PROJECT NO. RU-5

ANNUAL REPORT
COMPREHENSIVE RESEARCH ON RICE
January 1, 2005 - December 31, 2005

PROJECT TITLE: Defining the Forage Variability in Rice Hay

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COOPERATORS:
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Dr. Uppoor Krishnamoorthy - University of Agricultural Sciences, Bangalore, India
Dr. Kevin Holtman – USDA Ag Research Service, Albany, Ca.

LEVEL OF 2OO5 FUNDING: $29,950

OBJECTIVES:

1. Maceration improvement of rice hay forage quality.
   A. Treat hay at one location.
   B. Collect samples from treated and untreated rice hay.
   C. Wet chemistry and biological analysis were conducted to determine forage quality.
   D. Evaluate the impact of the treatment on forage quality by feeding 40 head of cattle.

2. Coordinate with other researchers in other countries working on rice hay forage utilization.
   A. Design a plan of work and supervise a student to research and summarize all work on forage rice hay studies in the United States
   B. Publish the review of rice hay forage research.

EXPERIMENTS CONDUCTED:

***Objective 1*- Evaluation of in field maceration of rice hay.**

2004 Methods

Rice hay has been used as a dry matter supplement for cattle. The low digestibility has been a limiting factor to its use. Previous studies by Zinn et al. indicate that maceration could greatly increase the digestibility of rice hay. Agland Industries of Manatoba, Canada provided a field macerator and hay was treated at the time of harvest when it had 60% moisture content. A split check design was used with half of each rice check split into macerated and unmacerated sections. It was allowed to dry and baled and stacked separately by treatment. Samples were taken in the field of each treatment and submitted to the laboratory for wet chemistry and biological analysis. To make sure that the maceration treatment is truly tested for it impact on rice hay utilization, a cattle feeding research study was designed and started on October 1, 2004. Forty heifers were weighed on Day 0 and assigned to blocks by weight and then randomly assigned into four groups with two receiving a diet of macerated hay and two groups receiving unmacerated hay. At the start of the trial, rice hay was fed as 40% of the ration by weight and the balance being 54 TDN alfalfa. Both alfalfa and rice hay were fed in the long stem form straight from the 3 twine bale twice a day in the morning and eveing. The flakes were broken up by hand and mixed in the concrete bunk. Each group were fed to the same refusal (or waste) rate of no more than 3% waste of the hay out of the bunk. Pounds of waste was estimated or weighed. The animal's consumption was recorded daily and animal weight and condition were collected on Days 13, 28, 42, 56, 70, and 84. At each weight, fecal samples were collected from a subset of 4 animals per treatment. The fecal samples were analyzed for the digestiblity differences.

2004 Results

Table 1. Composition of alfalfa hay and rice hays fed to the heifers

	Alfalfa Hay	Rice Hay		SEM	*P*	
		Control	Macerated		AH vs. RS	C vs. M
Dry matter, %	88.8	91.0	90.8	0.72	<0.01	0.72
Organic matter, % DM	90.92	84.0	83.9	0.29	<0.01	0.83
Fat, % DM	2.4	1.8	1.8	0.07	<0.01	0.58
ND fiber, % DM	35.4	70.6	71.9	0.58	<0.01	0.03
digestible NDF, % NDF	39.0	40.3	42.7	1.23	0.04	0.05
AD fiber, % DM	28.5	50.4	52.0	0.75	<0.01	0.04
Lignin, % DM	6.2	5.1	5.2	0.12	<0.01	0.87
Crude protein, % DM	24.2	4.6	5.2	0.23	<0.01	0.03
soluble CP, % CP	32.8	17.0	20.7	1.30	<0.01	<0.01
AD insoluble CP, % CP	4.3	25.6	23.3	1.52	<0.01	0.11
ND insoluble CP, % CP	10.2	39.8	40.6	1.53	<0.01	0.57
Calcium, % DM	1.27	0.43	0.42	0.019	<0.01	0.58
Phosphorus, % DM	0.33	0.09	0.09	0.005	<0.01	0.41
Potassium, % DM	2.18	2.18	2.25	0.032	0.22	0.05
Magnesium, % DM	0.43	0.17	0.18	0.006	<0.01	0.18
Sodium, % DM	0.29	0.02	0.02	0.005	<0.01	0.85
Iron, ppm DM	217	193	190	13.8	0.05	0.79
Manganese, ppm DM	35	1605	1700	37.4	<0.01	0.02
Zinc, ppm DM	33	38	39	2.1	<0.01	0.52
Copper, ppm DM	11	18	18	2.0	<0.01	0.66
Selenium, ppm DM	0.09	0.06	0.06	0.004	<0.01	0.33
ME, MJ/kg DM	10.47	5.59	5.75	0.203	<0.01	0.38
TDN, % DM	66.3	40.1	41.0	1.08	<0.01	0.37

