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Utilization Possibilities of Surplus Colostrum by Acidification with Formic Acid in Rearing Calves II. Performance of Calves Fed Acidified Colostrum Stored at Summer Ambient Temperatures or in a Refrigerator

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Abstract: Use of surplus colostrum, which was collected from the first eight milkings postpartum, in calf rearing programs was investigated in two trials. In trial 1, 18 Holstein calves were assigned at three days of age to one of two liquid diets consisting of acidified colostrum stored at summer ambient temperatures (ACAT), or acidified milk replacer (AMR). In trial 2 (ACRE), 10 Holstein calves were fed acidified colostrum stored in refrigerator (2 to 4°C). When surplus colostrum from their own dam was depleted, calves on ACAT and ACRE were fed acidified whole milk until weaning. Liquid diets were acidified with formic acid at 0.23% vol wt^{-1}. Colostrum diets were offered to calves at 9% of body weight per day and whole milk and milk replacer at 10% of body weight per day. Liquid diets were fed twice daily. The amounts of liquid diets offered were adjusted weekly according to body weight. Calves were offered pelleted starter and water for ad libitum intake throughout the trials. The trials continued for six weeks. All calves were weaned at the end of the fifth week (at 37 days of age) and calves received only water and starter during the sixth week of the trials. All calves were housed in individual pens. On an average, surplus colostrum was sufficient to feed calves for 17 days. Refusals of colostrum by calves on ACAT were high due to undesirable fermentation of colostrum. Refusals of liquid diets were minimal for calves on ACRE and AMR throughout the trials. Dry matter intakes from liquid diet and starter were lower for calves on ACAT. Body weight gain was also lower for calves on ACAT. Mean daily gains for calves on AMR, ACAT and ACRE during liquid diet period (3 to 37 days of age) were 463.3, 200.8 and 468.8 g, respectively. Reasons for decreased weight gains on ACAT were reduced intakes of liquid diet and starter and higher incidence of scours. Four calves (three males and one female) on ACAT were treated for scours. Based on feed expenses, cost of 1 kg weight gain during the trials was estimated to be TL 2,935,764 ($1.86), TL 2,967,282 ($1.88) and TL 1,745,220 ($1.10) for calves on AMR, ACAT and ACRE, respectively. If colostrum can be stored conveniently, the use of surplus colostrum will considerably reduce the feed cost.

Key words: Acidified colostrum, storage, summer ambient temperatures, refrigeration, acidified milk replacer, calf performance, scours

Introduction

Colostrum produced by dairy cows during the first three to four days postpartum is much more than can be utilized by the calf. In large dairy herds, surplus colostrum can be utilized by feeding to all calves in the herd. However, surplus colostrum can remain if calvings have not dispersed uniformly through the year. In small dairy herds, colostrum harvested during the first four days postpartum can not be consumed by the cow's own calf or by a few other calves in the herd. In these herds, a large amount of this surplus colostrum are generally discarded or consumed sometimes by the man.

Colostrum can be stored by freezing without nutrient loss during storage (Foley and Otterby, 1978). Colostrum can also be stored by fermentation. Several studies (Muller *et al*., 1975; Yu *et al*., 1976; Otterby *et al*., 1976 and Jenny *et al*., 1977a) showed that fermented colostrum could be used in calf feeding programs as an alternative to whole milk or milk replacer (MR). However, several problems such as undesirable fermentation, excessive acidity, reduced acceptability by calves, or increased nutrient losses were reported when colostrum was stored at warm ambient temperatures (Muller and Syhre, 1975; Muller *et al*., 1976; Rindsig, 1976; Jenny *et al*., 1977b; Polzin *et al*., 1977; Rindsig and Bodoh, 1977 and Rindsig *et al*., 1977). Chemical additives have been used to control fermentation, especially at warm ambient temperatures. Additions of propionic acid, formic acid, formaldehyde, benzoic acid, or sodium benzoate to colostrum stored at high temperatures maintained a relatively constant pH and odour, reduced nutrient losses and retarded bacterial growth (Muller and Syhre, 1975; Carlson and Muller, 1977; Muller and Smallcomb, 1977; Polzin *et al*., 1977 and Rindsig *et al*., 1977).

