EFFECTS OF DIFFERENT WEANING PROGRAMS ON PERFORMANCE, SKELETON GROWTH AND BLOOD PARAMETERS OF HOLSTEIN CALVES

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Abstract

The objective of this study was to investigate the effects of different early weaning programs on the performance, and its influence on skeleton growth and blood parameters of dairy calves. To meet this objective, 30 Holstein calves with initial body weight of 36 ± 8 kg were randomly assigned at birth to be weaned. Experimental treatments were: 1) Starter diet and whole milk from birth to 45 days (45 weaning day (WD), 2) starter diet and whole milk from birth to 65 days (65 WD), 3) starter diet and whole milk from birth to 90 days (90 WD). Starter diet and water were available adlibitum throughout the experiment. Dry matter intake (DMI) of daily starter and average daily gain (ADG) were measured until d 90 of life. Body weight (BW), body length, heart girth and withers height was measured at birth, 30, 60 and 90 day. Blood samples were collected from all calves at the end of the trail. BW and DMI in all measured periods (0, 30, 60 and 90 d) did not differ between treatments. Although 45 WD calves had higher ADG in 30 to 60 d than 65 WD and 85 WD calves. Consequently, in the overall period (d 0-90) greater ADG values were recorded for 45 WD calves. In the overall period, feed conversation ratio (FCR) affected by treatment and lowest values were recorded in 45 WD calves. Body measurements of calves did not differ among treatments at d 30, 60 and 90. Plasma concentration of cholesterol was lower in the 45 WD calves than in the 65 WD and 85 WD animals during the study. Under the conditions of this study, the results suggest that 45WD calves were more efficient at utilizing DMI for BW gain and growth.

Keywords: *Calves, Growth skeleton, Performance, Weaning programs*

1. INTRODUCTION

Dairy calf rearing is one of the most important and sensitive management plans in cattle farms as calves are considered major sources of profits for farms. Thus, it is principally important to apply proper approaches for rearing in order to improve growth and health of the calves [1]. Faster transmission of milk feeding to a solid diet, early feeding of starter diet and faster development of rumen papillae for preparing to transition period are some of these approaches [2]. In commercial dairy production systems, feeding milk is more costly than feeding solid feed. Therefore, shifting calves from milk to solid feed as early as possible has traditionally seemed as a way to diminish feed costs.

Time of weaning is a significant point in dairy calf rearing. Weaning at different times can influence performance and health parameters directly [3]. Early weaning decreases the duration of liquid feed nutrition since at this time the calves are susceptible to diarrhea and digestive problems [4].

For this reason, calf raisers try to wean their calves earlier to change the rumen metabolism, increase feed efficiency, increase body weight gain and increase rumen development and reduce the rearing costs. However, if early weaning exert with poor management, it may lead to decrease growth and poor calf health. Calves fed 680 to 900 gr solid starter diet for three consecutive days can be weaned [5]. There are scientific reports showing that the early weaning can cause increases in the concentration of short-chain fatty acids in the rumen [1] and data from Martin et al. [6] indicated that calves were able to use volatile fatty acids at 3 week of age. However, calves weaned as early as 3 week had similar performance as calves weaned at either 5 or 7 week [7]. Blanco et al. [8] showed that early weaned calves were lighter than traditionally weaned calves at weaning, but had similar weight gains in the feedlot. Moreover, any decrease in weaning age could enhance calves health, lessen

diarrhea and thus improves performance. Furthermore the early weaning of calves would greatly diminish calf rearing costs by decreasing feed and labor expenditures. Therefore, the aim of this study was to determine the effect of different early weaning programs on the growth performance, skeleton growth and blood parameters of Holstein calves.

