PROJECT NO. RU-5

ANNUAL REPORT
COMPREHENSIVE RESEARCH ON RICE
January 1, 2010 - December 31, 2010

PROJECT TITLE: **Dairy Feeding of Rice Hay**

STATUS OF PROPOSAL: ____/New x___/Continuing

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Rancho Teresita, Tulare
Triangle M Dairy, Chowchilla
David te Velde, Hanford

LEVEL OF 2OO9 FUNDING: $37,970
Work was not conducted on these two objectives until 2010. Our 2009 report covered the other three ojectives.

OBJECTIVES AND EXPERIMENTS CONDUCTED:

Objective 1 – Dairy demonstrations of rice hay forage in replacement heifer rations. Expose more dairy owners and consulting nutritionist to the positive experience of mixing and feeding rice straw.
The objective of this survey was to determine if straw that was sickle chopped by a harvester or straw baled by a slicer baler rice straws are acceptable to dairymen as part of heifer rations, and to evaluate which performs better in a number of different predetermined categories.

Methods
A total of 5 dairies in Madera, Tulare and Kings Counties took part in evaluating the two rice straws. Each received approximately half a load of Sickle Chop and half a load of Slicer Baled Rice Straw, and where asked to feed these to any type of animal at any level as they desired. Each type of rice straw was color-coded to prevent bias resulting from previous experience, word-of-mouth or other influences. An initial pre-feeding survey

was conducted to determine what the previous experiences with rice straw (if any) were, while a post-feeding survey was conducted to evaluate overall and specific feeding experiences of the dairymen with the two rice straws.

Results

Pre feeding survey of rice straw feeding experience

Site 1 ï Philip Verwey Farms No 2 .
Fed 4-5 years ago
Poor experience

Site 2 ï Cross-Creek
Was feeding rice straw at start of trial
General experience was positive

Site 3 ï Rancho Teresita
Fed 1-1.5 years ago (long rice straw)
Tough, poor mixing, expensive repairs
Poor experience

Site 4 ï David te Velde Dairy
No previous experience

Site 5 ï Triangle M Dairy
Fed 2 years ago
Experience was too high moisture, discolored, more sorting vs. wheat straw, no mixing problems

Chemical Analysis

During initial visits to all 5 participating dairies, samples were collected from both Sickle Chop and Slicer Baled Rice straws and sent for chemical analysis. Table 1 shows that the Slicer Baled Rice Straw was higher in ash, crude protein, acid detergent fiber (ADF) and silica (Si) as silica dioxide (SiO_2). However this is not a function of the processing, simply that they originated from different fields and rice straw cultivars. The ADFom or organic matter analysis shows that the straws should have similar digestibility. The higher silica or ash content of the Slicer Baler straw will not impact digestibility, but is inert matter that simply takes up space in the rumen with no nutritional contribution to the animals (see 2009 report for research findings on silica supporting this statement).

Table 1
Chemical composition of Sickle Chop and Harvester Slicer Baled rice straw

	Straw Type			
	Sickle Chop	Slicer Bailed	SEM	P
Dry matter, %	96.2	95.9	0.43	0.37
Ash, % DM	14.3	17.8	0.16	<0.01
CP, % DM	4.4	5.0	0.46	0.09
ADICP, % CP	11.9	10.1	3.28	0.46
NDFom, % DM	73.0	74.0	0.96	0.15
ADF, % DM	48.0	51.0	1.18	<0.01
ADFom, % DM	39.6	39.4	1.52	0.85
Lignin, % DM	4.2	4.5	0.70	0.61
SiO_2, g/kg DM	9.6	13.0	1.78	0.02

Survey

Rice Straw intakes varied widely, from 2 to 7 pounds/head/day as fed. All dairies fed the straw to heifers, while one also included it in their dry cow ration. The ingredients replaced by the rice straw included wheat straw, wheat hay, a corn silage/alfalfa hay mix and cotton gin trash. Four of the dairies used vertical mixers and one used a horizontal mixer.

