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The Effect of Weaning Age on Performance and Economics of Holstein Calves Reared under Organic Farming System

Research Article

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ABSTRACT

The objective of this study was to evaluate the effects of weaning age on dry matter intake (DMI), average daily gain (ADG), feed efficiency (FE), feed cost (FC) and benefit index (BI) of Holstein calves reared under organic farming system. Thirty two Holstein calves were divided into two treatments: early weaning (EW) *vs.* late weaning (LW). Calves in the both groups were provided with whole milk at the rate of 10% body weight (BW). Calves had free access to leafy alfalfa hay from birth until the end of the experiment. Also, the EW group was provided with starter diet after weaning till 90 days of age. The daily DMI and BW at 15-day intervals were measured and FE and FC were calculated for periods. The DMI of LW and EW calves was significantly different from third period to end of experiment. Moreover, ADG of EW was higher than LW in all of periods. Except for first and second, FE was significantly different between the groups in other periods. Also, due to an increase FC for calves reared on LW compared to EW-calves group, the BI was higher in EW-calves.

KEY WORDS dairy calf, feed cost, feed efficiency, organic farm.

INTRODUCTION

Age of weaning and rearing calves before and after weaning calf are the most challenging tasks in a dairy farm, particularly with an organic system. Many researchers showed that calf performance had significantly changes with decrease length of milk feeding (Purvis and Lusby, 1996; Hill *et al.* 2006; Gleeson *et al.* 2007; Hill *et al.* 2009; Wagenaara *et al.* 2011). Early weaning may offer a reduction in the labour input for calf care and a reduction in the cost of rearing (Kehoe *et al.* 2007; Wagenaara *et al.* 2011). Furthermore, the reduction in calf weaning age improved production efficiency due to reduced dry matter intake (Kehoe *et al.* 2007), however, maintenance costs are increased (Story *et al.* 2000). Other studies suggest that an increased milk feeding period does not necessarily produce calves with greater efficiency and BW (Hill *et al.* 2006; Khan *et al.* 2007). Terre *et al.* (2007) found that milk consumption can reduce solid feed intake and feed efficiency of Holstein calves. Furthermore, Purvis and Lusby (1996) showed that calves weaned at 12 weeks of age had greater growth rates and decreased signs of hunger during weaning and post-weaning compared with calves weaned at 24 weeks. Therefore, the objectives of this study were to investigate the effects of weaning age of Holstein dairy calves reared under organic system on performance and the relative feed costs. Lately, the increased focus on animal welfare has concentrated on ideas about 'good animal welfare' as specific goal for organic animal husbandry. Although organic production systems often claim increased animal welfare, this claim cannot always be substantiated (Rymer *et al.* 2006; Vasseur *et al.* 2010). Therefore, although the 90-day milk consumption in organic systems is rule, organic farmers tend to calf weaning based on age and live weight, housing availability and the possibility to form groups with calves of the same age. Accordingly, this study was conducted to determine the effect of weaning age of calves in organic system on efficiency and economic characteristics.