2. MATERIALS AND METHODS

2.1. Animals, housing and diet

Thirty newborn Holstein calves (15 male and 15 female) with average birth weight 36 ± 8 kg; age 1–7 days were selected from Moghan Agro-Industrial and Animal Husbandry dairy herd. All calves were fed colostrum within 72 h of birth. All The calves were housed individually with straw bedding in calf barns and were chosen to the experimental groups randomly and based on their age and weight to have similar age and weight average among the group. Experimental treatments were: 1) Starter diet and whole milk from birth to 45 days (45WD), 2) starter diet and whole milk from birth to 65 days (65WD), 3) starter diet and whole milk from birth to 90 days (85WD). Calves received whole milk from buckets to the wall of the pen. Calves also had continuous *ad libitum* access to water and calf starter (hay and concentrate) at 08:00 am and at 17:00 pm. Milk was offered in two equal meals daily at 08:00 am and 17:00 pm. The nutrient compositions and chemical analyses of diet were shown in *Table* 1. This study was agreed by the Ethics Committee for Experimental Animals and Animal Care at Isfahan University of Technology approved the study, and all experiments were carried out in accordance with the international guiding principles for veterinary research involving animals, which was revised in 1995 [9].

2.2. Data collections, measurements

Feed dry matter was measured by drying the sample at 100°C for 18 h. Samples of feeds were dried in a forced-air oven at 65-70ºC for 24 h and DM content calculated. Ground samples (1 mm) were analysed for ash (ID 942.05) [10] and Kjeldahl N (ID 954.01) [10]. Crude protein (CP) was calculated as Kjeldahl N×6.25 according to the AOAC procedure [10], neutral detergent fiber and acid detergent fiber were determined by the detergent procedures of Van Soest [11, 12]. Throughout the experiment, calves were weighed in birth, 30, 60, and 90 d, in the morning without prior deprivation of feed and water. During the experiment starter intake was measured daily, on an individual basis, by difference between feed offered and feed refused. Dry matter intake(DMI) (as fed), average daily weight gain (ADG) (kg/d)and feed conversation ratio (FCR)was calculated for the periods 3 to 30 d, 30 to 60 d, 60 to 90 and 3 to 90d.

Calves were measured for body length, heart girth, and withers height in birth, 30, 60 and 90 d of the trial. Withers heights were measured with a sliding-scale height stick with a bubble level. Heart girth and body lengths were measured using a weight tape (Dairy Innovations, Attica, NY).

2.3. Blood sampling and analyses

Blood samples were collected from the jugular venipuncture on the end of the trial (before morning feeding) into blood collection tubes containing heparin. Plasma was collected after centrifuging at 1,200×g for 15 min at 4°C, and stored at -20°C until analysis. Plasma concentrations of glucose, triglyceride, cholesterol, albumin and total protein were measured by using the commercial kits (Pars Azmoon co, Tehran, Iran).

2.4. Statistical Analyses

To survey the effect of treatment, data from Dry matter intake (DMI) (as fed), average daily weight gain (ADG) (kg/d), feed conversation ratio (FCR) and skeletal measurements were analyzed as a completely randomized design using the MIXED procedure of SAS statistical software [13] as repeated measurement analysis. The model included the fixed effects of treatment, time and their interactions and the random effect of calves within treatment [13] according to the following model:

$$Yijk = \mu + Wi + Tj + TWij + Eijk$$

Where Yijk= dependent variable; μ = overall mean; Wi= effect of weaning day (treatment); Tj= effect of the time, TWij= effect of interaction between the treatment and time; Eijk= residual error. Least squares means were determined for each treatment and the Tukey-Kramer adjustment of SAS was selected to different least squares means among treatments [13]. Significance treatment effects were determined at a probability of $P \leq 0.05$ and trends were defined at $0.05 < P \leq 0.10$. Initial BW and skeletal measures were considered as covariates for the final weight and growth analysis. Data from blood metabolites were analyzed using GLM produces of SAS with completely randomized design. Least squares means are reported throughout. $P \leq 0.05$ was considered as significance level.