Depending on chemicals used and season of the trial, various results on acceptability by calves of colostrum treated with chemicals were reported. On the other hand, various results on acceptability by calves were found also in several studies in which the same chemical was used. Several studies during various seasons showed that refusals of liquid diet were greater for calves fed adipic (Foley and Otterby, 1979), propionic (Muller *et al.*, 1976; Rindsig and Bodoh, 1977; Otterby *et al.*, 1980 and Jenny *et al.*, 1984), or acetic (Polzin *et al.*, 1977) acid-treated colostrum. In contrast, Polzin *et al.* (1977) reported that no refusals of propionic acid-treated colostrum occurred during summer. Colostrum with formaldehyde (Muller *et al.*, 1976 and Rindsig and Bodoh, 1977), colostrum with formic acid (Polzin *et al.*, 1977), or whole milk with formic acid (Kaya *et al.*, 2000) was accepted readily by calves. Jenny *et al.* (1980, 1984) reported that refusals of colostrum treated with sodium benzoate by calves were less.

In several studies, the growth of calves fed colostrum treated with chemicals was compared to calves fed fermented colostrum or whole milk. Several researchers reported that weight gains for calves fed colostrum treated with propionic acid (Rindsig and Bodoh, 1977; Polzin *et al.*, 1977; Otterby *et al.*, 1980 and Jenny *et al.*, 1984), acetic acid (Polzin *et al.*, 1977 and Daniels *et al.*, 1977), lactic acid (Foley and Otterby, 1979), formaldehyde (Rindsig and Bodoh, 1977; Jenny *et al.*, 1984 and Karioki *et al.*, 1995), or sodium benzoate (Jenny *et al.*, 1980, 1984) were similar to calves fed whole milk or naturally fermented colostrum. On the other hand, Foley and Otterby (1979) found that calves fed adipic acid-treated colostrum gained less weight to weaning than calves fed fermented colostrum. Polzin *et al.* (1977) reported that calves fed whole milk and formic acid-treated colostrum gained more than calves fed fermented colostrum.

The objective of this study was to examine utilization possibilities of surplus colostrum preserved by addition of formic acid in rearing calves. For this purpose; performance of calves fed acidified MR, acidified colostrum stored at summer ambient temperatures, or acidified colostrum stored in a refrigerator were examined.

Materials and Methods

In two trials, utilization possibilities of surplus colostrum preserved by addition of formic acid in rearing calves was examined. In trial 1, acidified colostrum that was stored at summer ambient temperatures (ACAT), or acidified MR (AMR) was fed to calves. Eighteen Holstein calves were assigned randomly, within sex, to one of two groups. Ten calves (five males and five females) were assigned to AMR and eight calves (four males and four females) to ACAT. The trial continued throughout summer and excess sourness and putrid odour occurred in acidified colostrum stored at summer ambient temperatures until it was depleted. Therefore, refusals of colostrum by calves occurred. Due to these undesirable developments, a second trial was conducted. In trial 2, 10 Holstein calves (six males and four females) were fed acidified colostrum stored in refrigerator (ACRE).

Trials were carried out at the calf-rearing unit in the dairy farm of the Animal Science Department of Ege University. The rearing unit was established in a semi-open barn and consisted of 10 individual calf pens that were 1.22 m wide and 2.00 m long.

Calves on AMR and ACAT (trial 1) were brought from the Agricultural Faculty Farm of Ege University, except one calf on each one. Trial 1 continued from June to October. Calves on ACRE (trial 2) were born in the dairy farm of the Animal Science Department. Trial 2 continued from mid-September through March. Temperatures averaged 26.2, 29.7, 28.6, 23.3, 17.5, 14.0, 10.1, 9.9, 9.4 and 15.4°C for the months of June, July, August, September, October, November, December, January, February and March.

Calves were separated from their dam immediately after birth and then were placed in individual pens. Calves were hand-fed their dam's fresh colostrum twice daily (1.5 to 2.0 kg per meal) for the first two days of life. On the third day, calves were weighed and switched to their respective liquid diets. The trials continued for six weeks. Calves on ACAT and ACRE were fed colostrum collected from their dam. When calves depleted their dam's colostrum, whole milk acidified with formic acid was fed until the end of the fifth week of the trials. Calves on AMR were fed all-milk sources MR. The MR powder was diluted 1:7 (1 kg powder to 7 kg of water). Liquid diets were offered to calves twice daily in equal portions from nipple pails for the first five weeks of the trials. The amount of liquid diet offered was determined according to body weight. Acidified colostrum was given to calves at 9% of body weight per day and AMR and acidified whole milk were given at 10% of body weight per day. The amount of liquid diet was adjusted weekly according to body weight. During the last week of liquid diet period (fifth week), the amount of liquid was reduced to half that fed in the fourth week. Liquid diet consumption and refusals were measured daily. Pelleted calf starter and fresh water were offered ad libitum during the trials (from 3 to 44 days of age). No hay was offered throughout the trials. Calves weaned at the end of the fifth week were fed only calf starter during the sixth week of the trials. Starter consumptions were measured regularly. Composition of the calf starter is in Table 1. Composition of liquid diets that was used in the trials was given in the previous paper (Kaya *et al.*, 2003).

