# Influence of Weaning Method on Growth, Intake, and Selected Blood Metabolites in Jersey Calves

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## ABSTRACT

Forty-three Jersey calves were assigned randomly at birth to treatments that evaluated the method of weaning on growth, intake, and concentrations of blood metabolites that were indicative of ruminal development. The three experimental treatments were 1) milk replacer fed at 10% of BW until abrupt weaning at 35 d of age, 2) milk replacer fed at 10% of BW until 28 d and then at 5% of BW until weaning at 35 d of age, or 3) milk replacer fed at 10% of BW until intake of calf starter reached 454 g/d for 2 consecutive d, at which time calves were weaned. Commercial milk replacer was reconstituted to 12.5% DM and fed twice daily. Commercial calf starter was offered from 3 d of age. When milk replacer was fed at 5% of BW from 29 to 35 d, BW gain was reduced compared with that of calves on the other treatments; however, BW at 56 d was unaffected by treatment. Concentrations of NEFA and blood urea N were higher from 29 to 56 d than when calves were fed milk replacer at 5% of BW from 29 to 35 d. Blood BHBA increased as starter DMI increased and was unaffected by treatment. Intake of milk replacer and feed cost were greater for calves that were weaned when calf starter intake reached 454 g/d for 2 consecutive d. For calves that were weaned according to intake, mean age at weaning was 40 d.
(**Key words**: calves, growth, weaning, Jersey)

**Abbreviation key**: **AW** = MR fed at 10% of BW and abrupt weaning at 35 d of age, **CS** = calf starter, **GW** = MR fed at 10% of BW to 28 d of age and then fed at 5% of BW to weaning at 35 d of age, **IW** = MR fed at 10% of BW and weaning when intake of CS reached 454 g/d for 2 consecutive d, **MR** = milk replacer.

## INTRODUCTION

Recent survey data from a national study of management practices of preweaned calves in the US (2) indicated three primary methods of weaning calves: weaning according to BW, age, or when intake reached a predetermined amount of dry feed intake. When age was used as a criterion for weaning, 32.9% of producers weaned calves at 8 wk of age, although some (2.3%) weaned calves as early as 3 wk, and others (14.2%) delayed weaning for ≥12 wk. A typical recommendation is to wean large breed calves when intake of calf starter (**CS**) reaches 700 to 1000 g/d for 3 consecutive d (9). However, recommendations for small breed calves are often later than 5 wk of age (13).

Successful weaning depends on adequate development of ruminal function prior to weaning, and calves have been weaned successfully as early as 2 to 3 wk of age without effect on growth (15, 16) or immune function (12). Withdrawal of milk or milk replacer (**MR**) from the diet of calves is usually stressful, particularly if adequate starter DMI has not been achieved prior to weaning (8).

Objectives of this study were to evaluate the effects of the method of weaning on growth, intake, and indices of ruminal development in young Jersey calves.

## MATERIALS AND METHODS

### Experimental Design

Jersey heifer calves (n = 45) were assigned randomly at birth within block (date of birth) to one of three treatments: calves were offered MR at 10% of BW and abruptly weaned at 35 d of age (**AW**), calves were offered MR at 10% of BW to 28 d of age and then offered MR at 5% of BW until weaning at 35 d of age (**GW**), or calves were offered MR at 10% of BW and weaned when CS intake reached 454 g/d for 2 consecutive d (**IW**). Commercial MR (Coop Maxi-Lac®; Tennessee Farmers Cooperative, LaVergne, TN) was reconstituted to 12.5% DM and fed at approximately 0800 and 1600 h. The amount of MR offered was adjusted weekly. The MR was formulated to contain a minimum of 20% CP and 20% fat. Commercial CS (Tennessee Farmers Cooperative) was offered for ad libitum consumption once daily from 3 d of age.

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Amounts of MR and CS consumed were measured at each feeding. Water was available at all times.

### Sampling and Analysis

Calves were weighed at birth and every 7 d until 56 d of age. Samples of MR and CS were collected weekly, composited by month, and analyzed for DM, CP, ash, and ether extract (1); NDF (4); and Ca, P, Mg, and K by atomic absorption spectrophotometry. Fecal consistency was scored at the a.m. feeding by the method of Larson et al. (7).

Jugular blood (approximately 10 ml) was collected into two evacuated containers without anticoagulant at approximately 2 h after the a.m. feeding every 7 d. A 2-ml sample was deproteinated and stored (−20°C) prior to analysis of BHBA (11). A second sample was added to 6% EDTA and stored (−20°C) prior to analysis of NEFA and urea N (11).

