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Evaluation of annual ryegrass straw:corn juice silage with cattle and water buffalo: digestibility in cattle vs. buffalo, and growth performance and subsequent lactational performance of Holstein heifers

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Abstract

Two experiments were undertaken to evaluate ryegrass straw:corn juice silage (35:65 wt./wt.) as a basal feed for Holstein heifers and to determine digestibility of this silage in water buffaloes and Hereford cows. In experiment 1, (143 d) 48 pregnant heifers (16 animals; 3 pens per treatment) were fed (1) mixed cool season grass hay (GH), (2) straw:corn juice silage (S), and (3) S + 125 g fishmeal d^{-1} (SF). All animals were also fed 2.27 kg concentrate per day. Average daily gain (kg) was 1.00, 0.82 and 1.02 for GH, S and SF groups, respectively. ADG in the SF group was higher ($P < 0.05$) than in the S group. Roughage DM intake was 7.77, 6.45 and 6.02 (kg d^{-1}) for the GH, S and SF treatments, respectively. Roughage intakes were lower ($P < 0.05$) for S and SF than for GH and lower ($P < 0.05$) for SF than F.

Feed efficiency was 12.91, 14.31 and 10.96 for H, S and SF, respectively. Feed efficiency was better in SF vs. S ($P < 0.05$). Subsequent milk yields and composition data were obtained for 300 days post-partum after the completion of the feeding trial. Milk, milk fat and SNF yields (kg d^{-1}) were 30.91, 1.13, 1.03; 31.5, 1.19, 1.05; and 32.06, 1.19 and 1.07 for H, S, and SF, respectively. None of the milk production parameters differed ($P > 0.05$) among animals from the different pre-partum treatments. In experiment 2, six water buffaloes and six Hereford cows were fed the same silage as fed to experiment 1 animals. The silage was mixed with 0.39% chromic oxide and fed for 15 days. Fecal grab samples were obtained over several days. Digestibility (percent) of DM, CP, NDF and ADF was calculated by determination of the chromic oxide concentration in feed and feces. Respective apparent digestibility values for buffaloes and cows were: dry matter,

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47 and 40%; crude protein, 47 and 34%; neutral detergent fiber, 47 and 41%; and acid detergent fiber, 43 and 35%. All digestibility parameters were significantly higher ($P < 0.05$) in buffaloes than in cows. In conclusion, straw:corn juice silage was equivalent to grass hay in supporting weight gain and feed efficiency of Holstein heifers, and FM supplementation of the silage significantly improved performance. There was no effect of pre-partum feeding of grass straw:corn juice silage on subsequent lactational performance of Holstein heifers as compared to the control diet containing grass hay.

Keywords: Cattle; Buffalo; Silage-rygrass straw:corn juice

1. Introduction

At present, about 1.0–1.2 million tons of grass straw are generated in Oregon by the grass seed industry (Conklin et al., 1991). After harvest of the seed crop, much of the straw residue is disposed of by open field burning, which helps in controlling diseases, recycling nutrients, maintaining genetic purity, facilitating establishment of the next crop, weed control, and increasing seed yields. However, open field burning has been under increasing public criticism, and may be totally banned in the future. Therefore, alternatives for straw disposal need to be found.

Another agricultural by-product produced in large quantity is corn juice, a waste product of corn canneries. Over 22 million l of waste corn juice are produced by Oregon canneries (A. Wakefield, Agripac Inc., personal communication, 1989). Disposal of corn juice by the traditional means of application to fields or discharge into sewage plants results in water pollution. Therefore, disposal of both grass straw and corn juice is a problem to agriculture. Grass straw and corn juice have opposite but complementary properties, such as high vs. low water content, high vs. low fermentable sugars, high vs. low fiber, etc. When mixed, these two by-products can be ensiled. Ensiling straw may help to improve its palatability and digestibility (Lal and Mudgal, 1967; Narang and Pradhan, 1974). Ensiling these two waste products (straw and corn juice) would reduce environmental pollution, as well as producing a feed for livestock production. For making silage from straw, it is necessary to add a minimum of 30% water, a source of fermentable carbohydrate and nitrogen. Corn juice is a good source of all these nutrients.