Table 1: Composition of calf starter

Component	
Dry matter (DM), %	90.34
Crude protein, g kg^{-1} DM	192.1
Crude fat, g kg^{-1} DM	29.3
Crude fiber, g kg^{-1} DM	88.1
Crude ash, g kg^{-1} DM	69.8
ME, MJ kg^{-1} DM	12.0

Calves were weighed at the beginning of the trial and then at weekly intervals.

Fecal consistency scores were recorded daily on a scale of 1 to 4 (1=normal, 2=soft, 3=runny and 4=watery) according to Larson *et al.* (1977). Calves with severe scours were treated with antibiotics by oral or i.m. routes. In addition, tea containing sugar and salt was given orally to maintain electrolyte balance. Calves were kep t on clean and dry straw bedding.

Colostrum collected for the first eight milkings postpartum from dams of calves assigned to the experiments was acidified with formic acid and stored separately in covered plastic containers of 60 or 120 l. Acidification of colostrum from each dam was performed in two stages. Firstly, colostrum from the first to the fourth milkings postpartum was mixed and acidified after the fourth milking (first composite). Then, colostrum from the fifth to the eighth milkings postpartum was mixed and acidified after eighth milking (second composite). Thereafter, first and second composites were mixed (total composite). Calves on ACAT and ACRE were fed first composite colostrum during the first two days of the trials. Beginning on day three, total composite colostrum was fed to calves.

In ACAT, first and second composites were stored in a cool place (10 to 15°C) before acidification. Each composite was transported to location of the experiment immediately after it was completed and then acidified. First and total composites were stored at summer ambient temperatures after acidification. In ACRE, all colostrum composites were stored in a refrigerator (2 to 4°C) at the experimental location before and after acidification. In this group, colostrum was removed from the refrigerator to warm up 10 to 14 h before feeding.

Pure formic acid of 98-100% (Riedel-de Haën) was used for acidification of liquid diets (0.23% vol wt^{-1}). Detailed description for acid addition procedure was given in the first paper (Kaya *et al.*, 2003).

Samples of calf starter were analysed for DM, crude protein, crude fat and crude ash by the Weende method (Naumann and Bassler, 1993) and crude fiber by the Lepper method (Bulgurlu and Ergül, 1978).

Data were analysed statistically using the GLM procedure of SAS (1989). The following general model was used in the analysis of intake, growth, feed efficiency and scours data for trial 1:

$$Y_{ijk}=\mu+t_i+s_j+(t\times s)_{ij}+e_{ijk}$$

Where,

Y_{ijk}=observation
μ=overall mean
t_i=effect of the i^{th} treatment (diet)
s_j=effect of the j^{th} sex
$(tx\ s)_{ij}$=Interaction due to the combination of the j^{th} sex with the i^{th} treatment
e_{ijk}=error term

Initial body weight was used as a covariate in the analysis of body weights and body weight gains for various periods. Where sex by treatment interactions were present, means for sex x treatment subgroups were compared by t-test.

In trial 2, data were analysed separately. Because there was only one treatment (ACRE) in trial 2, least squares means for traits considered was obtained using a model including only the effect of sex. Initial body weight was used as a covariate in the analysis of body weights and body weight gains.

Feed costs for the experimental period were calculated for AMR, ACAT and ACRE. Consumptions of whole milk, MR, calf starter and formic acid and weight gains during the trials were used in calculation of the feed cost. Colostrum was not considered as a component of cost because it is unmarketable. In calculation of cost, the prices of components in July 2002 were used (whole milk: TL (Turkish Lira) 350,000/kg; MR (dry): TL 2,592,000/kg; calf starter: TL 290,000/kg; formic acid (98-100%): TL 15,000,000/l) . To calculate costs as USD ($), exchange rate of the Central Bank of the Republic of Turkey on July 1, 2002 was used ($1 = TL 1,580,740).

Results

The amount of colostrum produced in the first eight milkings postpartum by dams of 18 calves assigned to ACAT and ACRE is shown according to parity in Table 2. Average colostrum production of Holstein cows for the first eight milkings postpartum was 68.1 kg, except for approximately 7 kg of colostrum fed to calves in first four meals (first two days of life).

In the first 17 days of the liquid diet period of 35 days, calves on both ACRE and ACAT were fed acidified colostrum (on an average, colostrum from their dams was

Table 2: Colostrum production (kg) for the first eight milkings postpartum in Holstein cows (mean±s.d.)