### Statistical Analysis

Weekly intake of CS and MR, BW, feed efficiency, blood parameters, and fecal scores from wk 5 to 8 were analyzed by mixed model ANOVA (14) using a randomized complete block design. However, birth BW was greater ($P < 0.05$) for calves on treatment IW, and blocking effects were not significant ($P > 0.10$) for any variable measured; therefore, data were reanalyzed using the model: $Y_{ijk} = \mu + T_i + C_{i(j)} + A_k + (AT)_{ik} + \beta(BW_{ijk} - \overline{X}) + e_{(ijk)}$ where $Y_{ijk}$ = observation, $\mu$ = overall mean, $T_i$ = effect of treatment (i = 1 to 3), $C_{i(j)}$ = effect of calf within treatment (j = 1. . .15 for treatment AW, 1. . .14 for treatments GW and IW), $A_k$ = effect of age (k = 5 to 8), $(AT)_{ik}$ = effect of age by treatment interaction, $\beta(BW_{ijk} - \overline{X})$ = covariate of initial BW, and $e_{(ijk)}$ = residual. Concentration of metabolites in blood collected were analyzed using the same model but excluding birth BW as the covariate. Significance was determined at $P < 0.05$ unless otherwise indicated.

TABLE 1. Chemical composition of milk replacer (MR) and calf starter (CS).

| Composition | MR[1] | | CS[2] | |
|---|---|---|---|---|
| | $\overline{X}$ | SE | $\overline{X}$ | SE |
| DM, % | 95.3 | 0.2 | 89.1 | 0.5 |
| | (% of DM) | | | |
| CP | 20.0 | 0.5 | 17.8 | 0.1 |
| Ash | 9.6 | 0.1 | 7.6 | 0.2 |
| NDF | ND[3] | . . . | 22.6 | 0.6 |
| Ether extract | ND | . . . | 3.8 | 0.2 |
| Ca | 0.56 | 0.02 | 1.23 | 0.05 |
| P | 0.71 | 0.01 | 0.73 | 0.02 |
| K | 2.30 | 0.02 | 1.29 | 0.03 |
| Mg | 0.17 | 0.01 | 0.36 | 0.01 |

[1]n = 4.

[2]n = 3.

[3]Not determined.

## RESULTS AND DISCUSSION

### Morbidity and Mortality

Two calves died during the study; they were from treatments GW and IW, and death occurred at >21 d of age. Calves were not replaced; therefore, least squares means are presented. Occurrences of scours were minimal and unrelated to treatment. The overall health of all other calves was excellent throughout the study.

### BW, Intake, and Feed Efficiency

Chemical composition of CS and MR (Table 1) were consistent with label guarantees, except that amounts of Ca in MR and CP in CS and MR were lower than the NRC (10) recommendations for these types of feeds.

Mean BW at birth and at 28 d of age was 24.9 (SE = 0.4) and 27.9 kg (SE = 0.1), respectively. There was no effect of treatment on BW at 28 or 56 d (Table 2). Weekly BW from 5 to 8 wk increased as age increased but was unaffected by method of weaning (Table 3). Mean BW gain from 5 to 8 wk of age was unaffected by treatment but was influenced by age and an interaction of age and treatment. Calves on treatment GW gained less than did other calves during wk 5 (215 vs. 260 and 342 g; Table 3). This reduction in BW gain might have been due to reduced MR intake; during wk 5, calves on treatment GW were fed MR at 5% of BW. Although these calves consumed more CS during this time, intake was insufficient to maintain BW gain comparable with that of other calves. However, during wk 6, calves on treatment GW gained BW more rapidly than other calves so that BW was not reduced by 56 d of age.

Consumption of MR was highest throughout the study for calves on treatment IW. Weekly mean DMI of MR by calves on treatment IW were 340, 119, 84, and 7 g/d for wk 5 to 8, respectively. The number of calves weaned during wk 5 to 8 was 6, 4, 3, and 1, respectively. Mean age at weaning was 40 d (SE = 1) for calves on treatment IW (range, 32 to 56 d). This age at weaning differs somewhat from other data (9) for large breed calves. When Holstein calves are fed limited MR for the first few weeks, the CS consumed is sufficient (>700 g/d) to allow weaning by 24 to 35 d of age (9). Our data suggest that Jersey calves would

TABLE 2. Least squares means of BW, DMI, feed efficiency, and feed costs for Jersey calves weaned according to three different methods.

