 l/day/cow in urban dairy production systems in Adama milkshed, reported by (Nigusu and Yoseph, 2014). The milk yield results of T2 and T3 were higher than the milk yield results 11.1, 11.6 and 10.8 kg/day, reported by (Assaminew and Ashenafi, 2015 and Dessalegn *et al*., 2015), respectively but comparable with the milk yield in T1. The variations could be resulted to management and lactation differences.

Milk yield of cows in third parity was higher (p<0.0001) than other groups which may be due to intake differences. Daily milk yield of heifers was also higher (p<0.001) than first parity cows but not different (p>0.05) from second parity cows which could be attributed to blind teats in some of the first parity cows. Similar to the current results, Jemila and Achenef (2012) reported that the average milk yield of primiparous cows was higher than multiparous cows. Shuiep *et al*. (2016) also studied crossbred cows showed significantly (p<0.01) higher average yield in different parities. The same authors highlighted also order of parity are significantly (p<0.01) affecting the daily milk yield.

3.4 Milk composition

As presented in Table 4, milk composition analysis results indicated that there were no significant differences (p>0.05) among treatment and parity groups. The non significant differences (p>0.05) in milk composition was also in agreement with Netsanet *et al*. (2015) who investigated milk total solids, crude protein, lactose, solid-not-fat, total ash and calcium and phosphors contents of milk samples from cows fed diets having different ratios of roughage to concentrate were not significantly varied (p>0.05) by diet differences. Milk compositions were also not significantly affected (p>0.05) by parities which is comparable with Jemila and Achenef (2012) who indicated that milk fat, SNF, protein, lactose and pH were not different (p>0.05) in primiparous and multiparous cows.

3.5 Reproductive parameters

As indicated in Table 5, BCS at the start of the experiment was not significantly different (p>0.05) among treatment groups. But BCS at 5 to 12 days after calving and at day 60 after calving were significantly different (p< 0.05) with T_1 lower than T_2 and T_3. Calving to first heat interval (CFHI) of cows in T_2 and T_3 were significantly higher (p<0.05) thanT_1. Calving to first service interval (CFSI) of cows in T_2 and T_3 were significantly higher (P<0.05) than T_1. CCI and estimated CI were significantly (p<0.05) varied in which T_2 and T_3 were faster than T1. But services per conception (S/C) was not varied (p>0.05) among treatment groups. Ferguson *et al*. (1994) determined that the BCS of an adult cow during the first two months of lactation should decrease by no more than 0.5 to 1 point which was consistent with the current results. Hasan *et al.* (2011) found significant (p< 0.01) effect of pregnancy rate on different BCS groups in which cows having BCS 3.1 - 4.0 (very good condition) showed better pregnancy rate. Unlike to the current results, Tolla and Vijchulata (2006) failed to report significant variations (P<0.05) in calving to first heat sign interval among treatment diets which could be attributed to management differences. The current result in S/C was comparable with Moges (2012) who studied 1.3 services per conception in urban areas in Gonder. At Bishoftu and Akaki CI were 13.0 and 13.8 months, respectively for cross breed cattle as reported by Dessalegn *et al*. (2015) which were higher than the current CI results. The current result in CCI was lower than the CCI of 176.8 days in the urban areas of Addis Ababa reported by Lemma and Kebede (2011). The variations could be due to BCS and management differences.

BCS at 5 to 12 days after calving for first parity cows was significantly higher (p<0.05) than heifers and third parity cows. But BCS of parity two cows was similar (p>0.05) with other groups. At day 60 after calving

BCS of third parity cows was statistically lower (p<0.05) than first and second parity cows but not different (p>0.05) from heifers. CCI and CI of heifers were higher (p<0.05) than the other parity groups. But non-significant differences (p>0.05) in CCI and CI were observed in first, second and third parity cows. Similar to the current study, non-significant effect (P>0.05) of parity on S/C was also reported by Ibrahim *et al.* (2011). Khan *et al.* (2015) reported higher conception rate in cows at second and third parity than that of cows at zero parity which are consistent to the current results.