Parity	No. of cows	1st to 4th milkings[1]	5th to 8th milkings	Totalcomposite
1	5	20.9±4.5	36.1±3.2	57.0±6.9
2	7	28.0±11.1	43.6±10.5	71.6±19.4
3	2	34.1±3.7	56.3±12.4	90.4±16.1
≥ 4	4	22.8±10.6	42.0±7.1	64.8±14.7
Total	18	25.5±9.4	42.6±9.7	68.1±17.3

[1] Except for approximately 7 kg of colostrum fed to calves in first four meals (first two days of life)

sufficient for 17 days). Thereafter, acidified whole milk was fed during the remaining 18 days (Table 3). Liquid diet refusals were high for calves on ACAT during the colostrum period. Liquid diet refusals began at the 5th to 10th days of the trial and continued throughout the colostrum period. Of the eight calves assigned to the ACAT, six calves partially or completely refused the acidified colostrum on an average 49.1% of the meals offered. These calves refused 26.9% of the total amount of acidified colostrum offered. Of the six calves with acceptability problem, four were males. In addition, both mean for meals refused and mean for amount of colostrum refused were higher for male calves than for female calves. After switching to acidified whole milk, refusals were low for calves on ACAT. At the beginning of the acidified whole milk period, three of the six calves with acceptability problem had low refusals (mean for meals refused was 5.9% and mean for amount refused was 2.9%). Few acceptability problems were encountered on AMR. Four calves on AMR refused small amounts of their liquid diets (Table 3). Liquid diet refusals on AMR occurred only during the first week of the trial. Almost no refusals of liquid diet by calves on ACRE occurred.

Least square means for liquid diet, calf starter and DM intakes of calves are in Table 4. For each period in trial 1, mean liquid diet, calf starter and DM intakes were significantly lower for calves on ACAT than for calves on AMR. Mean DM intakes from liquid diet throughout the liquid diet period (3 to 37 days of age) on AMR and ACAT were 496.9 and 432.0 g/day, respectively. In the same period, mean DM intakes from starter were 327.8 and 183.0 g/day, respectively. At week 6 (38 to 44 days of age), in which no liquid diet was given, mean DM intakes from starter on AMR and ACAT were 1271.6 and 975.0 g/day, respectively.

Mean DM intakes from liquid diet and from starter throughout the liquid diet period on ACRE (trial 2) were 514.5 and 318.0 g/day, respectively. At week 6, mean DM intake from starter was 1400.9 g/day.

Least square means for body weights and body weight gains for various age periods are in Table 5. Initial body

Table 3: Liquid diet refusals by calves

	Trial 1			Trial 2	
No. of calves	AMR	ACAT		ACRE	
Liquid diet	10	8		10	
period, days	Milk replacer	Colostrum	Milk	Colostrum	Milk
Mean	35.0	16.9	18.1	17.2	17.8
Minimum	35.0	13.5	9.5	13.0	11.5
Maximum	35.0	25.5	21.5	23.5	22.0
Liquid refusals					
No. of calves refusing	4 (1?, 3?)	6 (4?, 2?)	3 (?)	1 (?)	-
Meals refused, % [1]					
Overall mean	5.7	49.1	5.9	5.3	-
Mean for males	8.6	60.9	5.9	-	-
Mean for females	4.8	25.5	-	5.3	-
Minimum	1.4	7.4	2.8	5.3	-
Maximum	8.6	82.4	9.8	5.3	-
Amount refused, % [1,2]					
Overall mean	1.7	26.9	2.9	0.7	-
Mean for males	3.1	33.5	2.9	-	-
Mean for females	1.3	13.6	-	0.7	-
Minimum	0.2	1.8	0.6	0.7	-
Maximum	3.1	40.1	4.2	0.7	-

[1] Based on just the calves refusing their diets

[2] Ratio of total amount refused to total amount offered

Table 4: Least square means for liquid diet, calf starter and DM intakes of calves (mean ± s.e.)