| | Treatment[1] | | | | Contrast[2] | |
|---|---|---|---|---|---|---|
| Item | AW | GW | IW | SEM | 1 | 2 |
| BW, kg | | | | | | |
| Birth | 24.2 | 24.4 | 26.0 | 0.6 | NS[3] | 0.04 |
| 28 d, kg | 27.7 | 28.5 | 27.6 | 0.7 | NS | NS |
| 56 d, kg | 41.0 | 42.0 | 40.9 | 1.6 | NS | NS |
| BW Gain, g/d | | | | | | |
| 1–4 wk | 100 | 128 | 96 | 26 | NS | NS |
| 5–8 wk | 475 | 483 | 476 | 44 | NS | NS |
| Total DMI, g/d | | | | | | |
| 1–4 wk | 360 | 398 | 332 | 20 | NS | NS |
| 5–8 wk | 1095 | 1150 | 1023 | 80 | NS | NS |
| CS DMI, g/d | | | | | | |
| 1–4 wk | 66 | 92 | 35 | 16 | NS | NS |
| 5–8 wk | 1010 | 1105 | 885 | 84 | NS | NS |
| MR DMI, g/d | | | | | | |
| 1–4 wk | 294 | 306 | 297 | 6 | NS | NS |
| 5–8 wk | 86 | 45 | 138 | 13 | 0.03 | 0.09 |
| BW Gain:DMI, g/kg | | | | | | |
| 1–4 wk | 163 | 278 | 229 | 78 | NS | NS |
| 5–8 wk | 414 | 410 | 473 | 45 | NS | NS |
| Feed cost, $/d | | | | | | |
| 1–4 wk | 3.97 | 4.18 | 3.94 | 0.09 | NS | NS |
| 5–8 wk | 3.34 | 3.02 | 3.74 | 0.18 | NS | 0.03 |

[1]AW = Milk replacer (MR) offered at 10% of BW to weaning at 35 d of age, GW = MR offered at 10% of BW to 28 d of age and then offered at 5% of BW to weaning at 35 d of age, and IW = MR offered at 10% of BW and weaning when intake of calf starter (CS) reached 454 g/d for 2 consecutive d.

[2]Contrasts: 1 = AW versus GW; 2 = AW versus IW.

[3]$P > 0.10$.

be older at weaning than Holstein calves when weaned according to intake and fed MR at 10% of BW.

Consumption of CS was affected by age and an interaction of age and treatment (Figure 1). Consumption of CS by calves on treatments AW and GW did not differ significantly, although CS DMI at wk 5 tended ($P < 0.11$) to be greater for calves on treatment GW (Table 3). These data, together with reduced BW gain, suggest that CS did not increase during wk 5 to replace nutrients removed by reducing MR intake by 50%. Intake of CS was lower for calves on treatment IW until 7 wk of age because of continued MR feeding. The inhibition of CS DMI by continued milk or MR feeding is well documented (5, 6).

The rate of increase in CS DMI was marked during the week after weaning for all calves (Table 3). Calves on treatments AW and GW increased CS DMI by 567 and 445 g/d, respectively. However, in the 2nd and 3rd wk after weaning, increases in CS DMI were 333 and 241 g/d, respectively. The rapid increase in CS DMI followed by a slower increase in CS DMI in the 2nd wk after weaning suggests that calves on treatments AW and GW had greater difficulty in adapting to dry feed intake. The increase in CS DMI for calves on treatment IW was more nearly linear, increasing 389, 464, and 473 g/d during wk 6 to 8, respectively.

Feed costs were highest for calves on treatment IW and lowest for calves on treatment GW (Table 2). Total feed costs during the 56-d experiment were $28.56, $28.35, and $31.92 (SE = $1.14) for calves on treatments AW, GW, and IW, respectively. Prices used were $1.76/kg for MR and $0.28/kg for CS. Clearly, although later weaning reduced CS DMI and CS cost, the greater cost of MR resulted in greater total costs when calves were weaned according to intake. Delayed weaning reduced the profitability of the enterprise. When management practices increased the cost of milk feeding (e.g., feeding whole milk vs. MR) or inhibited early intake of CS and ruminal development, returns to the calf raising enterprise were impaired.