MATERIALS AND METHODS

Animals, diet and experimental design

This study was conducted at the Valfajr Agricultural re-Search Center farm, located in central Alborz range lands of the Kojour region, Mazandaran province in Iran, from December 2011 to early March 2012. All activities were performed under the guidelines approved by the standard committee of the ministry of agriculture and the veterinary organization of Iran. Animals were housed in a calf rearing barn with an average temperature of 21 ˚C (ranging from 18 ˚C to 31 ˚C, night to day, respectively). Completely randomized block designs with two treatment groups were used. Male (n=16) and female (n=16) calves were randomly distributed into two rearing system groups: early weaning (EW) and late weaning (LW). The average body weights (BW) in both groups were similar: 38.6 ± 1.2 kg and 39.7 ± 1.6 kg for EW and LW, respectively. Calves in groups were separated from their dams immediately after 4 days of colostrum consumption. In this way, the farmers could make sure that the cows showed sufficient mothering abilities and that the colostrum intake of the calf was satisfactory. Separation of the calf from the dam is usually recommended to decrease risk of exposure to environmental pathogens (Windsor and Whittington, 2010), to facilitate first care, and to control milk feeding. From day 4 of age, calves in both groups received whole milk with mobile plastic bottles (5 litre capacity) fitted with soft rubber nipples (10% BW); until 25 days of age. The bottles were washed using an iodine detergent after each feeding, dried, and stored in the inverted position. Milk from the farm bulk tank was transported by mobile tank (milk temperature ranged from 4 ˚C to 10 ˚C) to the calf rearing barn and fed twice a day, in the morning and evening (at 08:00 and 20:00 hours, respectively). The temperature of milk in steel buckets was raised to 36 to 37 ˚C using a water bath before feeding to the calves. No acidifier or any other additives was added to the whole milk before feeding to calves. 25-day-old calves in EW group were weaned (gradually by diluting milk with water) within 5 days and continued to be fed individually on a starter diet (the ingredients and chemical compositions is shown in Tables 1) till 90 days of age. This weaning method was used to reduce the variation in weight gains and solid feed intake and, thus, provide a more sensitive test of the feeding treatment than would be possible with abrupt weaning (Khan *et al.* 2007). Calves in the LW group were fed with whole milk at the rate of 10% of their BW constantly until 90 days of age and weaned. Furthermore, calves in both rearing systems were fed leafy alfalfa hay *ad libitum*, with the residual collected and subtracted during the experimental period. Fresh water was readily accessible to calves at all times. No calves were died or removed from the trial.

Table 1 The chemical composition and dietary ingredient of feedstuffs offered to calves throughout the experiment

Chemical compositions (%)	Milk	Starter diet	Leafy alfalfa hay
DM	11.6	91.4	85.1
Fat	3.70	3.60	2.10
Protein	3.40	18.2	17.2
Lactose	4.10	-	-
Ash	0.40	6.57	9.10
Organic matter	7.70	83.1	81.2
ME[1] (Mcal/kg of DM)	6.95	2.62	1.63
Ingredients (% of DM)			
Corn grain	-	35.0	-
Barley grain	-	20.0	-
Soy bean meal	-	30.0	-
Wheat bran	-	10.0	-
Salt	-	1.0	-
Mineral-vitamin mix[2]	-	2.0	-
Calcium carbonate	-	1.0	-
Sodium bicarbonate	-	1.0	-

[1] Calculated using (NRC, 2000) equations.
[2] The mineral mix was as: Ca: 180; P: 60; Mg: 50; Na: 50; Cu: 1.3; Zn: 6.0; Mn: 3.5; I: 0.06; Co: 0.032 and Se: 0.02 (g/kg); vitamin mix contained of: vitamin A: 600:000 (IU/kg); vitamin D3: 120:000 (IU/kg) and vitamin E: 1:300 (IU/kg).
DM: dry matter and ME: metabolizable energy.

Data collection and laboratory analysis

Samples of leafy alfalfa hay and the starter diet used in this experiment were packaged and sent to the laboratory for analysis (AOAC, 1991). Variables analysed were dry matter (DM), total digestible nutrients (TDN), crude protein (CP), crude fibre (CF), ether extract (EE), Ash and neutral detergent fibre (NDF). On the other hand, contents of calf's milk intake were measured.