The data obtained from the post-feeding survey, on a scale from 0 (poor) to 10 (excellent), revealed differences between the two straws in terms of "Mixability" and the "Overall Experience" as a combined analysis obtained by placing equal value to the responses on particle length, uniformity, color, texture, mixability, affect on time of mixing, sorting and whether leftover rice straw was finally eaten. Although numerical differences occurred between straws, no statistically significant differences was detected in the other responses (i.e., likeliness to use the specific product again, discount ($ per ton) that dairymen thought was acceptable if they had to purchase all the required rice straw for the year at once, the maximum acceptable particle length, and the % of particles allowed to be over this maximum particle length).

Table 2

Rice Straw Survey - Summary of Results

	Straw Type			
	Sickle Chop	Slicer Bailed	SEM	*P*
Particle length uniformity[a]	4.8	6.6	1.80	0.15
Color[a]	7.8	8.0	1.53	0.84
Texture[a]	7.6	7.2	1.50	0.68
Mixability[a]	4.2	6.0	1.45	0.085
Mixing time affected[a]	6.0	6.6	4.32	0.83
Sorting (10=no sorting)[a]	5.8	7.0	2.02	0.38
Leftover rice straw eaten[a]	6.4	8.4	2.56	0.25
Overall experience[a,b]	6.1	7.1	0.74	0.06
Overall experience[a,c]	5.4	7.0	1.91	0.22
How likely to use again[a]	5.4	7.8	3.00	0.24
Discount/ton to buy all at once ($)	11.8	10.5	2.80	0.53
Max acceptable particle length (inches)	4.8	4.8	1.10	1.00
% allowed over max particle length	25.0	29.0	13.78	0.66

a = 0 to 10 (0=poor, 10=excellent)

b = combined analysis of questions: Particle length uniformity, color, texture, mixability, mixing time affected, sorting (10 = no sorting), and leftover straw finally eaten

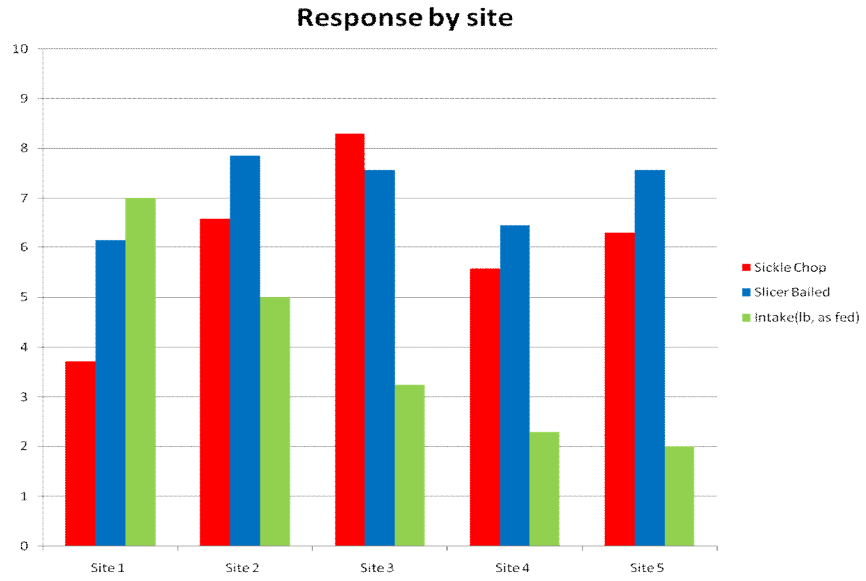

Figure 1. - Straw daily intake levels and numeric score for both kinds of straw (rating 1=poor 10=excellent)