Table 1. Calf starter ingredient and chemical compositions

Item	Amount
Ingredients (% of DM)	
Ground corn	43
Ground barely	14
Ground wheat	2
Soybean meal	37.8
Salt	0.2
Limestone	1
Calf mineral/vitamin premix	0.9
Chemical composition (%)	
DM	89.0
CP	18.1
EE	3.3
NDF	12.9
ADF	5.8
Ash	6.2
Ca	0.7
P	0.56

Vitamin Premix provided per kg of diet: vit A, 200,000 IU; vit D3, 300,000 IU; vit E, 10,000 IU; vit K, 2 mg; anti-oxidant 1000 mg/kg. Mineral premix provided per kg of diet: Cu, 3300 mg/kg; Fe, 100 mg; Zn, 16500 mg/kg; Mn, 9000 mg; 120 mg/kg; Co, 90 mg/kg; Se, 90 mg/kg.

3. RESULTS

3.1. Performance

Body weight, ADG, DMI and FCR in four periods are presented in *Table* 2. The interaction between time at treatment was not significant for any of the evaluated data and therefore, the main effects (age at weaning, treatment) were examined. Body Weight in all measured periods (0, 30, 60 and 90 d) did not differ between treatments, however BW in 90 day age tended (P=0.06) to be highest in 45 WD calves (95.83 kg) ($P > 0.06$; *Table* 2).The ADG from 30 to 60 d of age and overall period were high in calves weaning 45 WD than 65 WD and 85 WD calves ($P < 0.03$; *Table* 2). Dry matter Intake did not differ among treatments in all measured ages, ($P > 0.14$; *Table*2). Feed efficiency, calculated as kilograms of ADG per kilogram of DMI, in 60 to 90 day age tended (P=0.07) to be lowest in 65 WD calves, however in the overall period (d 3-90) FCR affected by treatment, and lowest in 45 WD calves ($P < 0.05$).

3.2. Body measurements

Mean body length, heart girth and withers height at birth, 30, 60 and 90 d of calves weaned at different time are shown in *Table* 3. Despite a tendency for increases in body length and withers height (P = 0.11 and P = 0.14) at d 30, mean body length, heart girth and withers height of calves did not differ among treatments at d birth, 30, 60 and 90 (*Table* 3).

3.3. Blood metabolites

The results for blood metabolite concentrations are presented in *Table* 4. Overall, no differences (*P* > 0.05) were observed in plasma glucose, albumin, globulin, and total protein among the 45, 65 and 85 days weaning calves.

Table 2. Performance data of calves in weaning at different time

	Weaning (treatment)				
	45 d	**65 d**	**90 d**	**SEM**	**P-value**
n*	10	10	10		
Weight (kg)					
At birth	36.00	35.7	36.2	1.34	0.86
At 30 d	47.61	46.6	48.7	2.07	0.63
At 60 d	68.61	61.3	63.7	3.94	0.22
At 90	95.83	85.9	92.7	4.98	0.06
ADG (kg/d)					0.18
3 to 30 d	0.369	0.363	0.397	0.139	0.92
30 to 60 d	0.700^{a}	0.499^{b}	0.457^{b}	0.205	0.03
60 to 90 d	0.907	0.995	0.819	0.096	0.33
3-90 d	0.659^{a}	0.620^{a}	0.534^{b}	0.136	0.05
DMI					
3 to 30 d	263.33	295.22	217.22	36.12	0.32
30 to 60 d	1195.90	1176.80	1052.60	98.15	0.54
60 to 90 d	4504.67	4429.89	4583.00	36.56	0.35
3-90 d	1821.00	1829.00	1751.00	29.14	0.14
FCR					
3-30 d	0.71	0.81	0.64	0.22	0.68
30-60 d	1.71	2.38	2.34	0.29	0.13
60-90 d	5.05	4.45	5.39	0.41	0.07
3-90 d	2.77^{b}	2.95^{ab}	3.27^{a}	0.15	0.05

Means within a row with different superscripts differ significantly, P < 0.05.

The interaction between times at weaning was not significant for any of the evaluated data.