Dry matter and ash content in milk was determined by the gravimetric method. The fat, protein and lactose content of milk samples were measured using a 134 A/B foss electric milk-O-scan. The daily feed intake of whole milk, calf starter and leafy alfalfa hay for individual calves was recorded from birth to 90 days of age. Data were averaged across 15-day periods so that calves had dry matter intake (DMI) records for 6 periods (birth to day 15 (d 15), d 16 to d 30, d 31 to d 45, d 46 to d 60, d 61 to d 75, d 76 to d 90). Also, maintenance energy intake (MEI, kg DM) based on the amount of energy available from the feed intake was calculated. The average daily gain (ADG, kg/d) of calves was measured at 15-day intervals prior to the morning feeding. With data spanning 90 days, calves were weighed 6 times (at birth (d 1), d 15, d 30, d 45, etc.). Feed efficiency (FE) was calculated by dividing the ADG on MEI of calves. Feed costs (FC) were calculated based on the purchase prices for the whole milk and starter diet ingredients, and the expenses paid during the field preparation, alfalfa harvesting, transport, chopping, electricity, labour cost, laboratory quality control and animal health. With data spanning 90 days, FC and percentage of income spent for feed cost (PIFC) records for 6 periods (d 1 to d 15, d 16 to d 30, d 31 to d 45, d 46 to d 60, d 61 to d 75, d 76 to d 90) were calculated for each calf and for each period, respectively. The PIFC was calculated based on the data collected for the costs of consumed feed (whole milk and leafy alfalfa hay for LW-calves, and those costs plus starter diet for EW-calves) divided by the revenue derived from live weight gained during the experimental period.

Statistical analyses

The independent variables were BW, FE, FC and the PIFC, and the model included the fixed effects of weaning group (EW and LW), sex of calf and the 15-day period nested within treatment group. The MIXED model procedure of SAS version 9.02 (SAS, 2004) was used with calf nested within treatment as a random variable with repeated measures. The autoregressive covariance (AR (1)) structure was used because it resulted in the lowest Akaike's information criterion (Littell *et al.* 1998). Results are presented as least square means with the SEM and the relative P-values. Birth weight of calves was included in the model as a covariate. Statistical differences were considered significant at P < 0.05.

RESULTS AND DISCUSSION

Dry matter intake

The means for DMI, the sum of whole milk and leafy alfalfa hay consumed by LW-calves; and milk, hay and starter diet consumed by EW-calves are presented in Table 2. Both the sex (P<0.05) and the 15-day periods nested within treatments significantly explained variations in DMI. From second period to the end of the experiment, a significant (P<0.05) difference was observed between the two weaning systems (Table 2). For the mean DMI of all periods, EW-calves had a significantly higher (P<0.01) DMI than LW-calves (1.36 *vs.* 0.94 kg per day, respectively). Results for DMI of calves in the current study are similar to those reported by Gleeson *et al.* (2007), Ozkaya and Turan Toker (2012) and Quigley *et al.* (1991) who reported that a delay in weaning age decreased solid DMI because of increased milk consumption early in life. Furthermore, Purvis and Lusby (1996) reported early weaning age increased forage consumption in calves. On the other hand, Hill *et al.* (2009) showed that feed intake of calves weaned at 28 days of age was 25 to 36% higher than that of calves weaned at 42 days of age, concluding that early weaned calves had higher feed intakes after weaning.

Table 2 Least square means and standard errors for dry matter intake and average daily gain of calves reared in either an early weaning system or a late weaning system, from birth to days 90

Measurment periods	LW	EW	SEM	P-value
DMI (kg/day)				
1	0.58	0.62	0.01	
2	0.68	0.78	0.01	†
3	0.78	1.35	0.01	**
4	0.92	1.53	0.01	**
5	1.01	1.79	0.01	**
6	1.73	2.11	0.01	*
Mean of periods	0.95	1.36	0.02	**
MEI (Mcal/kg of DM)				
1	3.50	3.78	0.19	†
2	4.19	4.89	0.19	*
3	4.89	5.46	0.19	*
4	5.86	3.81	0.19	***
5	6.49	4.39	0.19	***
6	6.66	5.23	0.19	***
Mean of periods	5.26	4.29	0.17	**
ADG (kg/d)				
1	0.527	0.587	0.04	†
2	0.513	0.593	0.04	*
3	0.327	0.660	0.04	**
4	0.440	0.567	0.04	***
5	0.467	0.587	0.04	**
6	0.480	0.500	0.04	
Mean of periods	0.459	0.582	0.03	**

† (P<0.1); * (P<0.05); ** (P<0.01) and *** (P<0.001).

