PROJECT NO. RU-5

ANNUAL REPORT
COMPREHENSIVE RESEARCH ON RICE
January 1, 2013 - December 31, 2013

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

STATUS OF PROPOSAL: ____/New x /Continuing

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OBJECTIVES AND EXPERIMENTS CONDUCTED:

Experiment 1
Hypothesis: *The drying of rice straw leads to collapse of cell wall networks and this reduces the access of the cell wall polymers to rumen microrganisms, so the polymers are not efficiently digested.*

Experiment 2
Hypothesis: *Penetration of rice straw by rumen microbes/enzymes is limited by a waxy cuticular layer.*

Experiment 3
Hypothesis: *the impact of the xylan barrier can be reduced by exogenous treatment of rice straw with xylan-digesting enzymes.*

Objective 1 –Improve Digestibility of Rice Straw
The major goal of the research has been to identify approaches for management of harvested rice straw that improve digestibility of the straw when it is eaten by dairy cattle. The polysaccharide types in rice vegetative tissue cell walls are (1) xylan (long linear chains of the 5-carbon sugar Xylose [Xyl], which are linked to each other with occasional side group additions of the 5-carbon sugar Arabinose [Ara]) and (2) cellulose (very long linear chains of the 6-carbon sugar glucose [Glc, the polymers are "glucans"] that are associated with one another via hydrogen bonds to produce multiple polymer "cables" called cellulose microfibrils. CMFs). There are two aspects of complexity that could contribute to the difficulty that rumen bacteria have when trying to digest rice straw. One of these is that rice straw is very hygroscopic (i.e., difficult to wet). In the rumen, bacteria attach to straw and secrete digestive enzymes which are intended to digest

the straw. However, the enzymes can only approach the straw and digest its inter-sugar bonds by diffusing into the cell wall structure. The "approach" and digestion are facilitated by intestinal contractions but a water medium through which the enzymes can diffuse is required. That rice straw is not easily wetted may be a factor that limits the straw's digestion. The second factor that could contribute to the difficulty in digesting rice straw is the structural interactions of xylan and cellulose in the rice cell wall. The xylan polymers are hydrogen-bonded to the surfaces of the CMFs, creating a structure roughly like the plastic insulation (i.e., xylan) around a multi-strand electricity-conducting wire (i.e., the CMF). Thus, the xylan shields the glucans of the CMF from any cellulose-digesting enzymes in the rumen. While this structure may limit rice straw digestibility, straws of other cereal crops have similar xylan-CMF structures and are more readily digested than rice straw. Thus our focus has been to identify ways to increase rice straw wettability.

The growing of rice includes a period of time during which a substantial portion of the plant is submerged in water. This is an ideal situation for various microbes to attack vegetative parts of the plant. Therefore it is not surprising that cultivated rice has developed ways to 'waterproof' itself and limit pathogen ingress. We have paid particular attention to the rice plant's surface cuticle. Most above-ground plant structures have a waxy surface coating to limit water loss and many potentially pathogenic microbes which produce and secrete cutinase enzymes that digest the wax to facilitate infection. In conversations with representatives of Novozymes, we learned of an enzyme product (designated as NS39042; hereafter NS) which contains cutinase, However, NS contains additional, unidentified, proteins meaning that the action of NS on rice straw can't be specifically attributed to cutinase. Nevertheless, we have used the NS enzyme prep in some tests to determine the extent to which enzyme treatments will affect wettability of straw and facilitate digestion of straw polysaccharides by xylan-digesting and other enzymes.

In many of our tests we have used commercially available enzyme preparations that contain mixtures of plant cell wall-digesting enzymes as a general indicator of the extent to which a test treatment has affected digestibility of a rice straw sample. The logic is that these enzyme mixtures will, to an undefined extent, mimic what rice straw will experience in the cow's rumen.

When incubated with the NS preparation, rice straw became visibly wetter. When untreated straw is mixed with water, or water + enzyme,s and stirred for extended periods of time, the straw tends to float on the water to form a mat, or splashes onto the wall of the flask and sticks to it. In other words, the straw takes on little water. However, we saw that straw stirred in an NS-containing solution would eventually become slightly translucent and settle below the surface, mixing well into the stirred liquid.

We believe that the NS treatment increased the wettability of the rice straw and completed a follow-up test of the digestibility of NS-treated straw. To do this, the NS-treated straw was incubated with (1) water, (2) with the NS preparation, or (3) with a combination of a commercial cellulase plus a mixture of additional wall-digesting enzymes (i.e., "Macerozyme").