**n: animal number.*

Table 3. Body measurements of calves in weaning at different time

	Weaning (treat)				
	45 d	**65 d**	**85 d**	**SEM**	**P-value**
Body length (cm)					
At birth	65.0	64.6	63.1	0.96	0.38
At 30 d	71.5	72.5	67.0	1.50	0.11
At 60 d	76.8	78.1	79.5	1.90	0.17
At 90 d	88.7	90.1	91.6	1.72	0.79
Heart girth (cm)					
At birth	77.8	77.5	77.7	1.20	0.86
At 30 d	88.7	89.5	85.8	2.14	0.63
At 60 d	99.3	98.7	101.7	2.08	0.27
1t 90 d	107.7	106.4	106.4	1.35	0.77
Withers height (cm)					
At birth	65.0	64.6	61.3	1.90	0.73
At 30 d	71.5	72.5	68.6	1.91	0.14
At 60 d	76.8	78.1	79.5	1.85	0.99
At 90 d	88.7	90.1	91.6	1.10	0.92

Means within a row with different superscripts differ significantly, $P < 0.05$.

The interaction between times at weaning was not significant for any of the evaluated data.

Table 4. Plasma concentration of glucose, cholesterol, total protein, albumin and globulin of calves in weaning at different time

	Weaning (treatment)				
	45 d	**65 d**	**85 d**	**SEM**	**P-value**
Glucose (mg/dL)	73.2	73.8	92.4	6.63	0.43
Cholesterol	65.8	74	99.8	4.78	0.002
Total protein (g/dL)	4.21	5.63	5.40	0.27	0.06
Albumin (g/dL)	3.71	3.66	3.79	0.08	0.82
Globulin(g/dL)	1.04	1.96	1.60	0.17	0.09

Means within a row with different superscripts differ significantly, $P < 0.05$

4. DISCUSSION

In the current study, BW and DMI in all measured periods (0, 30, 60 and 90 d) did not differ between treatments. Although, 45 WD calves consumed DMI similar to other groups, they had higher ADG in 30 to 60 d than 65 WD and 85 WD calves ($P < 0.05$). In the overall period (d 0-90), greater ADG values were recorded for 45 WD calves ($P < 0.05$). In the overall period (birth-90d) FCR affected by treatment and the lowest value measured in 45 WD calves ($P < 0.05$). The overall performance of calves in the present study was in agreement with Eckert et al. [15]. Therefore, 45WD calves were more efficient at utilizing DMI for BW gain.

Soberon et al. [16] analyzed the preweaning growth rate of heifers. They reported that approximately 25% of the variation in first-lactation milk production could be explained by preweaning ADG; so, every 0.1 kg increase in preweaning ADG led to produce 107 kg more milk during first lactation. This fact suggests that the high ADG in early stages of life can get better milk yields.

Kehoe et al. [17] reported that calves fed once daily and weaned at 4 wk of age had lower BW than those weaned at 6 and 12 wk of age, which is in agreement with the findings of this study. Additionally, Bjorklund et al. [18] suggested ADG for weaning groups was lower ($P < 0.05$) for the early weaned (0.51 kg/d) calves compared with the med weaned (0.63 kg/d) and late weaned (0.75 kg/d) calves. For the first 90 d of life, the early weaned calves had lower cost per kilogram of gain than the med weaned and late weaned calves. Blanco et al. [19] showed that early-weaned calves were lighter than traditionally weaned calves at weaning, but had similar weight gains in the feedlot. Consequently, they needed an additional 40 days to reach the target weight and early weaning increased the length of the feedlot period. In the another study, ADG from birth to 90 d and, consequently, weight at 90 d did not differ between early and traditionally weaned calves [19]. However, a report of the Scientific Committee on Animal Health and Animal Welfare (SCAHAW) [20] recommends a more careful management of the early-weaned calves than the late-weaned calves.

Body length, heart girth and withers height of calves did not differ among treatments at d birth, 30, 60 and 90. In consistent with our results, Heidaryan et al. [3] evaluated the effect of weaning age (30, 60 and 90 d) at skeletal growth of calves and showed no significantly differences among treatments in body length, heart girth and withers height of calves. Khan et al. [4] reported that skeletal growth of calves not affected by different levels of milk intake.