LW: late weaning; EW: early weaning; DMI: dry matter intake; MEI: maintenance energy intake and ADG: average daily gain.

SEM: standard error of the means.

Average daily gain

The least square means and the standard error of the means for ADG for each 15-day period across the 90 day experimental period are shown in Table 2. Similar ADG was observed for both EW- and LW-calves at first and 6th period; however, EW-calves had greater ADG than LW-calves from second (P<0.05) to 5th period (P<0.01). In general the changes in DMI and ADG of calves were consistent from the beginning to the end of the experiment. Numerous studies have shown that ADG at a given time in an EW rearing system is higher than that in a LW rearing system (Purvis *et al.* 1996; Khan *et al.* 2007; Hudson *et al.* 2010); because the nutrient requirements for growth of EW-calves had been removed. While, in our study showed that MEI in LW-calves was higher than EW-calves (5.26 *vs.* 4.29 Mcal/kg of DM, respectively). Therefore, perhaps providing of high protein in EW-calves caused an increase ADG in compare with LW-calves. The results of our study are in contrast to those of Story *et al.* (2000) and Hudson *et al.* (2010) who reported that calves weaned at an early age had lower ADG compared with LW-calves in spring and summer.

On the other hand, Quigley *et al.* (1991), Gleeson *et al.* (2007), Jasmine Rani *et al.* (2007), Hill *et al.* (2009) and Ozkaya and Turan Toker (2012) did not observe any significant differences between ADG of early and late weaned calves. But numerically LW was 7 to 11% less than the mean of calves weaned EW.

Feed efficiency

The changes of FE over the 90 days experimental period are shown in Figure 1. The results indicate that the FE differed significantly between EW- and LW-treatments from third until 6th period. On average, calves reared in an LW system had greater FE than calves reared in an EW system (0.093 *vs.* 0.129, respectively). In agreement with our results, Ozkaya and Turan Toker (2012) and Terre *et al.* (2007) showed that FE of early weaned calves was greater than that of later weaned calves. In contrary, Hill *et al.* (2009) reported that EW-calves had a lower FE than LW-calves. But, Jasmine Rani *et al.* (2007) and Gleeson *et al.* (2007) reported no significant differences in FE between early and late weaned calves.

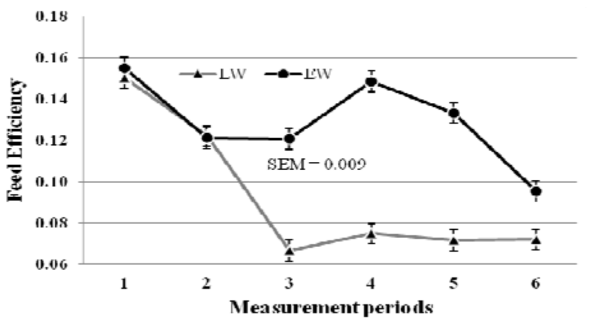

Figure 1 Feed efficiency from birth to 90-day, of calves in an early weaning and late weaning rearing system
Means of feed efficiency were statistically different among treatments at 3th, 4th, 5th and 6th periods (P<0.05)

Feed cost and case study farm simulations

On average, across the 90 day experimental period, LW-calves had higher (P<0.05) FC than EW-calves ($2.28 and $1.86 per day, for calves reared on EW *vs.* LW systems, respectively: Table 3).

The PIFC was significantly (P<0.05) greater for calves reared in an LW system compared to calves reared in an EW system (52.4% *vs.* 39.5%, for LW-calves and EW-calves respectively: Table3). The average cost of production for each of the 2 treatments is detailed in Table 4. Production costs were greater in the EW system compared to the LW system. The cost of preparing the farm for LW was lower than that for EW because of reduced storage, machinery and energy costs (Table 4), but animal health costs were slightly greater in the LW system than EW system.