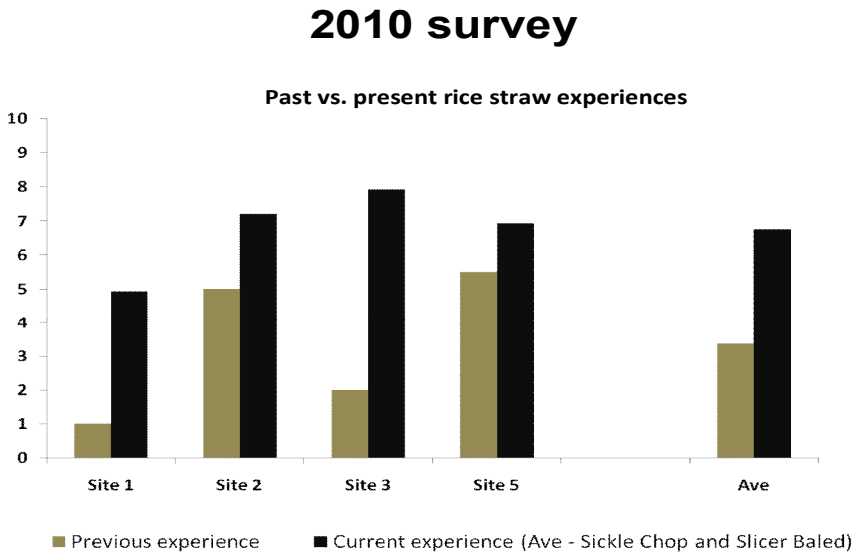

Figure 2. ï pre and post feeding experience with feeding rice straw (rating 1=poor 10=excellent)

Objective 2 – Rice straw verses wheat straw in replacement heifer rations.
Wheat straw is the traditional bulk filler used in dairy heifer growing rations and is the major competition to rice straw. A dairy heifer growing operation fed rice straw and wheat straw at the same intake levels and following to compare feeding performance:

In vitro gas analysis of straws and the total TMR diet
Body weight gain
Body score
Feed intake
Fecal - lignin(sa) ï subset of the pen every 2 weeks

Methods

Dairy, animals and management

The experiment was conducted on Rancho Teresita dairy near Tulare in the Central Valley of California, USA with approximately 3400 lactating Holstein cows. Four pens of approximately 180 heifers each where selected for the trial. Animals were moved from pen to pen once a month, so that pens consisted of animals of approximately the same age. The age of the heifers ranged from approximately 14 to 18 months. Feeding was done using a vertical mixer, and a prespecified quantity of feed was placed at each penôs feed bunk twice daily. All pens had headlocks, and manure was removed by flushing the pens once a day with water. The pens consisted of dry manure bedding that was restored approximately once a month.

Experimental Design

The experiment consisted of 2 periods of 28 days each, and the treatments consisted of a wheat straw TMR and a rice straw TMR, where the only difference between the two treatments was the substitution of rice straw for wheat straw on a dry matter basis. The two youngest pens received the rice straw ration and the older two received the wheat straw ration in the first period, and in the second period the treatments and pens were switched so that each heifer received each treatment for a 28 day period. This meant that the animals were followed during their movement from one pen to the next. Heifers moved from pens with a higher number to one with the next lower number, for example from pen 46 to 45.

Table 3. Heifer pens used for the respective treatments during the two 28 day periods of the experiment

	Period 1	**Period 2**
Wheat straw TMR	pens 43, 42	pens 45, 44
Rice straw TMR	pens 46, 45	pens 42, 41

Sample and data collection

Dry matter intake

Feed intake was recorded on Feedwatch, a program designed to record the weight of all ingredients placed into the TMR during mixing, and record the exact amount of TMR offered to each pen. DMI was calculated by using the total TMR drops to a pen for each day of the 4 week period and dividing this by the number of heifers in the pen determined by at least 2 physical counts per period, divided by the days.

DMI = total feed offered to pen/28 days/number of heifers in pen.

