Dry Matter Intake and Feed Conversion Efficiency of Pure Jersey Calves Reared on Two Whole Milk Feeding Systems

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ABSTRACT

Setting economically better level of milk for calves rearing is essential in dairy farming. The objective of this study was to evaluate feed intake, growth and feed conversion efficiency of pure Jersey calves at Adea Berga Research Station, Ethiopia. A study on rearing Jersey calves (males and females), utilizing two systems of whole milk feeding was conducted on 29 calves. Calves were fed colostrums from birth up to 4 days of age and assigned to either Holeta Research Center feeding standard set for crossbred calves (feeding 260 litres whole milk per calf from birth up to weaning) as Treatment 1, and 10% calf body weight level as Treatment 2. Calf starter and hay) were offered from two weeks of age. Daily whole milk consumption, feed intake and fortnightly body weights were recorded. Feed samples were collected and analyzed for chemical compositions. Data were analyzed using SAS version 9, 2004. Calves in Treatment1 consumed higher amount of whole milk during early life than those in Treatment 2. However, Calves in Treatment 2 consumed higher amount of whole milk than calves in Treatment 1 after seven weeks of age. Daily dry matter intake of calves was higher for calves reared under Treatment 2. Calves reared under Treatment 2 had higher growth rate starting at 7 weeks of age. Calves in Treatment 2 attained significantly ($P<0.05$) higher body weight at 6th months of age as compared to calves in Treatment 1. Calves in Treatment 2 had higher feed conversion efficiency (gain: feed) than calves in Treatment1. Thus it can be noted that for better growth performance of Jersey calves, feeding whole milk at the rate of 10% body weight is recommended.

Key words: milk level, calf starter, feed intake, body weight

INTRODUCTION

Calf rearing is one of the most important husbandry practices used as a basis for sustainability and productivity of the dairy farm. The overall target of raising dairy calves is accelerating growth and lowering mortality. In order to achieve these targets proper calf rearing practices and health care are very important.

The appropriate level of whole milk feeding for dairy calves has the potential to increase growth rates during the pre-weaning period (Kamiya *et al*, 2009 and Uys *et al*, 2011), to reduce time needed to reach a necessary body weight and attain age at first service early (Davis *et al*, 2006) and improve milk yield at first calving (Moallem *et al*, 2010 and Soberon *et al*, 2012). Disadvantages of providing more whole milk include reduced solid feed intake during the milk feeding period (Uys *et al*, 2011 and DePassille *et al*, 2011) and slower rumen development (Khan *et al*, 2007a,b). Bascom (2002) discussed that Jersey and Guernsey calves may have higher maintenance energy requirements and thus require a more energy-dense diet than calves of the Holstein or Ayrshire breed, as indicated by the breed differences in milk composition.

Jersey calves are unique due to their smaller frame size and lighter birth weights. Due to their smaller size, it is feasible to assume that Jersey calves might require more energy per unit of BW (Body Weight) for maintenance, because they have a greater body surface area per unit of BW, as indicated by their metabolic bodyweight, and thus are likely to use more energy to maintain their body temperature. Davis and Drackley (1998) recommend that milk replacer powder should contain between 18 and 24% CP (Crude Protein). However, the appropriate level of CP in the diet depends on the level of intake and energy supplied (Davis and Drackley, 1998). Calves consuming high levels of DM (as a percentage of BW) or high-energy diets require more dietary protein for lean tissue growth than calves on low energy or restricted levels of intake. Calves consuming milk or milk replacer at or near *ad lib* intake require a higher level of protein relative to energy than calves fed a restricted level of milk or milk replacer. This indicates maintenance energy requirement of Jersey calves may have been higher per unit of metabolic BW than Holstein calves and that NRC (2001) equations for maintenance energy may not be appropriate for Jersey calves.