An alternate approach for increasing utilization of poor quality roughages (PQR) such as straw is supplementation with sources of rumen by-pass protein. Feeding small quantities of fishmeal (FM) as a supplement to grass silage can improve liveweight gain (WG) in young cattle (Sanderson et al., 1992). Many researchers (Veira et al., 1985, Veira et al., 1988; Steen, 1989; Nicholson et al., 1992) have reported that cattle fed FM supplements tended to gain more and have more efficient feed conversion.

The objectives of this study were to prepare grass straw and corn juice silage, to evaluate the ensilage as a replacement for grass hay in diets for dairy heifers, and to evaluate the effects of supplementation of the silage with a source of by-pass protein (fishmeal). Lactational performance was measured to determine if prepartum feeding of straw-corn juice silage influenced subsequent milk production. In addition, the digestibility of straw:corn juice silage was determined in water buffaloes vs. Hereford cows.

2. Materials and methods

2.1. Experiment 1

2.1.1. Silage preparation

Silage was prepared by mixing chaffed annual ryegrass straw with corn juice in a mixer wagon. The straw was chopped in a forage tub grinder, before mixing it with corn juice. The ratio of straw:corn juice was 35:65 (wt./wt.). After mixing, the material was packed into a large plastic bag (Ag Bag) and allowed to ferment for about two months, which resulted in good quality silage. The color and aroma of the silage were good and pH was 3.88.

Corn juice is a waste by-product of the sweet corn canning industry. After kernels are separated from cobs, the cobs, husk and broken kernels are pressed to squeeze out corn juice. The corn juice used contained 15% DM; the DM contained 14.5% CP, 7.5% NDF and 3.20% ADF. The dry matter of corn juice comes mainly from broken corn kernels.

2.1.2. Animals and feeding management

Forty-eight pregnant Holstein dairy heifers were used in experiment 1 which lasted for 143 days (January–June 1992). Heifers were stratified by stage of gestation and then within each stratum were randomly allotted to three treatments (16 heifers and 3 replicates per treatment). Average gestation length ± SD at the start of experiment was 123 ± 67, 118 ± 68, and 121 ± 69 days for the control (GH), silage (S) and silage + fishmeal (SF) treatments, respectively. Animals were allotted as they became available during normal management of the Dairy Center, so they did not all begin the experimental period at the same time. Equal numbers per treatment were placed on experiment at each allocation time. Body weights of heifers at time of allocation to treatment were in the range 450–600 kg. The three treatments were (1) mixed cool-season grass hay (GH) which was used as a control; (2) annual ryegrass straw:corn juice silage (S); and (3) S + 125 g FM day^{-1} (SF). All animals were also fed dairy concentrate (Table 1) at 2.27 kg d^{-1}. All roughages were offered free choice. Each animal also received 56 g of vitamin/mineral mixture daily (Ca, 14–16%; P, 8%; NaCl, 4–5%; Mg, 6%; K, 3%; S, 2%; Mn, 0.44%; Zn, 0.57%; Cu, 0.1%; Fe, 0.1%; I, 0.006%; Co, 0.003%; Se, 0.005%;

Table 1
Chemical composition (Percent-DM basis) of feeds used in dairy heifer experiment

Feed type	Composition DM	CP	NDF	ADF	Ash
Silage	37.85	6.39	74.21	49.62	6.79
Grass hay	89.92	6.93	71.49	41.42	7.90
Fishmeal [a]	91.71	57.4	–	2.10	4.81
Dairy Concentrate [b]	89.15	15.19	31.02	15.40	7.35

[a] Fishmeal was provided by Advanced Hydrolyzing Systems, Astoria, OR. [b] Dairy concentrate ingredient composition (percent) = wheat mill run, 7.5; corn, 25; oats, 10; wheat, 7.5; canola fines, 4.4; SLS40 [c], 26.25; mixed screenings, 15; salt, 0.5; molasses, 2.5; trace minerals/vitamins, 1.35. [c] SLS40 is a proprietary mix having soy, linseed and sunflower meals with 40% CP, 2.75% fat and 9.5% crude fiber.

vitamin A, 550,000 IU kg^{-1}; vitamin D_3, 154,000 IU kg^{-1}; vitamin E, 440 IU kg^{-1}). Trace mineral blocks (Zn 0.35%; Mn 0.2%; Fe 0.2%; Mg 0.15%; Cu 0.33%; I 0.007%; Co 0.005%) and water were available free choice. Animals were fed in a semi-covered barn with three pens per treatment. After feeding the roughage, the concentrate, vitamin/mineral mixture and fishmeal were offered each morning. All these supplements were consumed in a few minutes. Mangers were cleaned three times a week. Out of 143 days of total experimental period, roughage intake was accurately recorded for 60 days by feeding the weighed quantity of roughage every day, and then weighing the orts three times a week. Animals were transferred to the Dairy Center approximately one week before the expected date of calving. Cows were weighed every 15 days and at the beginning and end of the feeding period for calculating weight gain.