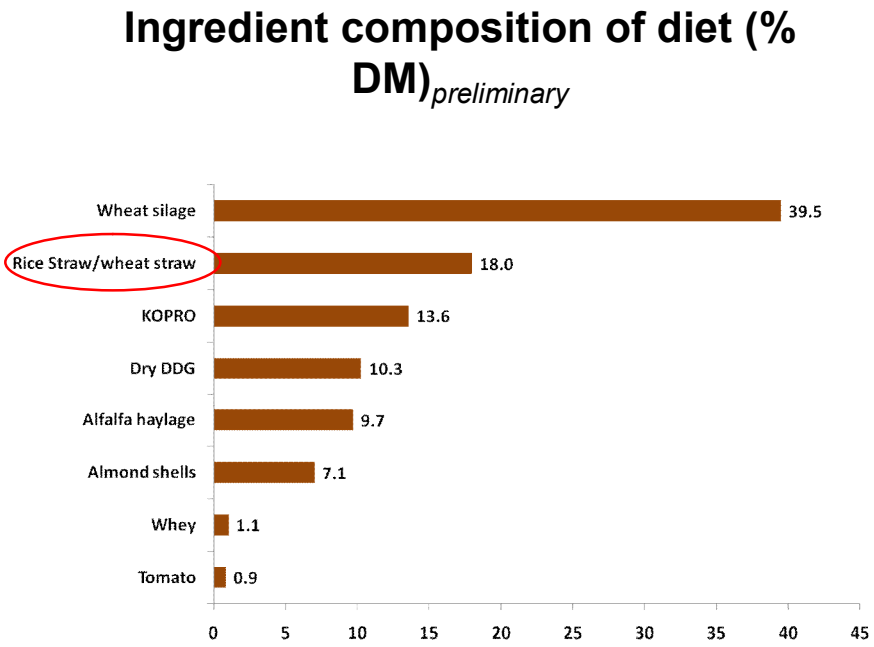

Figure 3. - Diet ingredient list and percents fed in the TMR.

Tailhead height

Tailhead height was measured using a Nasco METRE, making sure that the METRE was perpendicular to the ground by checking the water level indicator. The tailhead height was used as an indicator of growth in height, as the classical hip height measurement was judged to be too impractical and could risk the safety of the operator due to the nature of the lock-up. Measurements were done on the last day of each period, and the difference was calculated by subtracting the tailhead height value of the animal at the start of the period from the measured value on the day. Only animals that were measured at the start of the experiment and at the end of each period were considered for statistical analysis.

Hip width

Hip width was measured using a Hipometer, measuring the width at the greater trochanters of the left and right femurs as shown in Fig. 1 (Dingwell et al., 2006). Although the Hipometer is generally used to estimate the mass of dairy heifers, in this study it was used to determine hip width as an indicator of skeletal growth. Some heifers used in this study were older than 18 months, which is an age group in which the Hipometer does not accurately predict heifer weight (Dingwell et al., 2006). Therefore, using the Hipometer as a predictor of mass would most likely have lead to biased results in some animals.