Jersey calves are being raised at Adea Berga Research Center which is located in West Shewa Zone, Oromia Region, Ethiopia as a replacement for pure Jersey herd. Adea Berga Research Center was governmental dairy state farm before it was transferred to EIAR. It was established to support milk supply to Addis Ababa market. This herd has been also serving as genetic pool to recruit best sire for semen collection which has been used by National Artificial Insemination Center (NAIC). In addition, there will be a possibility to adopt and practice raising pure Jersey cattle by private holders in the near future because of high fat content of milk from Jersey breed, which is suitable for manufacturing cheese and other milk products. However, Jersey calves at Adea Berga have been raised by feeding unlimited amount of whole milk. There is no clear whole milk feeding guide to implement regular practice. However, unpublished data indicates each calf consume 669 litres of whole milk and weaned at 6 months of age. This type of calf rearing incurs extra cost of milk and labor. Therefore, generating technologies that support rearing of Jersey calves especially in early life is crucial both for profitable farming and productive life span of the animals. The objective of this study was to evaluate DM consumption, growth and feed conversion efficiency of pure Jersey calves reared on two whole milk feeding systems.

MATERIALS AND METHODS

Location

The study was conducted at Adea Berga Research Station, West Shewa Zone of Oromia Region, Ethiopia, which is located 70 km west of Addis Ababa. The center lies within 9^{o}16’N and 38^{o}23’E and has an altitude of 2500m a.s.l. It has an annual mean temperature of 18^{o}C and annual mean rainfall of 1225mm (HARC, 2010).

Experimental Design

The experimental design was RCBD with two treatments (blocked by calf sex), using 8 replicates. Originally, it was planned to use 16 male and 16 female Jersey calves (32 Calves for the experiment). Thirty two Jersey calves were randomly assigned to experimental treatments right after birth. However, three calves have died and their data was excluded from analysis. Data from twenty nine calves were used for statistical analysis.

Two treatments consisting standard check (whole milk feeding standard practiced by Holeta Research Center, in which calves are fed colostrums over 4 days, and expected to consume 260 litres of whole milk over 94 days), (Table 1) and 10% calf body weight whole milk feeding levels (as recommended by Amaral-Phillips, *et al*, 2006) daily were used as treatments 1 and 2 respectively. Calves on both treatment groups were weaned at 98 days of age.

Table 1. Calf whole milk feeding standard of Holeta Research Center (litres)

Calf Age range (days)	A.M.	P.M.	Total/day	Days on milk
0-4	colostrum	colostrum	colostrum	4
5-15	1.5	1.5	3.0	11
16-43	2.0	2.0	4.0	28
44-63	1.5	1.5	3.0	21
64-85	1.0	1,0	2.0	21
86-98	0.5	0.5	1.0	13

Daily whole milk consumption**,** feed intake, and fortnightly body weights were measured and recorded. Animal weighing scale was used to measure calf body weights. Growth rate of calves was computed by regression analysis of fortnightly body weights, body weight as dependent and age as independent variable. Daily body weight gain was calculated as predicted final weight minus predicted initial weight divided by age of the calf. Feed conversion efficiency was calculated by dividing mean daily weight gain by mean daily feed DM intake. Data were analyzed using least square mean procedure of SAS system (SAS, 2004).

Experimental animal management

Calves were housed in separate well ventilated calf room. The floor is concrete with suitable drainage system. Each calf was kept in separate calf box with feed trough for hay feeding. Plastic buckets were used for watering and feeding calf starter.

Concentrate feed mixture with estimated 0.73 Mcal DE/Kg energy and 18 % CP was formulated to be supplemented to the calves. Calf starter used was a mixture of 73% wheat bran, 26% *noug* cake 1% Calcium Carbonate. Hay harvested from natural pasture from Adea Berga Research Center was used as roughage source. Hay feeding commenced starting at first week of age, while calf starter feeding was commenced starting at two weeks of age. Calves were offered dry feed at the rate of 3% body weight on DM basis. Calf starter and hay were offered only once every morning after weighing feed refusals of last day's feeding. Concentrate: roughage ratio of 30:70% was used to feed the calves. The amount of calf starter and hay offered was adjusted weekly.

Calves were watered *ad lib* both in the morning and afternoon in pails starting at one week of age. Calf room was cleaned twice per day every morning and in the afternoon. Oat straws were used as bedding material. The bedding was changed twice per day after cleaning urine and faces. Calves were allowed to exercise for an hour daily outside their rearing room every morning.