Milk yield and milk composition data were collected from the Dairy Center for all cows used in the three treatments for approximately 300 days post-partum, and were statistically analysed to determine any long term effects of these pre-partum feeding treatments on post-partum milk production and composition.

2.1.3. Chemical analysis

Chemical composition of the roughages and supplements is given in Table 1. Feed samples were collected weekly for chemical analysis. These samples were dried at 55 °C for 48 h for DM determinations, which were then used to calculate roughage and total DM intake. The dried samples were ground to pass through a 1 mm screen and stored for further laboratory analysis. DM, ash and CP were determined by standard procedures (AOAC, 1990). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined as described by Goering and Van Soest (1970) but modified by a micromethod as described by Waldern (1971). Silage pH was determined once a month by mixing distilled water with silages and reading on a pH meter. Milk composition (fat, solids-not-fat) data were collected from the production records of the Dairy Center. Routine analyses of the milk are performed in the Oregon State Department of Agriculture milk-testing program.

2.1.4. Statistical analysis

Feed intake, weight gain, feed efficiency, lactation length, milk, fat and solids not fat (SNF) production data were analysed as a completely randomized design using the GLM procedure of SAS (1987) and means were assayed by the LSD procedure (Steel and Torrie, 1980). The same statistical procedures were used in the buffalo vs. cattle digestibility experiment (Expt. 2).

2.2. Experiment 2

In this experiment, six mature female Asian water buffaloes and six mature Hereford cows were used to evaluate comparative digestibility of the silage used in experiment 1. Chromic oxide was mixed in the silage at 2.5 kg chromic oxide per 636 kg of silage, using a mixer wagon. Silage without chromic oxide was fed to buffaloes and cows in the first week. During the second week, chromic oxide mixed silage was fed ad libitum to both cows and buffaloes. Fecal samples from all the animals were collected for the last

Table 2
Feed intake (DM basis) and performance data of dairy heifers

Parameter	Feed types [d]			
	GH	S	SF	SE
Weight gain [e] (kg d^{-1})	0.998 [ab]	0.824 [a]	1.02 [b]	0.05
Roughage intake [f] (kg d^{-1})	7.77 [a]	6.45 [b]	6.02 [c]	0.09
Total feed intake [f] (kg d^{-1})	9.84 [a]	8.52 [b]	8.15 [c]	0.10
Feed/gain [f]	10.42 [ab]	11.82 [a]	8.41 [b]	0.80

[abc] Values in the same row with different superscripts differ ($P < 0.05$). [d] GH = grass hay; S = ryegrass straw:corn juice silage; SF = S plus 125 g fishmeal per head per day. [e] Weight gain calculated for each animal for the entire period that it received the test diets. [f] Measured for a 60 day period; F/G calculated for this period only. SE = Pooled standard error.

five days, three times a day.Water was available free choice. Fecal samples of each animal were composited, dried at 50 °C for 72 h, and ground to pass through 1 a mm screen. Silage samples were collected every day, dried, ground and stored for further analysis. Feed and fecal samples were analysed for chromic oxide by the method of Suzuki and Early (1991). Other chemical analysis procedures were as described in Expt. 1.

3. Results and discussion

Chemical composition of the feeds used in the dairy heifer experiment (Expt. 1) is shown in Table 1. Feed intake (FI) and weight gain (WG) data are given in Table 2. WG for the silage plus FM group (SF) was significantly higher ($P < 0.05$) than for the unsupplemented silage-fed group (S). However, differences between hay (GH) and S and GH and SF were not significant ($P > 0.05$). Roughage and total feed intake were different ($P < 0.05$) among treatments. FE (F/G ratio) was significantly ($P < 0.05$) lower in SF compared to S, while differences between GH vs. S and GH vs. SF were not significant ($P > 0.05$). Milk production and milk composition data are shown in Table 3. No differences ($P > 0.05$) in lactation length, milk yield, milk fat and SNF yield were

Table 3
Milk production and composition data (kg per animal per day)

Parameter	Feed types [a]			
	GH	S	SF	SE
Lactation length (days)	309	307	331	16
Milk yield	30.91	31.50	32.06	1.43
Milk fat yield	1.13	1.19	1.19	0.05
SNF yield	1.03	1.05	1.07	0.04

[a] GH = grass hay; S = ryegrass straw:corn juice silage; SF = S plus 125 g fishmeal per head per day. SE = pooled standard error.