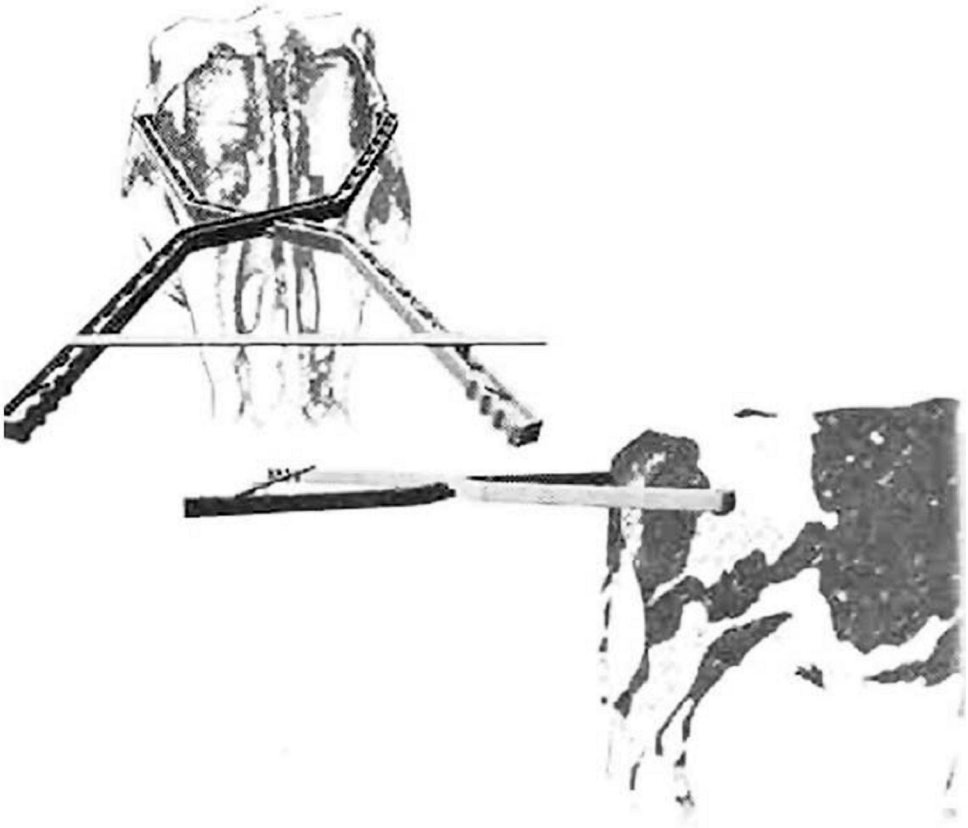

Figure 4. Diagrammatic representation of the placement of the Hipometer on the greater trochanters of the left and right femurs to determine hip width of dairy heifers (Adapted from Dingwell et al., 2006).

Corrected hip width

The corrected hip width was a calculated value of hip width to attempt to remove any potential effect of change in body condition score on actual skeletal width of the hip. 25 heifers within all 4 treatment pens where selected according to tailhead height and body condition scores, selecting several heifers within extreme and intermediate values for both parameters, so as to have a representative spread of the dataset. The skinfold thickness at the pin bone of these heifers was measured using a calliper, and it was assumed that this value was equal to the skinfold thickness at the position where hip

width was measured. The skinfold thickness was not measured directly at the point where the hipometer was placed as this was impractical and difficult due to the toughness of the skin. The values for skinfold thickness, age, body condition score, tailhead height and hip width where entered into SAS, using the STEPWISE procedure (backward elimination) with a minimum significance level of 0.1, to create an equation to predict the correction according to the variables. The equation produced by SAS was:

$BCS_{correction}$ (mm) = (3.2 x BCS) + (0.8 x age in months) ï 6.09

This equation was then used on each heifer to calculate the animalôs corrected hip width, by subtracting the correction value in mm from the recorded hip width.

Heifer Frame Score

Heifer Frame Score is a calculation of a hypothetical two dimensional area encompassing the tailhead height and the corrected hip width. The objective of this was to have a more robust, two dimensional prediction of skeletal growth by including both width and height of skeletal growth, while removing any variability associated with changes in body condition score (subcutaneous fat thickness). There was no need to correct tailhead height as visual assessment and palpation of the area indicated that there was a negligible amount of subcutaneous fat on the tailhead, and therefore any attempt at creating a correction would not be practical or necessary. The following formula was used to calculate the Heifer Frame Score:

Heifer Frame Score (mm^2) = tailhead height (mm) x corrected hip width (mm)

BCS

BCS was determined by using 8 anatomical locations of the heifer and assigning a value between 1.00 and 5.00, with intermediate values of 0.125**.** The same person conducted the scoring at the beginning of the experiment and at the end of each period. Body condition scoring was done on the last day of each period, and the difference was calculated by subtracting the BCS value of the same heifer at the start of the period.

TMR and feed sampling

TMR and feed ingredients where sampled twice during the last week of each period. The feed samples were placed into premarked ziplock bags and immediately frozen at -20ºC.

Fecal sampling

Fecal collection occurred on the last day of each period, from rectal grab samples placing each animalôs sample into a separate, clean plastic container marked with the animal ID and date. The samples were immediately frozen at -20ºC.

Fecal samples were defrosted and oven-dried at 55°C for 48 hours, turning and breaking the samples into quarters after 24 hours, after which they where ground with a 4 Wiley Mill using a 1 mm screen, the powdered sample being placed into premarked plastic ziplock bags. 20 samples were collected from each pen each period, resulting in a total of 160 samples. The samples were separated into groups of 10 samples each according to

pen and period. The selection of animals was based on listing the heifers of each pen according to age, and selecting every second heifer on the list to be incorporated into the group. This ensured the two groups of 10 heifers per pen were as similar as possible in average and spread of age. Composite samples were created by weighing out 10 g of each of the 10 samples so as to create a replicate for each pen within period.