Feed sample collection and laboratory analysis

Feed samples (calf starter and hay) were collected daily and bulked. The bulked samples were thoroughly mixed and sub sampled for laboratory analysis. Dried feed samples were clipped and ground using Wiley Mill to pass 1 mm sieve. Samples were analyzed for Dry Matter (DM), Ash, and CP using standard procedure (AOAC, 1990). Neutral Detergent Fiber (NDF) and Acid Detergent Fiber (ADF) were determined according to the procedure described by Van Soest, and Robertson (1985). Two-stage technique of Tilley and Terry (1963) was used to determine In-vitro Dry Matter Digestibility (IVDMD) of the feedstuff.

RESULTS

Chemical compositions of calf starter and hay used in the study are presented in Table 2.There were no significant ($p > 0.05$) differences between treatments in feed chemical compositions. Whole milk consumptions of calves in the study are presented in Fig 1. Calves in Treatment1 were fed higher amount of whole milk from day 5 up to 7 weeks of age as compared to calves in Treatment 2. However, calves grouped in Treatment 2 had consumed higher amount of whole milk as compared to calves in Treatment 1 from 7 weeks of age up to weaning.

Table 2. Chemical composition of feeds used in the study

Chemical component	Calf starter		Hay		CV%	R^2
	Given	Left	Given	Left		
DM (%)	92.0±0.21	92.1±0.21	92.6±0.19	92.8±0.22	0.63	0.35
CP (% DM)	19.3±0.32	19.2±0.32	4.5±0.30	4.7±0.34	7.62	0.99
ADF (% DM)	19.4±1.47	19.0±1.47	34.6±1.38	35.7±1.57	15.3	0.81
NDF (% DM)	23.8±2.68	23.7±2.68	52.2±2.53	50.3±2.87	20.2	0.80
IVDMD (%)	87.3±0.98	87.7±0.98	58.9±0.92	59.3±1.04	3.76	0.97

Hay consumption of calves over the period of six months is presented in Fig 2. Daily hay consumption was increasing with advancing age in both treatment groups. However, calves reared under Treatment 2 had relatively higher hay intake as compared to calves reared on Treatment 1.