Table 3. Dry matter and nutrient intakes during pre and post partum period of crossbred dairy cows

Parameters	Hay (kg/d/c)	Concentrate (kg/d/c)	Total DMI/d/c	Total ME, MJ/d/c	Total CP, gDM/d/c
	Feed and nutrient intakes during pregnancy period				
Treatments					
T_1	6.7^c	3.5^a	10.2	91.0^a	2699.2^a
T_2	7.5^a	2.8^b	10.3	88.0^b	1456.0^b
T_3	7.2^b	2.8^b	10.0	86.2^b	1430.8^b
SEM	0.1	0.03	0.1	0.8	18.6
p-value	<0.0001	<0.0001	0.064	<0.0001	<0.0001
Parity					
P_0	7.6^a	2.9^b	10.5^a	90.6^a	1896.0
P_1	6.9^b	3.1^a	10.0^b	87.3^b	1851.2
P_2	7.0^b	3.0^{ab}	10.0^b	87.2^b	1838.5
P_3	7.1^b	3.0^{ab}	10.1^b	88.1^{ab}	1862.2
SEM	±0.1	±0.04	±0.1	±1.0	±21.5
p-value	<0.0001	0.01	0.008	0.043	0.261
Treatments	Feed and nutrient intakes during milking period				
T_1	7.9^a	5.3^c	13.2^b	121.0^c	3499.3^a
T_2	6.9^b	7.6^a	14.5^a	141.1^a	2229.6^b
T_3	6.2^c	6.8^b	13.1^b	129.3^b	2039.3^c
SEM	±0.7	±0.7	±0.1	±1.0	±18.0
p-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Parity					
P_0	6.8^b	6.4^c	13.2^b	126.4^{bc}	2534.3^b
P_1	6.7^b	6.6^b	13.4^b	128.8^b	2556.0^b
P_2	7.8^a	6.0^d	13.8^{ac}	130.2^b	2620.1^a
P_3	6.7^b	7.3^a	14.0^a	136.0^a	2647.3^a
SEM	±0.08	±0.08	±0.1	±1.2	±20.8
p-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

^{a,b,c,d} Means within column with varied subscripts are different at p<0.0001, p<0.0), p<0.01; SEM = Standard Error of the Mean; T_1= treatment one (control, farm concentrate); T_2= Treatment two; T_3= Treatment three; DMI= Dry matter intake; d= day; c= cow; ME=Metabolizable Energy; MJ= *Megajoule*; CP=Crude protein; P_0= Heifer; P_1= first parity; P_2= second parity; P_3 = third parity

Table 4. Milk yields (l/day/cow) and milk composition (%) of crossbred dairy cows fed on different treatments

Measurements	ADMY (L/d/c)	Acidity%	Fat%	Protein%	SNF%	Density (G/ML)	pH	TS%	Lactose%	Ash%	Temp.(^{0}C)
Treatments											
T_1	11.0^c	0.19	4.2	3.2	7.7	1.028	6.7	11.6	3.7	0.70	35.8
T_2	15.8^a	0.21	4.5	3.4	7.9	1.028	6.6	12.4	3.9	0.72	36.1
T_3	14.2^b	0.20	4.3	3.5	7.8	1.028	6.7	12.0	3.8	0.71	35.8
SEM	±0.1	±0.01	±0.4	±0.1	±0.02	±0.01	±0.01	±0.4	±0.2	±0.01	±0.3
p-value	<0.0001	0.15	0.84	0.28	0.80	0.84	0.11	0.51	0.77	0.38	0.62
Parity											
P_0	13.2^b	0.20	4.5	3.2	7.5	1.027	6.6	11.7	3.6	0.71	35.8
P_1	12.5^{bc}	0.20	4.7	3.6	8.4	1.030	6.6	12.8	4.1	0.71	35.7
P_2	12.8^b	0.20	3.9	3.3	7.9	1.029	6.7	11.8	3.9	0.71	36.2
P_3	15.8^a	0.19	4.2	3.4	7.3	1.026	6.7	11.8	3.5	0.70	36.0
SEM	±0.1	±0.01	±0.4	±0.1	±0.3	±0.01	±0.01	±0.5	±0.2	±0.01	±0.3
p-value	<0.0001	0.86	0.66	0.15	0.11	0.18	0.15	0.48	0.20	0.79	0.70