Calculations

According to the NRC (2001) and NRC (1986, the formula for calculating net energy for maintenance requirements is as follows:

NE_M (megacalories per day) = 0.086 x $SBW^{0.75}$ x COMP) + a2

Where

SBW = 0.96 of full body weight (FBW)
COMP = compensatory effect for previous plane of nutrition
a2 = maintenance adjustment for previous temperature effect (MCal/d/kg $SBW^{0.75}$)

Assuming no compensatory effect of previous plane of nutrition and no maintenance adjustment for previous temperature effect (i.e., assuming an average temp of 20 degrees celcius), this simplifies to the following:

(NRC 2001 p 240)

NE_M (megacalories per day) = 0.086 x $SBW^{0.75}$

= 9.093 MCal/d

Net energy for growth requirements are calculated as follows:

NE_G (megacalories per day) = (0.035 x $BW^{0.75}$) x ($LWG^{1.119}$) + LWG

where NE_G = net energy for gain and
LWG = live weight gain.

The average BW of heifers in the wheat straw treatment was taken to be 500 kg and the LWG 0.8 kg per day, based on observational data using the Hipometer to predict mean live weights and live weight gains of heifers of different ages in the medium age groups of the experimental dataset (approximately 15-16 months of age)., over a 4 week period.

Substituting the values of 500kg mean body weight and ADG of 0.8 kg into the formula, the net energy for growth value for the heifers in the wheat straw treatment group was:

NE_G (megacalories per day) = (0.035 x $500^{0.75}$) x ($0.8^{1.119}$) + LWG

= 3.683

The NE_G value for heifers in the rice straw TMR treatment group was taken to be directly proportional to that of the wheat straw TMR treatment group by using the Heifer Frame Score as the measure of growth, using the following formula:

$$NE_{G(\text{rice straw})} = (NE_{G(\text{wheat straw})}) \times (HFS_{(\text{rice straw})} / HFS_{(\text{wheat straw})})$$

Results

Statistical analyses

For tailhead height, hip width, heifer frame score and body condition score the general linear model (GLM) procedure of SAS was used, using period, pen and treatment as CLASS variables. Dry matter intake was analysed with the GLM procedure of SAS, but daily values were combined into weekly values to remove some day to day variation typical of intake. For energetic output in growth, total energy output, and feed intake efficiency, the GLM procedure was used, using period, pen and treatment as CLASS variables.

Significance of differences between treatments was determined by using the PDIFF function in SAS, with $0.05 < P < 0.1$ accepted as a tendency and $P < 0.05$ as significant.

Only those heifers that were collected during all 3 collection periods were used for statistical analysis.

Table 4. - Tailhead height, hip width, heifer frame score and body condition score for heifers fed wheat straw and rice straw TMR rations, expressed on an average and change per 30 day period basis

		Treatment			
		Wheat straw	Rice straw diet	SEM	*P*
Average	Tailhead height[a]	143.12	142.70	1.46	0.277
	Hip width[b]	48.75	48.62	0.54	0.367
	Heifer Frame Score[c]	6711	6681	116.8	0.343
	Body Condition Score	3.31	3.31	0.10	0.786
Change per 30 days	Tailhead height[a]	1.28	0.44	0.94	0.001
	Hip width[b]	1.63	0.68	1.44	0.014
	Heifer Frame Score[c]	8.46	3.82	6.85	0.011
	Body Condition score	0.01	-0.14	0.09	<0.0001

[a] Tailhead height in mm as measured with a Nasco METRE

[b] Hip width in mm as measured with a Hipometer

[c] Heifer frame score in mm^2 calculated using the formula: (tailhead height) x (corrected hip width) (see

text for details)

Table 5

Nutrient profile of the total mixed ration based on wheat straw (WS) and rice straw (RS) fed to heifers