Table 4
Comparative digestibility of ryegrass straw:corn juice silage in water buffaloes vs. Hereford cows

Variable	Digestibility (percent)		
	Buffaloes	Cows	SE
Dry matter	47 [a]	40 [b]	1.09
Crude protein	47 [a]	34 [b]	1.74
NDF	47 [a]	41 [b]	1.56
ADF	43 [a]	35 [b]	1.55

[ab] Values in the same row with different superscripts differ ($P < 0.05$). SE = pooled standard error.

found among treatments. Numerically, milk and SNF yields were slightly higher in the SF vs. S and GH treatments. Fat yield was lowest in GH and similar in S and SF groups.

Comparative digestibility data of annual ryegrass straw:corn juice silage (same silage as used in Expt. 1) in water buffaloes vs. Hereford cows are given in Table 4. Digestibility of DM, CP, NDF, and ADF was significantly higher ($P < 0.05$) in water buffaloes than in Hereford cows.

In the dairy heifer experiment (Expt. 1), supplementation of S with 125 g FM improved weight gain and feed efficiency, compared to the non-supplemented S treatment. Numerically, FI in FM supplemented animals was lower than in those fed silage alone. Several researchers (Veira et al., 1985, Veira et al., 1988; Steen, 1989; Nicholson et al., 1992) have reported that supplementation of roughage-based cattle diets with FM increased gain and feed conversion efficiency. Gill et al. (1987) found that when steers were offered silage ad libitum and supplemented with 150 g FM kg^{-1} DM, WG was increased without an increase in FI. When grass silage or ammoniated grass hay was supplemented with 0.75 g FM kg^{-1} liveweight, Gibb and Baker (1987) found WG improved by 148 and 88 g for silage and hay diets, respectively. Steen (1988); Steen (1989); Steen (1992) reported that inclusion of FM in a supplement for beef cattle fed silage gave a WG response of about 580 g per kg FM. However, much greater responses in WG (1150 to 2000 g per kg FM) were obtained when FM was given as a supplement to low quality silages (Garstang et al., 1979; Garstang, 1980; England and Gill, 1985). In our experiment, the WG response to FM supplement was 1568 g per kg FM. Seoane et al. (1993) found that protein supplementation of either hay or silage diets with FM (95 g per 100 kg BW) increased hay DM intake but not silage DM intake. Thus, a number of studies support our results indicating a performance response in cattle to FM supplementation of low quality roughages. This is probably a response to high quality by-pass protein (Hussein and Jordan, 1991).

In the present study, there were no effects of pre-partum feeds on post-partum milk production and composition. This agrees with the findings of Wiley et al. (1991), who reported that prepartum nutrition had no effect on post-partum milk production.

In experiment 2, comparative digestibilities of silage DM, CP, NDF, and ADF were significantly ($P < 0.05$) higher in buffaloes than in Hereford cows. Because the animals were fed ad libitum, there could have been an influence of level of intake on the apparent digestibility values. The silage was fed without protein supplementation, which might have limited ruminal fermentation capacity. Contradictory observations regarding superiority of buffaloes over cattle in efficiency of feed utilization are found in the literature. Many researchers (Singh and Mudgal, 1967; Poonappa et al., 1971; Razdan et al., 1971; Katiyar and Bisth, 1989) have reported higher digestibility of fibrous feeds in water buffalo vs. cattle, while others (Naga and El-Shazly, 1969; Chaturvedi et al., 1973) reported no digestibility differences between the two species.

In conclusion, straw:CJ silage was equal to cool-season grass hay in terms of FI, WG and FE. When supplemented with FM, it gave better dairy heifer performance than did hay alone. There were no long term effects of these feeds on milk production and composition. Apparent digestibility (DM, CP, NDF and ADF) of this silage was significantly higher in water buffaloes than in Hereford cows when measured using a chromic oxide indicator method.

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