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A Nutritious Whey Silage Fed to Beef Cows During Maintenance

D.R. ZoBell, K.C. Olson, R.D. Wiedmeier, C. Stonecipher and C. Kim Chapman
Department Animal, Dairy and Veterinary Sciences,
University of Logan,Utah State,UT 84322-4815, USA

Abstract: Two studies were conducted with the objective of evaluating the effects of feeding liquid whey ensiled with wheat straw and wheat middlings to beef cows under maintenance conditions. Whey silage was produced by combining liquid whey, barley straw and wheat middlings at levels of 28.7, 46.8 and 24.6% for study one (DMB) and 30.3, 45.8 and 23.9% for study two (DMB) respectively. Dry, pregnant beef cows, initial weight 613.0 kg and 578.0 kg for studies one and two respectively, were randomly assigned to either a control (C) or Treatment (T) group with five head per pen and three pens per treatment. Length of study was 56 days for study one and 140 days for study two. In study one the C cows received grass hay and the T ration that consisted of 83.3, 16.0 and .70% whey silage, barley grain and limestone respectively. Study two C cows received a diet consisting of 27.6% alfalfa hay, 55.2% barley straw and 17.2% barley grain and T cows received whey silage and a small amount of limestone. In both studies a TM salt was provided free choice to all cows. Feed intake was recorded daily on a pen basis and adjusted after each weighing such that cows from both treatments gained approx. .20 kg d^{-1}. Cows in study one gained weight equally between treatments ($p>.05$), with no differences in change of body condition score ($p>.05$). In study two, C cows gained 88.0 kg versus 107.4 kg for the T cows ($p<.05$) although the change in body condition score was not different ($p>.05$) between treatments. Dry matter digestibility was not different between treatments ($p>.05$) with values of 63.1 and 67.8% for the C and T groups respectively. Neutral detergent fiber digestibility differed (C-60.4 and T-49.9%; $p<0.05$). For both studies the T cow's diets were approximately 30% lower in cost than C diets. This study confirms that whey silage is a viable alternative to more traditional diets for beef cows under maintenance conditions.

Key words: Cheese whey, beef cattle, silage

INTRODUCTION

Feed accounts for the highest input cost for beef cows. Traditional feedstuffs consist of predominantly harvested forages which are either produced on the farm or purchased. Forage prices fluctuate depending on supply, which can be affected by a number of factors and can vary from year to year.

The use of agricultural and industrial by-products for beef cattle are well documented[1,3]. Residue feeds such as wheat straw, liquid whey and wheat middlings have been combined and ensiled to produce a whey silage that provided a nutritious and palatable feedstuff for growing and finishing cattle[4,5]. The objective of two studies was to evaluate whey silage as a feedstuff for beef cows under maintenance conditions.

MATERIALS AND METHODS

Silage preparation: Whey silage was produced for two studies using the nutrient profiles and proportions of the feedstuffs as shown in Table 1 and 2. The cheese whey used for each study varied little in dry matter percent and nutrient content and came from the same cheese plant. The feedstuffs whey, wheat straw and wheat middlings were ensiled in a bunk type silo to produce the whey silage. The whey silage was sampled 3-4 weeks later for nutrients, fermentation characteristics, and analyses were continued throughout each feeding trial. All nutrient and feedstuff analyses reported in these studies were conducted at a commercial laboratory using procedures of Bull[5,6] standard procedures and those outlined by ZoBell[7]. Fermentation properties of the whey silage are shown in Table 3.

Feeding trials: British-based crossbred beef cows were used in the two studies. Initial weights for study 1 were 603.4 and 623.3 kg and for study 2, 571.5 and 585.5 kg for C and T cows respectively. There was no difference between treatments for initial weight in both studies ($p>.05$). In study 1 there were 5 cows per pen and three pens per treatment and in study 2, 6 cows per pen and

Corresponding Author: D.R. ZoBell, Department of Animal Dairy and Veterinary Sciences, University of Logan, Utah State UT 84322-4815, USA

Table 1: Feedstuff nutrient levels for Study 1 and 2 (DMB)