	WS	RS	SEM	*P*
g/kg DM				
Dry Matter	512	504	0.92	0.11
Ash	165	171	4.5	0.51
Crude protein	133	136	0.44	0.13
ADIN	2.2	2.1	0.18	0.87
aNDFom	429	431	1.5	0.55
aNDF	482	489	7.5	0.64
ADF	339	336	3.1	0.16
Crude Fat	32	32	0.28	0.59
Starch	64	69	0.71	0.13
Lignin (sa)	60	59	0.99	0.50
Ca	12	12	1.3	0.75
K	22	22	0.42	0.56
P	5.1	5.2	0.21	0.80
Cl	0.9	0.6	0.42	0.14
mg/kg DM				
S	2866	2855	53.9	0.91
Na	3259	2320	14.8	0.01
Fe	1308	1032	41.9	0.13
Zn	88	98	9.3	0.61
Mn	132	219	1.3	0.01
Cu	43	44	4.1	0.88
B	21	17	0.98	0.18
Se	0.2950	0.3000	0.0035	0.50

Table 6

Whole tract digestibility (g/kg DM) of the total mixed ration fed to heifers consuming rice straw (RS) and wheat straw (WS) based diets[a]

	WS	RS	SEM	P
Dry matter	545	576	5.3	<0.01
ADF[b]	369	404	7.1	0.01
aNDF[c]	438	462	9.1	0.08
aNDFom[d]	508	525	7.7	0.19
Crude protein	524	578	5.6	<0.01
Ash	277	352	18	0.03
Crude fat	784	822	3.9	<0.0001
P	286	348	13	<0.01
K	873	890	3.6	0.02

S	543	575	4.1	<0.01
B	660	652	5.0	0.32
ADIN	-48	-162	20	0.30
Ca	-3	184	13	<0.0001
Mg	30	116	14	<0.01
Zn	11	146	15	<0.01
Mn	110	175	10	<0.01
Fe	89	-26	23	<0.01
Cu	64	62	11	0.92
Na	790	763	28	0.48
Se	90	221	28	0.02
Cl	790	739	7.4	<0.01

a Based on two TMR samples collected per treatment per period (8 samples total) and composite fecal samples pooled by period and split within pen (i.e., 2 composite samples of 10 heifers each per period per pen).
b Acid detergent fiber.
c Neutral detergent fiber assayed with heat stable amylase.
d aNDF expressed exclusive of residual ash.

Ration evaluation and digestibility

The rice straw TMR had significantly lower sodium and higher manganese concentrations as compared to the wheat straw TMR, but did not differ in any other chemical components (Table 5). Dry matter, ADF, crude protein, ash, crude fat, P, K, S, Ca, Mg, Zn, Mn and Se digestibilities were significantly elevated in heifers consuming the rice straw based diet, and there was a trend for a higher aNDF digestibility for the rice straw. There was a lower chloride and iron digestibility for the heifer on the rice straw *vs.* wheat straw based diet.

References

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CONCISE GENERAL SUMMARY OF CURRENT YEAR′S RESULTS

Objective 1 – Dairy demonstrations of rice hay forage in replacement heifer rations. Expose more dairy owners and consulting nutritionist to the positive experience of mixing and feeding rice straw.

Overall, dairymen consistently had better feeding experiences with Sickle Chop and Slicer Baled Rice Straws compared to previous experiences (6.8 versus 3.4, respectively). The two products evaluated had a number of differences in chemical composition as well as feeding experience. Sickle Chop had higher silica and crude protein levels, while the dairymen rated Sickle Chop lower in terms of mixability and the Overall Experience (as a combined analysis of seven questions). Overall, Slicer Baled was preferred over Sickle Chop.

Terminology that communicates the feeding quality to the dairymen is recommended. Particle length may need to be used in future to encourage purchase of rice straw by dairymen. An example is ñSlicer Baled 4-6 inch Rice Strawò

Objective 2 – Rice straw verses wheat straw in replacement heifer rations.

Dry matter intake was significantly reduced in the heifers consuming the rice straw based diet as compared to wheat straw. This is likely due to the effect of rumen fill that results from the rice straw in the diet. As a consequence of reduced feed intake, these heifers had reduced rate of skeletal growth, as measured by hip width, tailhead height and heifer frame score.