	Trial 1			Trial 2
	AMR	ACAT	P	ACRE
No. of calves	10	8		10
Liquid diet intake, kg/calf/day				
3 to 23 days	4.29±0.14	3.26±0.16	***	4.04±0.10
24 to 37 days	3.69±0.11	3.25±0.12	*	3.71±0.08
3 to 37 days	4.05±0.12	3.26±0.14	***	3.91±0.09
Calf starter intake, g/calf/day				
3 to 23 days	154.9±18.9	72.6±21.1	*	163.0±22.6
24 to 37 days	674.4±53.8	398.0±60.1	**	635.7±43.3
38 to 44 days	1407.2±64.9	1079.4±72.5	**	1550.5±50.1
3 to 37 days	362.7±31.0	202.9±34.7	**	352.1±29.7
3 to 44 days	536.9±34.8	348.8±39.0	**	551.8±31.9
DM intake from liquid diet, g/calf/day				
3 to 23 days	525.7±20.5	447.8±22.9	*	550.0±10.4
24 to 37 days	453.4±13.5	407.6±15.1	*	461.0±10.6
3 to 37 days	496.9±17.1	432.0±19.1	*	514.5±9.5
DM intake from starter, g/calf/day				
3 to 23 days	140.1±17.0	65.6±19.1	*	147.1±20.4
24 to 37 days	609.4±48.6	359.6±54.3	**	574.1±39.1
38 to 44 days	1271.6±58.6	975.0±65.5	**	1400.9±45.2
3 to 37 days	327.8±28.0	183.0±31.3	**	318.0±26.9
3 to 44 days	485.1±31.5	315.1±35.2	**	498.4±28.8
Total DM intake, g/calf/day				
3 to 23 days	665.7±28.8	513.5±32.2	**	697.0±21.8
24 to 37 days	1062.5±53.0	767.3±59.2	**	1035.2±44.7
38 to 44 days	1271.6±58.6	975.0±65.5	**	1400.9±45.2
3 to 37 days	824.3±36.1	614.9±40.4	**	832.4±29.6
3 to 44 days	899.0±37.6	675.0±42.0	**	927.0±31.2

* P<0.05; ** P<0.01; *** P<0.001

Table 5: Least square means for body weights and body weight gains for various age periods (mean ± s.e.)

	Trial 1			Trial 2
	AMR	ACAT	P	ACRE
No. of calves	10	8		10
Body weight, kg				
Day 3 (initial body weight)	39.57±1.23	39.71±1.38	NS	39.45±1.14
Day 23	47.35±0.82	42.08±0.92	***	48.17±0.86
Day 37	55.85±0.99	46.66±1.10	***	56.10±1.17
Day 44	59.17±1.21	49.91±1.36	***	59.90±1.40
Body weight gain, g/calf/day				
3 to 23 days	367.7±39.1	116.4±43.8	***	404.1±41.1
24 to 37 days	606.6±32.5	327.3±36.3	***	566.0±32.5
38 to 44 days	474.6±55.5	464.0±62.1	NS	542.7±56.9
3 to 37 days	463.3±28.2	200.8±31.5	***	468.8±33.3
3 to 44 days	465.2±28.9	244.9±32.3	***	481.2±33.3

NS = Nonsignificant (P>0.10); *** P<0.001

Table 6: Least square means for feed efficiencies (kg DM/kg weight gain) for various age periods (mean±s.e.)

	Trial 1					Trial 2
	AMR		ACAT			ACRE
	Males	Females	Males	Females	P	
No. of calves	5	5	4	4		10
3 to 23 days	1.88±1.01[b]	1.83±1.01[b]	12.60[1]±1.31[a]	2.13[1]±1.31[b]	***[2]	1.86±0.20
24 to 37 days	1.77±0.23		2.68±0.26		*	1.85±0.09
38 to 44 days	2.93±0.30		2.35±0.34		NS	2.83±0.29
3 to 37 days	1.85±0.49[b]	1.74±0.49[b]	5.96± 0.55[a]	2.62±0.55[b]	**[2]	1.81±0.11
3 to 44 days	2.00±0.40[b]	1.89±0.40[b]	4.41 ± 0.45[a]	2.47±0.45[b]	*[2]	1.96±0.10

[1] Based on three calves because one male and one female calf on ACAT lost weight during 3 to 23 days of age
[2] Probability level for sex by treatment interactions
[a,b] Row means with unlike superscripts within trial 1 differ significantly (P<0.01)
NS = Nonsignificant (P>0.10); * P<0.05; ** P<0.01; *** P<0.001

Table 7: Least square means for fecal consistency score and days with scours for various age periods (mean ± s.e.)

	Trial 1			Trial 2
	AMR	ACAT	P	ACRE
No. of calves	10	8		10
Fecal consistency score[1]				
3 to 23 days	2.24±0.10	2.28±0.12	NS	2.00±0.11
24 to 37 days	1.26±0.08	1.39±0.09	NS	1.31±0.10
38 to 44 days	1.19±0.11	1.25±0.13	NS	1.22±0.10
Days with scours, %[2]				
3 to 23 days	17.14±3.51	22.62±3.92	NS	10.91±2.85
24 to 37 days	No scours	5.36±2.29	NS	1.79±1.53
38 to 44 days	1.43±1.50	1.79±1.68	NS	3.57±3.05
No. of calves treated for scours	0	4 (3?, 1?)		0

[1] Fecal consistency score, 1 = normal, 2 = soft, 3 = runny, 4 =watery
[2] Days with a fecal consistency score of ≥ 3
NS = Nonsignificant (P>0.10)

weights on AMR, ACAT and ACRE were 39.57, 39.71 and 39.45 kg, respectively.