In contrast to the results of this study, Bjorklund et al. [18] reported that early weaning (47 d) calves had lower BW, hip height, heart girth, and total gain to weaning than the med weaning (60 d) and late weaning (90 d) calves; however, the early weaning calves were not statistically different from med weaning calves for hip height at weaning.

Physical and metabolic improvement of the reticulo-rumen is significant both for unproblematic shift from pre-ruminant to mature ruminant condition and improving calf health [21, 22]. High milk or milk replacer intake resulted in lower starter concentrate intake during the pre-weaning period, and this led to inadequate solid feed intake for weaning at wk 8 because starter intake is inversely correlated with milk replacer intake. We observed a significant higher ADG for 45WD calves in overall period that was possibly due to higher starter intake. An increase in starter intake has a positive effect on rumen development [23] and permits animals to continue performance after weaning. DMI is highly correlated with future performance of animals according to Heinrichs and Heinrichs [24] and each of 1 kg increase in DMI after weaning is followed by an increase of 290 kg of milk produced during the first lactation.

Plasma concentration of cholesterol was lower ($P < 0.05$) in the 45 WD calves than in the 65 WD and 85 WD animals during the study. Ingredients of ration and amount of milk intake may manipulate the concentrations of cholesterol in calves [27]. Data showed a tendency in 45 d weaned calves to have lower total protein and globulin concentrations ($P = 0.06$ and $P = 0.09$). Albumin concentration in this trial was in range of normal values reported by Mohri et al. [25]. However, glucose concentration was higher and globulin and total protein was lower than normal values. Higher concentration of plasma glucose observed here could be due to different metabolism pathways of calves compare to mature cattle so, young calves rely more on glucose for energy metabolism rather than VFAs, [2]. In addition, the amount and time of colostrum intake has direct effect on the amount of plasma total protein (and globulin) in neonatal calves [26].

5. CONCLUSION

The results of this study found that 45 weaned calves were more efficient at utilizing DMI for BW gain and growth.

REFERENCES

1. Anderson KL, Nagaraja TG, Morrill JL 1987, Ruminal Metabolic Development in Calves Weaned Conventionally or Early. *J Dairy Sci*, 70, 1000–1005.
2. Khan MA, Weary DM, Von Keyserlingk MAG 2011, Invited review: effects of milk ration on solid feed intake, weaning and performance in dairy heifers. *J Dairy Sci*, 94, 1071–1081.
3. Heidaryan M, BayatKouhsar J, Mostafalou Y, Sadeghi B, moslemipour F 2015, The effects of different weaning programs on growth performance, rumen fermentation parameters, blood of Holstein calves. *Anim prod*, 18: 461-475 (In Persian).
4. Khan MA, Lee HJ, Lee WS, Kim HS, Kim SB, KS K, Ha JK, Lee HG, Choi YJ 2007, Pre- and post-weaning performance of Holstein female calves fed milk through step down and conventional methods. *J Dairy Sci*, 90: 876-885.
5. Franklin T, Amaral-Phillips DM, Jackson JA, Campbell AA 2003, Health and performance of Holstein calves that suckled or were hand-fed colostrum and were fed one of three physical forms of starter. *J Dairy Sci*, 86(6):2145–2153.
6. Martin WG, Ramsey HA, Matrone G, Wise GH 1959, Responses of young calves to a diet containing salts of volatile fatty acids. *J Dairy Sci*, 42(8), 1377–1386.
7. Winter KA 1985, Comparative performance and digestibility in dairy calves weaned at three, five, and seven weeks of age. *Can J Anim Sci*, 65, 445–450.
8. Blanco M, Casaus I, Palacio J 2009, Effect of age at weaning on the physiological stress response and temperament of two beef cattle breeds. *Anim*, 3 (1): 108-117.
9. Iranian Council of Animal Care 1995, Guide to the Care and Use of Experimental Animals, vol. 1. Isfahan University of Technology, Iran.
10. Association of Official Analytical Chemists (AOAC) 2000, Official Methods of Analysis, 16th ed., USDA, Washington, DC.
11. Van Soest PJ 1994, Nutritional Ecology of the Ruminant. 2nd ed., Ithaca, NY: Cornell University Press.
12. Van Soest PJ, Robertson JB, Lewis BA 1991, Methods for dietary fiber, neutral detergent fiber, and non-starch polysaccharides in relation to animal nutrition. *J Dairy Sci*, 74(10): 3583-3597.
13. SAS Institute 2001, 'SAS/STATuser's guide: Statistics. Version 9.1, (SAS Institute Inc. Cary, NC).
14. Hulbert LE, Cobb CJ, Carroll JA, Ballou MA 2011, The effects of early weaning on innate immune responses of Holstein calves. *J Dairy Sci*, 94: 2545–2556.
15. Eckert E, Brown HE, Leslie KE, DeVries TJ, Steele MA 2015, Weaning age affects growth, feed intake, gastrointestinal development, and behavior in Holstein calves fed an elevated plane of nutrition during the preweaning stage. *J Dairy Sci*, 98(9): 1–12.
16. Soberon F, Raffrenato E, Everett RW, Van Amburgh ME 2009, Early life management and long term productivity of dairy calves. *J Dairy Sci*, 92(Suppl. 1), 238 (Abstr.).
17. Kehoe SI, Dechow CD, Heinrichs AJ 2007, Effects of weaning age and milk feeding frequency on dairy calf growth, health and rumen parameters. *Livest Sci*, 110:267–272.