^{a,b,c} Means followed by varied superscript letters within a column are different at P<0.0001; SEM = Standard Error of the Mean; ADMY= Average daily milk yield; SNF= Solid not fat; TS= Total solids; T_1= treatment one (control, farm concentrate); T_2= Treatment two; T_3= Treatment three; P0= Heifer; P1= first parity; P2= second parity; P3 = third parity

Table 5. Reproductive parameters of crossbred dairy cows fed on different diets

Measurements	BCS at start of the experiment	BCS at 5 to 12 after calving	BCS at day 60 after calving	CFHI, days	CFSI, days	CCI, days	S/C	CI, months
Treatments								
T_1	2.9	2.8^b	2.5^b	68.3^a	78.0^a	80.4^a	1.4	12.1^a
T_2	3.3	3.3^a	3.2^a	28.0^b	56.0^b	61.5^b	1.3	11.4^b
T_3	3.3	3.3^a	3.1^a	24.1^b	55.5^b	64.0^b	1.3	11.5^b
SEM	±0.13	±0.11	±0.13	±6.3	±5.6	±2.6	±0.01	±0.2
p-value	0.087	0.016	0.015	0.023	0.038	0.049	0.286	0.037
Parity								
P_0	2.92	2.92^b	2.75^{ab}	33.7	64.3	87.2^a	2.0	12.3^a
P_1	3.50	3.50^a	3.25^a	40.0	55.3	55.3^b	1.0	11.2^b
P_2	3.25	3.17^{ab}	3.17^a	31.1	64.6	64.9^b	1.0	11.5^b
P_3	3.00	2.92^b	2.42^b	37.6	66.7	67.1^b	1.0	11.5^b
SEM	±0.2	±0.13	±0.15	±15.3	±4.3	±3.6	±0.2	±0.07
p-value	0.112	0.047	0.026	0.894	0.222	0.027	0.286	0.017

^{a,b,c} Means followed by varied superscript letters within a column are different at P<0.05; SEM = Standard Error of the Mean; BCS= Body Condition Score; CFHI= Calving to First Heat Intervals; CFSI= Calving to First Service Interval; CCI= Calving to Conception Interval; S/C= Number of Service per Conception; CI= Calving Interval; T_1= treatment one (control, farm concentrate); T_2= Treatment two; T_3= Treatment three P0= Heifer; P1= first parity; P2= second parity; P3 = third parity

4. Conclusions

From the current feeding trail it can be concluded that, good quality agro-industrial by-products alone can be used as suitable feed ingredients in formulating dairy ration when they are formulated according the cow requirements in different stages of production. Appropriate and separate feeding schedule of different parity cows during pre-calving period improves post-calving milk production, body condition score, initiation of ovarian cyclicity and calving to conception intervals. Furthermore, differences in ration, dry matter and nutrient intakes and parity causes variation in milk yield among cows. Higher protein and relatively lower energy intakes also reduce milk production. Additionally, in the current trail early postpartum milk composition was not varied because of the diet and parity differences. Further experiments should be carried out to investigate the more appropriate agro-industrial by-products for ration formulation with other roughage feeds and more experimental animals during the last pregnancy and post-calving periods according to dairy cows requirements in relation to the environment the animals are found. Since the price of commercial dairy concentrate is becoming high and is also inaccessible for most dairy farmers, more information is needed on how to scientifically replace it with other locally available dairy feeds which are easily accessible to farmers.

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