Throughout the trial (3 to 44 days of age), mean daily body weight gains for calves on AMR and ACAT were 465.2 and 244.9 g, respectively. The difference was significant (P<0.001). Also for days 3 to 23, 24 to 37 and 3 to 37 of age during the liquid diet period, mean daily body weight gains were lower (P<0.001) for calves on ACAT than for calves on AMR. However, mean daily body weight gains during the postweaning period (38 to 44 days of age) did not differ (P>0.10) between AMR and ACAT.

Mean body weight gains for calves on ACRE (trial 2) were 404.1, 566.0 and 468.8 g/day for days 3 to 23, 24 to 37 and 3 to 37 of age during the liquid diet period, respectively. Throughout the trial, mean body weight gain was 481.2 g/day.

Least square means for feed efficiencies (kg DM kg^{-1} weight gain) for various age periods are in Table 6. In trial 1, sex by treatment interactions were significant (P<0.05) for feed efficiencies during 3 to 23, 3 to 37 and 3 to 44 days of age. In these periods, male calves on ACAT were least efficient while feed efficiencies did not differ between female calves on ACAT and male and female calves on AMR. No sex by treatment interactions were present (P>0.10) for feed efficiencies during 24 to 37 and 38 to 44 days of age. For days 24 to 37 of age, calves on ACAT were less efficient (P<0.05) than calves on AMR. Feed efficiencies during the postweaning period (38 to 44 days of age) did not differ (P>0.10) between AMR and ACAT.

In trial 2 (ACRE), feed efficiencies during 3 to 23, 24 to 37 and 38 to 44 days of age were 1.86, 1.85 and 2.83 kg DM kg^{-1} gain, respectively. It was 1.96 kg DM kg^{-1} gain for 3 to 44 days of age.

Except incidence of scours, no other health disorders occurred during the trials. Fecal consistency score and days with scours were considered to reveal severity and duration of scours. Least square means for these traits are in Table 7.

In trial 1, fecal consistency scores did not differ (P>0.10) between AMR and ACAT for all age periods. Percent days with scours were higher on ACAT than AMR for all age periods although there was no difference in percent days with scours between treatments. Moreover, half of the calves on ACAT were treated for scours. No severe scours requiring treatment occurred on AMR and on ACRE (trial 2).

The effect of sex on all variables was not significant (P>0.05), except variables in which sex by treatment interactions were present (feed efficiencies for days 3 to 23, 3 to 37 and 3 to 44 of age in trial 1).

Throughout the trials, feed cost for calves according to groups are in Table 8. Feed costs per calf on AMR, ACAT and ACRE were TL 57,247,400 ($36.22), TL 30,563,000 ($19.33) and TL 35,777,000 ($22.63), respectively. Feed costs per kg of body weight gain in these groups were TL 2,935,764 ($1.86), TL 2,967,282 ($1.88) and TL 1,745,220 ($1.10), respectively.

Table 8: Feed cost for calves according to groups

Components of cost	Price (TL kg^{-1})[1]	AMR Intake[1] (kg)	AMR Cost (TL)	ACAT Intake[1] (kg)	ACAT Cost (TL)	ACRE Intake[1] (kg)	ACRE Cost (TL)
Whole milk	350,000	0	0	62.5	21,875,000	69.5	24,325,000
MR (dry)	2,592,000	17.7[2]	45,878,400	0	0	0	0
Colostrum	0	0	0	51.6	0	68.1	0
Formic acid	15,000,000	0.321	4,815,000	0.295[3]	4,425,000	0.313	4,695,000
Calf starter	290,000	22.6	6,554,000	14.7	4,263,000	23.3	6,757,000
Cost, TL/calf			57,247,400		30,563,000		35,777,000
Cost, $/calf			36.22		19.33		22.63
Body weight gain (BWG), kg			19.50		10.30		20.50
Cost, TL/kg BWG			2,935,764		2,967,282		1,745,220
Cost, $/kg BWG			1.86		1.88		1.10

[1] Price and amount of intake for formic acid are in litre
[2] Correspond to 141.6 kg of liquid diet when reconstituted
[3] It also includes the amount of formic acid in colostrum refused

Discussion

The amount of surplus colostrum production was considerably high. Mean amount (68.1 kg) for colostrum produced in the first eight milkings postpartum is a liquid diet source to be sufficient on an average for 17 days for a calf when fed 4 kg daily. The amount of colostrum fed to calves per day in this study was higher compared to amounts reported in many other studies (Muller *et al.*, 1975; Muller *et al.*, 1976; Rindsig, 1976 and Yu *et al.*, 1976). However, colostrum from the first six milkings was used in those studies, while colostrum from the first eight milkings, in which mean DM content is lower compared to colostrum from the first six milkings, was used in our study.