Feedstuff	Study	DM (%)	NE_m (Mcal kg^{-1})	NE_g (Mcal kg^{-1})	CP (%)	Ca (%)	P (%)
Whey	1	16.8	1.98	1.19	5.20	1.60	2.10
	2	20.9	2.09	1.41	8.30	.55	1.18
Wheat Straw	1	92.1	.77	.24	4.20	.40	.22
	2	80.0	.73	.20	6.00	.36	.20
Wheat Middlings	1	88.5	1.39	.81	14.9	.15	.62
	2	90.3	1.85	1.21	18.2	.11	.56
Alfalfa Hay	2	91.4	1.25	.68	18.0	1.07	.30
Grass Hay	1	90.8	1.21	.64	8.70	.46	.17
Barley Grain	2	88.5	2.02	1.36	12.5	.07	.38

Table 2: Composition of silage on a dry matter basis, energy values and nutrient analysis for Study 1 and 2

Silage composition % (DM)					Nutrient^Z				
Study^Y	Whey	Straw	WM^X	DM	NEm	NEg	CP	Ca	P
1	28.7	46.8	24.5	42.0	1.47	.90	8.1	.39	.38
2	30.3	45.8	23.9	43.1	1.58	.99	10.6	.41	.63

^{Z}DM=Dry matter (%); NEm=Net energy for maintenance (Mcal kg^{-1}); NEg=Net energy for gain (Mcal kg^{-1}); CP=Crude protein (%); Ca=Calcium (%); P=Phosphorus (%). ^{Y}Study 1 Whey DM=16.8%; Study 2 Whey DM=20.9%. ^{X} WM=Wheat middlings

Table 3: Fermentation properties of whey silage for Study 1 and 2

Study	pH	Lactic acid (% DM)	Acetic acid (% DM)	Total VFA (% DM)	Ammonia (% DM)
1	4.39	4.6	.28	4.90	.50
2	4.20	6.1	.48	6.82	.90

three pens per treatment. All cows had been pregnancy tested prior to trial initiation. Cows were fed at 08:00 h daily with about 5% orts. Individual cow weights were recorded at the start of the tests, every 28 days and at trial termination (study 1-56 d; study 2- 140d) . Feed intake was adjusted after each weighing such that cows from both treatments gained approximately. 20 kg d^{-1}. In study 1, C cows were fed grass hay and T cows, whey silage with barley grain. In study 2, C cows received a mixed ration of alfalfa hay, barley grain and barley straw and T cows, whey silage Table 4.

Digestibility trials: The C and T diets that were used in the cow diets in Study 2 were fed to four ruminally cannulated beef cows in a digestibility trial using a replicated 2×2 Latin square design. Cows were individually housed in open front 4 m×10 m pens with concrete floors. All feedstuffs were fed once daily at 0800 for a 21-d adaptation period followed by a 6-d collection period. Diets were fed to appetite such that there were no refusals. During the collection periods, fecal grab samples (300 g) were obtained at 0800 from each cow. Samples of the Total Mixed Ration (TMR), feces and individual feedstuffs were also obtained throughout the collection period. Feed samples were weighed and dried at 60° C for

Table 4: Feedstuffs and composition of diets used for Study 1 and 2 (DMB)

Feedstuff^Z	Units	Study 1 Control	Treatment	Control	Study 2 Treatment
AH	%	-	-	27.6	-
GH	%	100	-	-	-
WS	%	-	83.3	-	99.3
BG	%	-	16.0	17.2	-
BS	%	-	-	55.2	-
Lim	%	-	.70	-	.70

^{Z}AH=Alfalfa hay; GH=Grass hay; WS=Whey silage; BG=Barley grain; BS=Barley straw; Lim=Limestone

72 h and ground in a Wiley mill to pass a 1- mm screen and the ground material analyzed for DM[6]. Total N was determined using a LECO CHN-1000 Combustion Analyzer[8,9] and ADF determined using an Ankom Fiber Analyzer (Ankom Technology, Fairport, NY). The ADF was assayed without sodium sulfite, with alpha amylase, and without residual ash. Acid insoluble ash (AIA)[10] was used as an internal marker to estimate apparent nutrient digestibility. Net energy for maintenance and net energy for gain was calculated using DE values following NRC[11] procedures and the DE values were calculated from measured percent ADF[5]. Calcium and phosphorous were analyzed using methods described by Isaac and Johnson[12]. Fecal samples were weighed and dried at 60°C for 72 h and ground to pass through a 1-mm screen and proportionately composited by cow for each of the two collection periods. DM was determined after grinding. Analysis of fecal samples followed the same procedures and methodologies as those used for the feed samples.