Eicher-Pruiett et al. (3) weaned Holstein bull calves when dry feed intake reached 1.3% of BW at birth. When that weaning criterion was applied to data in the present study, weaning would be expected to occur at 5 wk of age for calves on AW and GW treatments and between 5 and 6 wk of age for calves on treatment IW. However, in the study by Eicher-Pruiett et al. (3), calves were fed whole milk at 8% of BW at birth prior to weaning. Because CS DMI prior to weaning was inversely related to liquid feeding, calves in the present study probably consumed less CS as a proportion of BW than did calves in the study of Eicher-Pruiett et al. (3). When expressed as a proportion of weekly BW, calves in this study consumed between 0 and 40 g of CS/kg of BW and reached 13 to 15 g of CS DMI/kg of BW at approximately 5 wk of age. This amount of CS DMI appeared to be an appropriate criterion for weaning Jersey calves when fed according to this MR feeding regimen. Calves may respond differently when fed other feeding programs, such as a fixed amount of MR throughout the liquid feeding period.

## Blood Parameters

Blood BHBA concentration increased as age increased (Table 4) and was highly correlated with CS DMI (r = 0.71). There was no significant effect of treatment on blood BHBA. Blood BHBA increased to peak at 7 (treatment AW) or 8 (treatments GW and

TABLE 3. Least squares means[1] of weekly BW, DMI, and feed efficiency for Jersey calves weaned according to three different methods.

| | Treatment[2] | | | | Contrast[3] | |
|---|---|---|---|---|---|---|
| Item | AW | GW | IW | SEM | 1 | 2 |
| BW,[4] kg | | | | 1.4 | NS[5] | NS |
| 5 wk | 30.2 | 30.1 | 29.2 | | | |
| 6 wk | 33.1 | 34.4 | 31.9 | | | |
| 7 wk | 37.0 | 38.4 | 35.6 | | | |
| 8 wk | 40.9 | 42.0 | 41.0 | | | |
| BW Gain,[4,6] g | | | | 80 | NS | NS |
| 5 wk | 342 | 215 | 260 | | | |
| 6 wk | 428 | 628 | 373 | | | |
| 7 wk | 566 | 577 | 521 | | | |
| 8 wk | 566 | 511 | 750 | | | |
| Total DMI,[4,6] g/d | | | | 88 | NS | NS |
| 5 wk | 722 | 690 | 584 | | | |
| 6 wk | 957 | 962 | 752 | | | |
| 7 wk | 1253 | 1332 | 1180 | | | |
| 8 wk | 1449 | 1617 | 1576 | | | |
| CS DMI,[4,6] g/d | | | | 93 | NS | NS |
| 5 wk | 388 | 516 | 243 | | | |
| 6 wk | 955 | 960 | 633 | | | |
| 7 wk | 1251 | 1330 | 1096 | | | |
| 8 wk | 1446 | 1615 | 1569 | | | |
| BW Gain:DMI, g/kg | | | | 92 | NS | NS |
| 5 wk | 397 | 234 | 436 | | | |
| 6 wk | 385 | 630 | 550 | | | |
| 7 wk | 453 | 457 | 442 | | | |
| 8 wk | 421 | 320 | 462 | | | |
| Feed cost,[4,6,7] $/wk | | | | 0.25 | 0.05 | 0.08 |
| 5 wk | 5.20 | 3.40 | 4.96 | | | |
| 6 wk | 2.14 | 2.14 | 2.94 | | | |
| 7 wk | 2.79 | 3.00 | 3.50 | | | |
| 8 wk | 3.23 | 3.59 | 3.56 | | | |

[1]Means were adjusted by analysis of covariance for BW at birth.

[2]AW = Milk replacer (MR) offered at 10% of BW to weaning at 35 d of age, GW = MR offered at 10% of BW to 28 d of age and then offered at 5% of BW to weaning at 35 d of age, and IW = MR offered at 10% of BW and weaning when intake of calf starter (CS) reached 454 g/d for 2 consecutive d.

[3]Contrasts: 1 = AW versus GW; 2 = AW versus IW.

[4]Age effect ($P < 0.05$).

[5]$P > 0.10$.

[6]Interaction of age and treatment ($P < 0.05$).

[7]Prices were $1.76/kg for MR and $0.28/kg for CS.

IW) wk of age. Increased concentration of BHBA in the first few weeks after weaning was similar to that reported previously by Quigley et al. (11); concentration of BHBA increased approximately twofold in the 1st wk after weaning. A smaller increase in the next week was followed by stable or declining BHBA concentrations [(11); Table 4]. The close relationship between blood BHBA and CS DMI indicated that changes in blood BHBA concentrations were primarily due to alimentary ketogenesis. The decline in blood BHBA concentrations between 7 and 8 wk of age for calves on treatment AW was probably due to a reduction in the rate of increase of CS DMI during this time. Similarly, blood BHBA of calves on treatment GW did not increase significantly between wk 7 and 8 (Table 4), which was related to the small increase in CS DMI at that time.