The amount of colostrum produced in the first eight milkings postpartum increased until the third lactation and began decreasing in the fourth and subsequent lactations. Colostrum yield was lowest in first lactation. Similar results were found by Muller *et al.* (1975) and Rindsig (1976).

During colostrum-feeding period (approximately 17 days), six of the eight calves assigned to ACAT partially or completely refused the acidified colostrum on an average 49.1% of the meals offered. Other researchers also reported that refusals of colostrum with chemical additives occurred especially during summer months. Studies during summer (Muller *et al.*, 1976) and during spring through summer (Rindsig and Bodoh, 1977) reported that refusals of propionic acid treated and naturally fermented colostrum had occurred while there was no refusals of colostrum treated with formaldehyde. Otterby *et al.* (1980) found that the pH of colostrum with propionic acid decreased exceedingly (pH 3.98) during summer and refusals occurred. On the other hand, Polzin *et al.* (1977) reported that no refusals of colostrum with propionic acid or naturally fermented colostrum occurred during summer. They carried out two other trials from mid-autumn through spring and reported that refusals of liquid diet were greater for calves fed acetic acid-treated colostrum than for calves fed fermented colostrum; and refusals of liquid diet were similar for calves fed formic acid-treated colostrum or naturally fermented colostrum. Foley and Otterby (1979) reported that adipic acid-treated colostrum was less acceptable to calves than fermented colostrum.

Evaluations of published results on feeding calves with preserved colostrum indicate that problems with intake occurred depending on ambient temperatures and type and amount of chemicals used. Refusals of colostrum have been attributed to greater acidity, putrid odour, dislike of the flavour and high nonprotein nitrogen content or, a combination of these factors (Muller *et al.*, 1976; Rindsig and Bodoh, 1977; Foley and Otterby, 1979; Otterby *et al.*, 1980). The high refusal rate on ACAT can be attributed to the factors such as beginning of fermentation in colostrum before acidification due to some undesirable conditions, exceedingly decreased pH (pH < 4) in consequence of continuation of fermentation after acidification due also to the effect of high ambient temperatures and putrid odour. On the other hand, severe scours was observed in four of the six calves with acceptability problem on ACAT. This may have caused more refusals of colostrum. There were no problems with intake of acidified colostrum by calves on ACRE because none of the undesirable conditions mentioned above occurred. Due to the same reasons, no considerable refusals of liquid diets were observed in calves on ACAT during acidified whole milk period and in calves on AMR during liquid diet period. Other researchers also reported that AMR (Jaster *et al.*, 1990) or acidified whole milk (Kaya *et al.*, 2000) was accepted readily by calves.

Refusals of acidified colostrum on ACAT were greater for male calves than for female calves. No explanation other than severe scours can be given for this. Severe scours

was observed in three of the four male calves with acceptability problem on ACAT. Eppard *et al.* (1982) also reported that male calves tended to have higher refusals and were more sensitive to acid than female calves.

Intakes of liquid diet and DM from liquid diet were lower for calves on ACAT for each period. Lowered intake on ACAT has been a consequence of higher refusals of acidified colostrum by most of the calves in this group. Intakes of calf starter also were lower for calves on ACAT for each period. It is expected that intake of starter tends to increase as intake of DM from liquid diets decreases (Appleman and Owen, 1975 and Foley and Otterby, 1978). This tendency is not reflected by our results. Other studies also showed that calves that had considerable refusals of liquid diet had also lower intakes of starter (Muller *et al.*, 1976; Daniels *et al.*, 1977; Rindsig and Bodoh, 1977 and Foley and Otterby, 1979).

Body weight gains were lower for calves on ACAT. Reasons for decreased weight gains on ACAT were reduced intakes of liquid diet and starter and higher incidence of scours. Similarly, Foley and Otterby (1979) reported that decreased weight gains of calves fed colostrum treated with adipic acid were related to reduced colostrum consumption and lower consumption of starter in comparison to calves fed frozen or naturally fermented colostum. We could not find other research comparing performance of calves fed colostrum treated with chemicals, or AMR. Colostrum treated with chemicals usually was compared with whole milk or MR in several studies. Studies conducted during summer showed that calves fed colostrum treated with propionic acid (Muller *et al.*, 1976 and Polzin *et al.*, 1977) or formaldehyde (Muller *et al.*, 1976) had lower weight gains than calves fed whole milk even though the difference was not significant. In another trial conducted from mid-autumn through spring, Polzin *et al.* (1977) found that weight gains for calves fed colostrum with formic acid or whole milk were similar.