Volatile Fatty Acid (VFA) concentrations in Study 2 were measured in acidified samples using gas chromatography (Hewlett Packard 5890, Avondale, PA) with a 1.83 m×2 mm ID glass column packed with GP 10% SP-1200/1% H_3PO_4 on 80/100 mesh Chromosorb W-AW. The study was approved and conducted according to the protocol established by the Institutional Animal Care and use Committee (IACUC) at Utah State University.

Statistical analysis: Data were statistically analyzed in a completely randomized design using the MIXED procedure of SAS (SAS Institute, Cary, NC). Pens were the experimental units. Cow BW and BCS were analyzed using diet treatments and weigh date as fixed effects in a factorial treatment structure. Weigh date was designated a repeated measure. The Kenward-Roger option was used to estimate denominator degrees of freedom. The variance-covariance matrix was chosen in an iterative process wherein best fit was chosen based on the Schwarz's Bayesian Criterion. Cow change in BCS and weight and DM intake during each experiment were analyzed with diet treatment as the only independent variable. In this model, pens were designated as random effects. Least squares means were calculated for main effects and when significant, interactions. Dry matter and NDF digestibility in Study 2 were analyzed as a replicated 2×2 Latin square design by using animals as the experimental units with periods of the Latin square incorporated as repeated measures of feed treatments. Treatment and period were fixed effects and animal was a random effect. Volatile fatty acid and pH data for Study 2 were analyzed using the same model as DM and NDF digestibility, except hour of ruminal sampling was incorporated as an additional repeated measure. Sampling hour and its interaction with feed treatment were considered fixed effects. Significance was interpreted at $p \leq 0.05$ for all tests unless otherwise indicated.

RESULTS AND DISCUSSION

Fermentation properties are shown in Table 3 for studies 1 and 2. The whey silage had adequate levels of essential silage characteristics for adequate fermentation. The T cows consumed their ration well each day and palatability appeared to be adequate.

In study 1, all cows (C and T) gained weight equally and there was no treatment effect (P = .281). This carried over into BCS with similar results for the C and T treatments (P = .91).). In study two, C cows gained 88.0 kg versus 107.4 kg for the T cows ($p<.05$) although the change in body condition score was not different ($p>.05$) between treatments Table 5. Dry matter digestibility was not different between treatments ($p>.05$) with values of 63.1 and 67.8% for the C and T groups respectively. Neutral detergent fiber digestibility differed (C-60.4 and T-49.9%; $p<.05$) Table 6.

Table 5: Study 2 weights and body condition score for control and treated cows

Treatment	Initial weight (kg)	Final weight (kg)	P	SEM	Δ weight (kg)
C	571.5	649.4	<.0001	6.41	88.0
T	585.5	679.5	<.0001	9.32	107.4
P	.57	.24			.02
SEM	22.2	22.2			4.68
	Initial BCS	Final BCS	P	SEM	Δ BCS
C	4.86	4.93	.60	.13	.07
T	4.94	5.07	.39	.13	.09
P	.78	.65			.30
SEM	.28	.28			.02

Table 6: Fermentation and digestibility properties of treatments in Study 2

	Treatment			
	Control	Whey silage	SEM	P
Rumen parameters[a]				
pH	6.47	6.37	.08	.38
Acetate (mol 100 mol^{-1})	62.10	45.30	1.66	<.0001
Propionate (mol 100 mol^{-1})	15.60	17.10	.95	.24
Butyrate (mol 100 mol^{-1})	7.68	11.60	.81	.0004
Total (mmol L^{-1})	88.32	75.45	2.22	.0013
Whole tract digestibility (%)[b]				
DM digestibility	63.10	67.80	1.27	.07
NDF digestibility	60.40	49.90	1.98	.04

[a] VFA = volatile fatty acids, [b] DM = dry matter; NDF = neutral detergent fiber

An economic analysis was conducted for both studies and results showed that the T cow's diets were approximately 30% lower in cost than C diets.

Implications: The whey silage was a combination of three residual feeds commonly found in agricultural areas of the US. When these residual feeds were combined and ensiled, a nutritious and economical feedstuff was produced. Production and economic data demonstrated that feed costs can be decreased when whey silage is fed, compared to more traditional harvested forage.

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