Blood NEFA concentrations were lower for calves on the GW treatment than for calves on AW treatment throughout the study (Table 4). Blood NEFA were closely correlated (r = 0.67) with MR DMI and negatively correlated (r = –0.63) with CS DMI. Thus, differences in NEFA were probably a result of differences in CS DMI, particularly from 29 to 35 d of age.

Concentrations of blood urea N were greater for calves on the GW treatment than for calves on the AW treatment throughout the 28-d study (Table 4). Concentrations were highest during wk 6 and might have been related to partial removal of MR during wk 5.

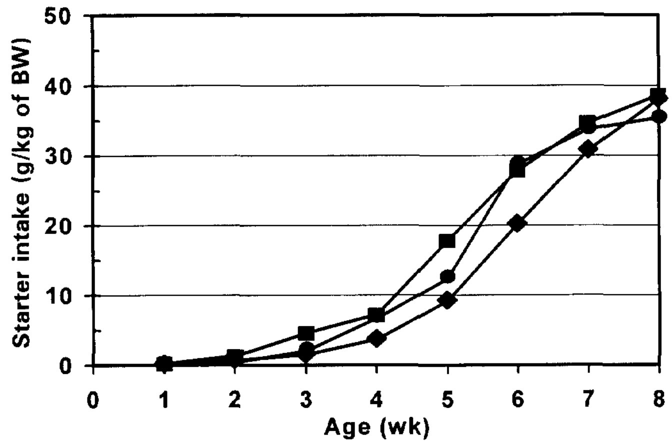


Figure 1. Starter intake (grams per kilogram of BW) of calves fed milk replacer (MR) at 10% of BW and weaned abruptly at 35 d of age (■), fed MR at 10% of BW until 28 d of age and then at 5% of BW from d 29 until weaning at 35 d of age (●), or weaned when intake of calf starter reached 454 g/d for 2 consecutive d (♦).

## CONCLUSIONS

Jersey calves were abruptly or gradually weaned at 35 d of age or when CS intake reached 454 g/d for 2 consecutive d. When MR intake was reduced to 5% of

TABLE 4. Least squares means of blood metabolites for calves weaned according to three treatments.

| | Treatment[1] | | | | Contrast[2] | |
|---|---|---|---|---|---|---|
| Item | AW | GW | IW | SEM | 1 | 2 |
| BHBA,[3] μM | | | | 96 | NS[4] | NS |
| 5 wk | 314 | 373 | 284 | | | |
| 6 wk | 670 | 558 | 414 | | | |
| 7 wk | 838 | 628 | 590 | | | |
| 8 wk | 731 | 640 | 772 | | | |
| NEFA,[3,5] μM | | | | 20 | 0.06 | NS |
| 5 wk | 228 | 125 | 257 | | | |
| 6 wk | 76 | 82 | 129 | | | |
| 7 wk | 66 | 69 | 81 | | | |
| 8 wk | 89 | 88 | 65 | | | |
| Urea N,[3] mg/dl | | | | 0.8 | 0.05 | NS |
| 5 wk | 10.0 | 10.9 | 9.9 | | | |
| 6 wk | 11.6 | 13.8 | 10.5 | | | |
| 7 wk | 10.9 | 12.3 | 10.8 | | | |
| 8 wk | 11.1 | 11.7 | 11.1 | | | |

[1]AW = Milk replacer (MR) offered at 10% of BW to weaning at 35 d of age, GW = MR offered at 10% of BW to 28 d of age and then offered at 5% of BW to weaning at 35 d of age, and IW = MR offered at 10% of BW and weaning when intake of calf starter (CS) reached 454 g/d for 2 consecutive d.

[2]Contrasts: 1 = AW versus GW; 2 = AW versus IW.

[3]Age effect ($P < 0.05$).

[4]$P > 0.10$.

[5]Interaction of age and treatment ($P < 0.05$).

BW from d 29 to 35, nutrient intake from MR was also reduced, but this reduction was not reflected in a concomitant increase in CS DMI. Calves weaned according to intake resulted in later weaning and greater cost than other methods. When calves were weaned abruptly at 35 d of age, CS DMI ranged from 366 (treatment AW) to 500 (treatment GW) g/d or 13 to 15 g/kg of BW. Jersey calves weaned according to intake may be weaned when CS DMI reaches this range.

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