In trial 1, sex by treatment interactions were present for feed efficiencies during days 3 to 23, 3 to 37 and 3 to 44 of age. In these periods, male calves on ACAT were least efficient. Reduced feed efficiency for male calves on ACAT was attributed to the fact that three of the four calves with severe scours were male calves. No sex by treatment interactions were present for feed efficiency during 24 to 37 days of age, but calves on ACAT were less efficient than other calves. This maybe resulted from the carry over effects of scours occurred in early period. Feed efficiencies were similar for ACRE and AMR. Daniels *et al.* (1977) found that feed efficiency was better for calves fed colostrum with acetic acid than for calves fed MR. Studies conducted during summer (Muller *et al.*, 1976) and during spring through summer (Rindsig and Bodoh, 1977) showed that feed efficiencies did not differ significantly for calves fed colostrum treated with propionic acid, colostrum treated with formaldehyde, or whole milk, even so calves fed colostrum with propionic acid were most efficient.

Except incidence of scours, no other health disorders and mortalities occurred during the trials. Almost all incidences of scours were observed during the first three weeks of the trials. Calves are highly susceptible to diseases of the digestive tract especially in the first three weeks of life (Radostits, 1975). No severe scours requiring treatment occurred on AMR and ACRE. However, four calves on ACAT were treated for severe scours. All calves on ACAT and AMR, except one calf on each one, were brought from the Faculty Farm, which is approximately 40 km away from location of the experiment. Higher incidence of scours on ACAT may have occurred due to changing environmental surroundings. Moreover, calf scours was a common problem at the Faculty Farm. However, calves on AMR were less affected by scours. Besides formic acid, which has antimicrobial properties (Bothmer, 1988), MR was containing antibiotics added by manufacturer and it was consumed by calves in sufficient amount. Calves on AMR readily consumed MR even if they have scours. Thus, they overcame the scours without detrimental effect on their health. However, scours and acceptability problems occurred simultaneously on ACAT. Thus, calves on ACAT did not have regular intakes of formic acid due to refusals of liquid diet. Reduced incidence of scours in calves on ACRE may have occurred because environmental surroundings did not change for these calves because they were born at location of the experiment. In addition, colostrum offered was milked and stored under suitable conditions and therefore problems with intake did not occur.

Based on published results, it can be said that there is not an obvious relationship between scours and feeding colostrum treated with chemicals. Muller *et al.* (1976) reported that incidence of scours was low in calves fed whole milk, fermented colostrum, colostrum with propionic acid, or colostrum with formaldehyde although the trend was toward a higher incidence in calves fed colostrum with formaldehyde. Rindsig and Bodoh (1977) found that incidence of scours was lowest in calves fed propionic acid-treated colostrum with calves fed whole milk, fermented colostrum and colostrum treated with formaldehyde giving similar results. Polzin *et al.* (1977) reported that incidence of scours was low in calves fed whole milk, fermented colostrum, or colostrum treated with propionic, acetic or formic acid.

Feed cost per kg of body weight gain was TL 1,222,062 ($0.77) and TL 1,190,544 ($0.75) lower for calves on ACRE than for calves on ACAT and AMR, respectively. In this case, the total feed cost for an average body weight gain of 20 kg has been TL 23,810,880 ($15) lower on ACRE compared to AMR. If colostrum can be stored conveniently, the use of surplus colostrum in rearing calves will considerably reduce the feed cost. Yu *et al.* (1976) and Karioki *et al.* (1995) also showed that surplus colostrum-feeding program ensured an important saving compared to the whole milk feeding program.

Based on the results from this study and from the previous study (Kaya *et al.*, 2003), the following recommendations can be given for the use of surplus colostrum preserved by acidification in feeding programs of calves.

- Colostrum should be milked and stored under sanitary conditions (during milking and storage, microbial contamination should be minimized as much as one can)
- Colostrum should be acidified immediately after milking. If colostrum will be acidified after collection, it should be stored by refrigerating (2 to 4 °C) until acidification.
- Storing acidified colostrum in a refrigerator has given satisfactory results with regard to preservation and feeding of colostrum. Our practical experiences indicated that storing acidified colostrum at cool ambient temperatures has also given satisfactory results.
- Further research should be conducted to determine the changes in composition and characteristics and the feeding value of colostrum in case that colostrum milked under sanitary conditions and acidified immediately after milking has been stored at summer ambient temperatures.

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