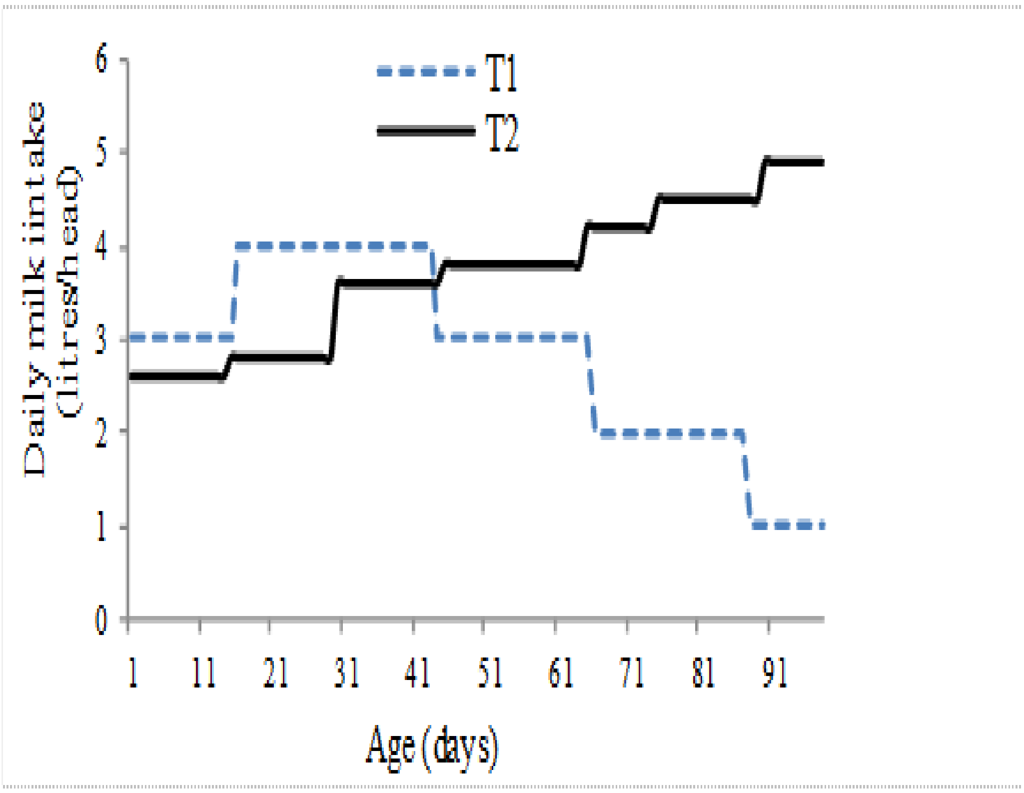

Figure 1. Whole milk intake of calves

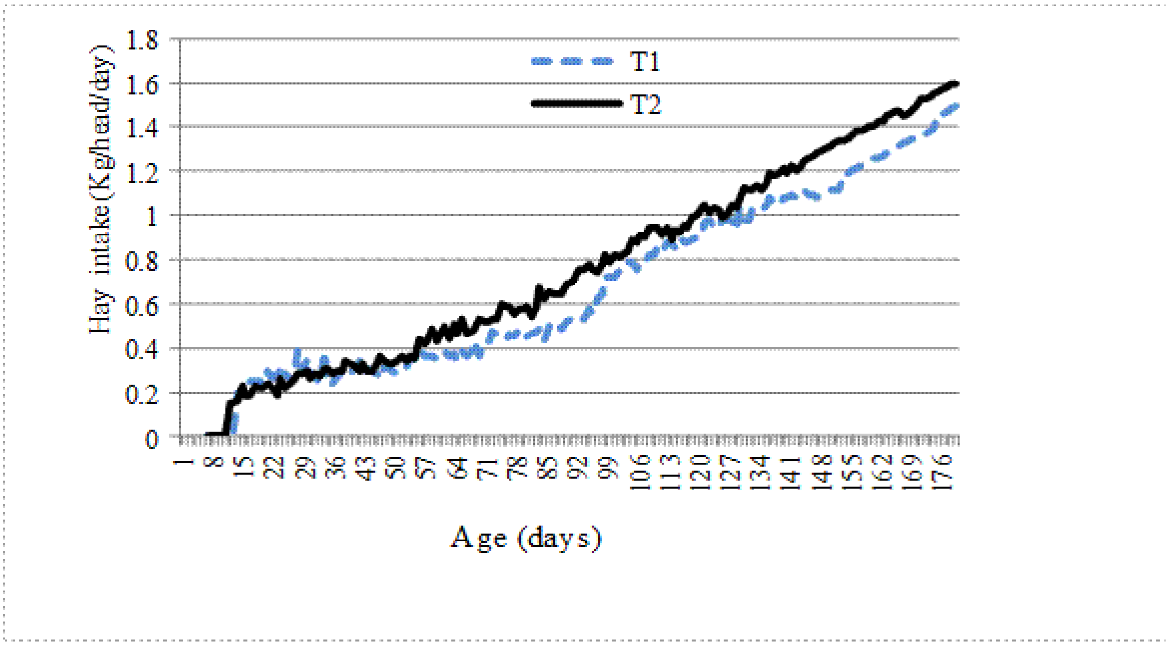

Figure 2. Mean daily hay intake

Daily calf starter intake was also surging with advancing age in all calf groups (Fig 3). During initial rearing age both groups had similar intake levels which showed disparity trend with advancing age. Calf starter intake was higher for calves in Treatment 2 thereafter. Daily calf starter intake was almost similar for both groups towards the end of the rearing period.