All samples are being analyzed for changes in digestibility by using an *in vitro* biological assessment of the potential ruminal fermentability of its NDF in order to determine digestibility. This work is to be completed in January 2014.

Experiment 4

Hypothesis: *Dried rice straw is hydrophobic and rehydration in the rumen takes time, thus causing decreased digestibility.*

Rice straw samples of different 'ages' (i.e., years post harvest) were obtained from Jerry Maltby's on December 12, 2012. They examined tested for rehydration or water absorbance during different time periods. The results of that work are seen below.

Dry Matter (48 hours in pans at Cole A drying room)

ID #	Variety	Crop Year	As sampled gross Weight	Tare	As sampled net weight	Dry Weight	DM (%)
1	S102	2012	142.3	9.2	133.1	135.6	95.0
2	S102	2011	118.9	9.2	109.7	108.8	90.8
3	H4	2012	116.5	9.2	107.3	111	94.9
4	H4	2011	133.0	9.2	123.8	127.3	95.4
5	H4	2010	126.1	9.2	116.9	116	91.4
6	205	2008	123.5	9.2	114.3	102.4	81.5
7	L206	2012	134.7	9.2	125.5	128.3	94.9

Run 1: Water Holding Capacity at 1.0 h **12/14/2012**

ID #	Material	Rep	Dry Weight	Wet Weight	Tare	Water Holding (g/g)	Mean
3	2012	1	6.0	32.7	2.75	5.0	
3	2012	2	6.9	30.6	2.75	4.0	
3	2012	3	5.5	36.0	2.75	6.0	5.0
4	2011	1	7.7	64.1	2.75	8.0	
4	2011	2	6.5	34.4	2.75	4.9	
4	2011	3	6.6	42.5	2.75	6.0	6.3
5	2010	1	6.5	35.5	2.75	5.0	
5	2010	2	5.6	29.4	2.75	4.8	
5	2010	3	7.2	39.4	2.75	5.1	5.0

Run 3: Water Holding Capacity at 0.5 h **1/8/2013**

ID #	Material	Rep	Dry Weight	Wet Weight	Tare	Water Holding (g/g)	Mean	NDF (estimate)	Water Holding g/g NDF
3	2012	1	7.0	40.0	2.75	5.3			
3	2012	2	7.0	37.3	2.75	4.9			
3	2012	3	7.1	35.4	2.75	4.6	5.0	0.70	7.07
8	Wht Str	1	7.1	33.0	2.75	4.3			
8	Wht Str	2	7.1	32.9	2.75	4.2			
8	Wht Str	3	7.0	34.2	2.75	4.5	4.3	0.63	6.88
9	Alfalfa	1	7.0	19.5	2.75	2.4			
9	Alfalfa	2	7.0	21.4	2.75	2.7			
9	Alfalfa	3	7.0	22.3	2.75	2.8	2.6	0.37	7.07

Run 2: Water Holding Capacity at 0.5 h **12/26/2012**

ID #	Material	Rep	Dry Weight	Wet Weight	Tare	Water Holding (g/g)	Mean
3	2012	1	7.0	37.6	2.75	5.0	
3	2012	2	7.0	38.5	2.75	5.1	
3	2012	3	7.0	37.1	2.75	4.9	5.0
4	2011	1	7.0	62.6	2.75	8.6	
4	2011	2	7.1	64.3	2.75	8.7	
4	2011	3	6.8	41.4	2.75	5.7	7.6
5	2010	1	7.1	34.5	2.75	4.5	
5	2010	2	7.2	37.4	2.75	4.8	
5	2010	3	6.9	35.6	2.75	4.8	4.7

PUBLICATIONS OR REPORTS

Rainer, R., Cun, G., Nader, G., Robinson, P.H.. 2014. Effects of rice straw *versus* wheat straw as ingredients in a total mixed ration on intake, digestibility and growth of Holstein heifers. Animal Production Science (*in press*)
http://www.publish.csiro.au/view/journals/dsp_journals_pip_abstract_Scholar1.cfm?nid=72&pip=AN13298

CONCISE GENERAL SUMMARY OF CURRENT YEAR'S RESULTS

Objective 1 –Improve Digestibility of Rice Straw

Results are still pending on three of the research focuses. The water absorbing or rehydration does not appear to be related to the 'age' of the rice straw. Thus field reports of increased intakes of older straws by cattle does not appear to be due to faster rumen hydration of rice straw.