Table 3 Least square means and standard errors f for feed cost and percentage of income spent for feed cost of calves reared in either an early weaning system or a late weaning system, from birth to d 90

Measurment periods	LW	EW	SEM	P-value
		FC ($/day)		
1	1.66	1.72	0.03	-
2	2.03	2.19	0.03	†
3	2.32	2.21	0.03	†
4	2.63	1.41	0.03	***
5	2.90	1.65	0.03	***
6	2.16	1.96	0.03	**
Mean of periods	2.28	1.25	0.02	***
		PIFC (%)		
1	36.1	36.1	2.13	-
2	38.4	36.6	2.13	-
3	62.3	43.1	2.13	***
4	58.9	34.6	2.13	***
5	62.5	40.2	2.13	***
6	56.5	46.8	2.13	**
Mean of periods	52.4	39.5	2.09	***

† (P<0.1); ** (P<0.01) and *** (P<0.001).
LW: late weaning; EW: early weaning; FC: feed cost and PIFC: percentage of income spent for feed cost.
SEM: standard error of the means.

Table 4 A comparisons of simulated annual income and annual feed and production costs associated with rearing calves in either an early weaning system or a late weaning system

Item	LW	EW
Income		
Total BW (kg/period)	878.90	1013.1
Total revenue ($/period)	4583.2	4935.6
Gross revenue ($/farm/period)[1]	810.3	1581.2
Feed cost		
Milk consumption (kg/period)	5,832.0	1586.0
Price of total milk ($/period)	2,157.8	564.7
Total feed consumption (kg DM/period)	317.2	1502.1
Grain consumption (kg DM/period)	73.6	1148.4
Forage consumption (kg DM/period)	287.6	353.7
Feed intake cost ($/period)	102.7	1273.3
Grain intake cost ($/period)	67.1	1210.4
Forage intake cost ($/period)	35.6	62.9
Fixed cost ($/period)[2]	1,512.4	1579.3
Production cost		
Field preparation ($/period)	50.8	1233.8
Seed, harvest, chopping and labour ($/period)	21.2	1077.1
energy and machinery ($/period)	15.5	64.5
Storage feed ($/period)	14.1	92.2
Laboratory ($/period)	14.2	8.1
Animal health ($/period)	37.7	31.4
Benefit index[3] (P<0.05)	1.21	1.47

[1] Aggregation of income from the sales of farm outputs (GR=$\sum^{N} R_{xi} Y_i$).
[2] Fixed costs included: purchase costs of calve and maintenance costs of farm.
[3] Benefit index: the ratio of total revenue to total expenses (BI ratio=total revenue/total expenses).
LW: late weaning; EW: early weaning and BW: body weight.

The results of this study indicate that EW rearing system had the highest benefit index (BI) compared to the LW rearing system (1.47 and 1.21, respectively: Table 4). A result obtained for FC values in this experiment is consistent with Story *et al.* (2000) confirming that the FC of animals fed in an EW system was lower than those in an LW system. Similarly, Kehoe *et al.* (2007) and Jasmine Rani *et al.* (2007) reported that lowering the weaning age to 50 days significantly reduced the cost of raising calves. Finally, due to the increase in FC for calves reared in an LW system compared to calves reared in an EW system, PIFC was greater for calves reared in an LW system. Hence, based on BI, PIFC and FC, an EW rearing system for calves is more profitable than a LW rearing system.

CONCLUSION

Calves reared in an EW system had higher DMI and ADG compared to those in a LW system. Although differences in FE were not highly remarkable between two treatments, it was more favourable in calves reared on a LW system. Overall, calves reared on LW system had significantly higher FC leading to increased PIFC. The findings reported here demonstrate that an EW rearing system for calves is likely to prove more profitable than a LW rearing system based on BI, FC and PIFC.

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