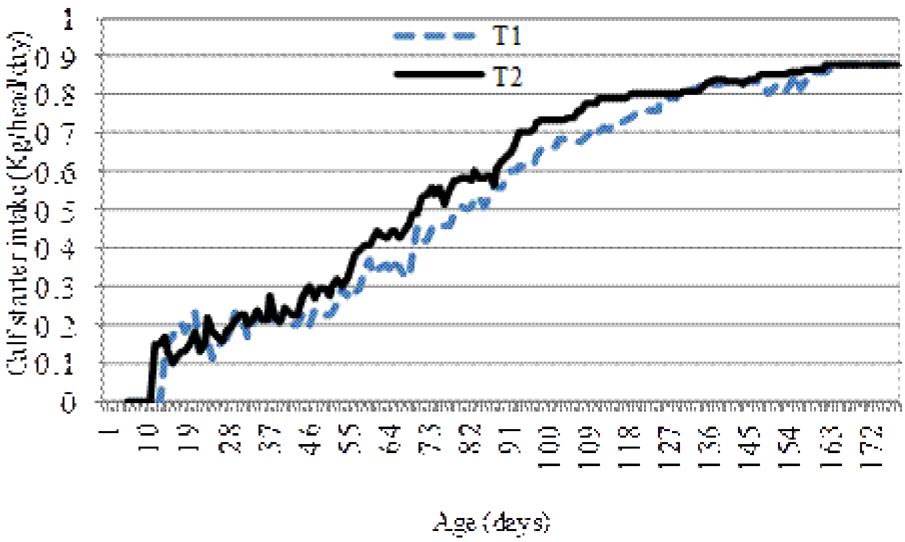

Figure 3. Mean daily calf starter intake

Daily total Dry Matter (DM) intake of calves was generally higher for calves reared under Treatment 2 as compared to calves in treatment 1 (Fig 4). Daily total DM intake was similar for calves in Treatments 1 and 2 during early calf life. However, total DM intakes between treatments showed variation after two months of age, where both groups showed linear increasing trend.

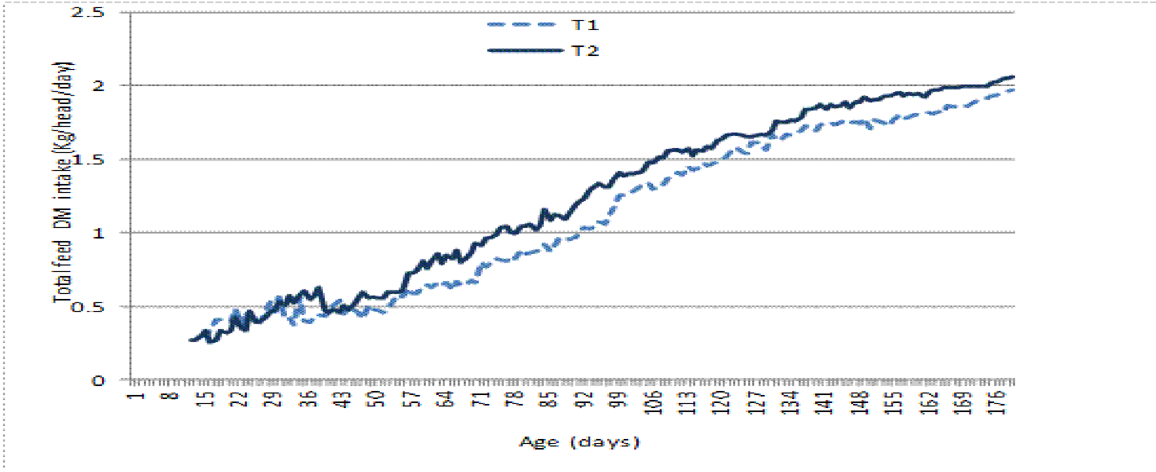

Figure 4. Daily total DM intake of calves

Body weight of calves attained at 3 and 6 months of age are presented in Table 3. Calves reared under Treatment 2 had significantly ($p < 0.05$) higher body weight at 3rd and 6th months of age as compared to calves reared under Treatment 1. Similarly, male calves had significantly ($p < 0.05$) higher bodyweight than females at 6 months of age. Least square mean calf daily weight gains during pre and post weaning periods are presented in Table 4. Daily body weight gains of calves were not significantly different ($p > 0.05$) between Treatments. However, daily weight gains of calves in Treatment 2 indicated higher growth trend during pre-weaning and post weaning rearing periods.