18. Bjorklund EA, Heins BJ, Chester-Jones H 2013, Whole-milk feeding duration, calf growth, and profitability of group-fed calves in an organic production system. *J Dairy Sci*, 96(11):1–8.
19. Blanco M, Villalba D, Ripoll G, Sauerwein H, Casasus I 2009, Effects of early weaning and breed on calf performance and carcass and meat quality in autumn-born bull calves. *Livest Sci*, 120(1-2): 103–115.
20. Scientific Committee on Animal Health and Animal Welfare (SCAHAW) 2001, The welfare of cattle kept for beef production. In Directorate General Health and Consumer Protection, Directorate C – Scientific Health Opinions, Unit C2, SCAHAW. European Commission, Brussels, p. 150.
21. Khan MA, Weary DM, Von Keyserlingk MAG 2011, Hay intake improves performance and rumen development of calves fed higher quantities of milk. *J Dairy Sc*i, 94(7): 3547–3553.
22. Drackley JK 2008, Calf nutrition from birth to breeding. *Vet Clin North Am Food Anim Pract*, 24(1): 55–86.
23. Kristensen NB, Sehested J, Jensen SK, Vestergaard M 2007, Effect of milk allowance on concentrate intake, ruminal environment, and ruminal development in milk-fed Holstein calves. *J Dairy Sci*, 90(9): 4346-4355.
24. Heinrichs AJ, Heinrichs BS 2011, A prospective study of calf factors affecting first-lactation and lifetime milk production and age of cows when removed from the herd. *J Dairy Sci*, 94(1): 336–341.
25. Mohri M, Sharifi K, Eidi S 2007, Hematology and serum biochemistry of Holstein dairy calves: Age related changes and comparison with blood composition in adults. *Res Vet Sci*, 83(1): 30-39.
26. Zanker IA, Hammon HM, Blum JW 2001, Delayed feeding of first colostrums: are there prolonged effects on haematological, metabolic and endocrine parameters and on growth performance in calves? *J Anim Physiol Anim Nutr (Berl)*, 85: 53–66.
27. Garcia M, Greco LF, Favoreto MG, Marsola RS, Martins LT, Bisinotto RS, Shin JH, Lock AL, Block E, Thatcher WW, Santos JEP, Staples CR 2014, Effect of supplementing fat to pregnant non-lactating cows on colostral fatty acid profile and passive immunity of the newborn calf. *J Dairy Sci*, 97(1): 392–405.