Calf sex had marked ($p < 0.05$) effect in daily weight gains during post weaning and overall rearing periods. There was no significant difference ($p > 0.05$) between male and female calves in daily weight gain during pre-weaning period but male calves grew significantly higher ($p < 0.05$) than female counterpart during post-weaning period.

Table 3. Least square mean calf body weights at different ages (Kg)

Variables	Number	Birth	Three Months	Six Month
Overall mean	29	22.93	51.52	63.23
Treatments				
1	14	22.93±0.58	49.57±1.96^{b}	61.99±2.20^{b}
2	15	22.92±0.56	53.53±2.07^{a}	63.35±2.20^{a}
Calf sex				
Males	15	23.07±0.56	51.93±1.9	64.71±1.92^{a}
Females	14	22.79±0.58	51.16±2.14	60.63±2.53^{b}
CV		9.42	14.27	11.34
R^2		0.005	0.08	0.09

Least square means with the same superscripts within rows are not significantly different (p>0.05)

Table 4. Least square mean daily weight gain of calves (g)

Variables	Number	Birth to 3months	3-6 months	Birth to 6 months
Overall mean	29	318.25	156	238.48
Treatments				
1	14	296.83±0.02	146.24±0.02	235.07±0.01
2	15	339.29±0.02	169.34±0.02	242.90±0.01
Calf sex				
Males	15	321.00±0.02	170.37±0.02[a]	244.90±0.01[b]
Females	14	315.30±0.02	145.21±0.02[b]	233.07±0.01[b]
CV%		24.75	53.7	21.73
R^2		0.08	0.05	0.02

Least square means with the same superscripts within rows are not significantly different (p>0.05)

Calves reared under Treatment 2 had higher feed conversion efficiency (gain: feed ratio) as compared to calves reared under Treatment 1. However, feed conversion efficiency of calves in both rearing groups was higher at early age which diminished post weaning (Fig 5).

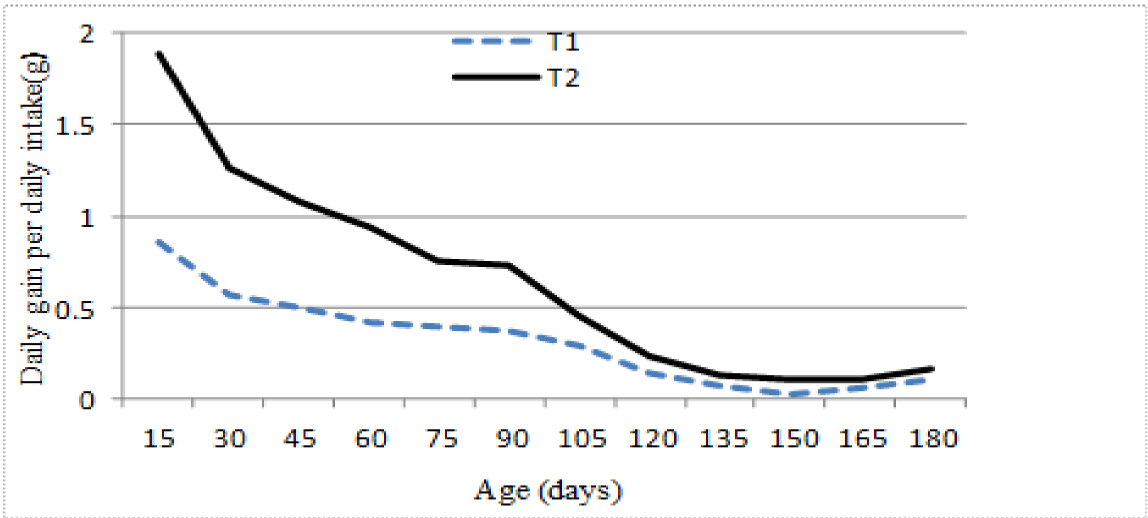

Figure 5. Feed conversion efficiency (DM basis) of calves

DISCUSSION

Crude protein (CP) value (4.48%) of hay used in this study was too low relative to usual CP values of hay harvested from natural pasture. Calves require best quality hay with 8 to 14% CP, which was designated as good to excellent (Radunz, and Schriefer, 2011). Stimulation of growth by increasing dietary CP has been reported previously in calves (Gerrits *et al*, 1996). Hay quality at Adea Berga Research Center is usually harvested late after maturity due to the fact that, the hay field is too marshy during September and October to let in farm machineries for mowing. This may have contributed to lower CP available for the calves to support whole milk and calf starter. Thus, since the same hay was used for all calves in both experimental groups, its effect was expected similar for both groups.

Whole milk intake of calves was declining as age advanced up to weaning for calves in Treatment 1 due to the feeding system that gradually reduces whole milk level up to weaning, while it was rising opposite to this trend for calves in Treatment 2. In Treatment 1 the amount of whole milk was presented as predetermined, while it was based upon calf body weight change in Treatment 2.Therefore, weaning was gradual in Treatment 1, while it was abrupt in Treatment 2. Both practices may also have their own impact on calf feed intake and growth performances. The total amount of whole milk consumed was slightly higher for calves in Treatment 2 (360 litres) as compared to those in treatment 1(260 litres), resulting in higher growth rate in agreement with previous study on dairy calves fed milk replacers containing different amounts of CP at two feeding rates (Bartlett *et al*, 2006). However, disadvantages of providing more milk include reduced solid feed intake during the milk-feeding period (Terre et al., 2007) and slower rumen development (Khan et al., 2007a, b) have been reported.

At early age calf starter and hay intakes were minimal and therefore calves mostly depend upon whole milk. Hay and calf starter intakes of calves was rising smoothly as age advanced, due to the fact that calves' rumen development with advance in age leading to full transformation from liquid to dry feeds.

Body weight change of calves showed disparity starting at three months of age. This indicates whole milk feeding levels were effective to show body weight variation after three months of age. Calves in treatment 2 significantly gain more weight (4 kg at 3 months and 1.3 kg at 6 months age) than those in treatment 1. This is partly due to consumption of more milk. Calves grouped in treatment 1 consumed 260 litres of whole milk; while those grouped under treatment 2 consumed 310 litres per head from birth up to weaning. Similar to our finding, Appleby et al. (2001) and Diaz et al. (2001) noted that higher weight gains of calves fed more milk. Body weight variations between male and female calves became prominent at six months of age, indicating physiological growth variation due to sex starts from six months of age. Similarly, male calves were significantly heavier than females by 4.74 kg at 6 month weight and 4.48 kg at weaning age (Bayou *et al*, 2016).

Feed conversion efficiency (gain: feed) for calves in Treatment 2 was higher than that of calves in Treatment 1, indicating higher body weight gain of these calves on lower amount of dry feed. The lowest feed conversion efficiency of calves grouped in Treatment 1 indicates they didn't utilize the CF more efficiently than calves grouped in Treatment 2 as reported earlier (Nat *et al*, 2016). Earlier studies also showed gain: feed was greater for calves fed at 1.75% of BW daily than for calves fed at 1.25% of BW daily and increased in a quadratic manner as CP was increased, with greatest efficiencies observed for calves fed milk replacer (based on whey protein concentrate, dried whey, lard, and tallow) with 22% CP (Bartlett *et al*, 2006). Feed conversion efficiency in both treatment groups was declining as age advanced, indicating calves had accelerated growth at early age but had slow growth rate with advancing age. Additionally calves had low amount of dry feed intake at early age and survived on whole milk which was not accountable in computing feed conversion efficiency.

CONCLUSION

Pure Jersey calves fed whole milk at 10% body weight and weaned at 98 days of age had higher feed intake, growth rate feed conversion efficiency as compared to Holeta Research Center whole milk feeding system designed for crossbred calves. These calves had lower feed dry matter intake and expected to have better productive performance in their later age due to their higher metabolic efficiency. Therefore, the slightly higher milk consumption per rearing life as compared to calves reared on HRC standard (310 liters' versus 260 liters) can be economically offset in later age. That means calves can reach productive age (slaughter weight for males and age at first calving for female calves) at early age so that cost due to additional milk compensated and more income generated in lifetime.

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