Table 2. Composition of feces, and whole tract digestibility of NDF, in the heifers as affected by maceration of the rice hay.

	Diet			
	Control	Macerated	SEM	*P*
Fecal composition				
Organic matter, % fecal DM	77.5	76.9	0.65	0.22
ND fiber, % fecal DM	58.6	58.7	1.24	0.86
digestible NDF, % fecal NDF	8.9	6.2	0.86	<0.01
AD fiber, % fecal DM	46.6	46.9	0.97	0.64
AD lignin, % fecal DM	13.5	13.5	0.37	0.84
Crude protein, % fecal DM	11.5	11.2	0.23	0.44
Digestion of NDF				
Whole tract, % of consumed NDF	48.4	48.4	0.46	0.88

Table 3. Intake, body weight gains and efficiency of body weight gains of the heifers as affected by maceration of the rice hay.

	Diet			
	Control	Macerated	SEM	*P*
Dry matter intake				
Alfalfa hay intake, lb/d	8.65	8.58	0.473	0.89
Rice hay intake, lb/d	5.26	5.13	0.306	0.58
Total intake, lb/d	13.91	13.71	0.767	0.80
Body condition score (BCS) and body weight change				
BCS change, units/mo	0.00	0.02	0.061	0.56
Body weight gain, lb/d	0.99	0.78	0.140	0.20
Efficiency of body weight change				
Feed/gain, lb/lb	14.2	18.7	2.17	0.10
Gain/feed, lb/100 lb	7.06	5.59	0.707	0.09

2005 Research Methods

Learning from the 2004 research feeding study, the 2005 study design was altered to improve confidence in the results that maceration did not significantly improve the intake or digestibility of rice hay. The research design was increased to 8 groups of 10 steers – four groups being fed macerated and four unmacerated. The steers were weighed on Day 0 and assigned to blocks by weight and then randomly assigned to one of the eight groups. Each group was fed a 60 % alfalfa, rice bran, cottonseed and 40% rice hay diet by weight at the start of the study period. Then the each pen is fed rice hay adjusted to their consumption refusal (or waste) rate of no more than 3% Another change in the study design is that alfalfa, rice bran, cottonseed, and oyster shell are fed in the morning at 8 am. The animals were allowed to completely consume all contents in the cement feeding bunk and then rice hay is fed in the long stem form, straight from the 3 twine bales. This will allow for all the refusal to be rice hay. The previous work had combined alfalfa and rice hay in the refusal. The steers will be fed to minimize waste of the hay out of the bunk to no more than 3%. Pounds of waste will be estimated or weighed and the daily consumption is being recorded. The feeding period started in October and conclude in late December. Weights of the animals are being taken on Day 0, 14, 28, 42, and 56. At each weight, fecal samples will be collected from a subset of 4 animals per treatment and combined in one zip lock bag. The feces will be analyzed for digestiblity differences.

2005 Results

The results are pending due to the conclusion of the research trial occuring after the December 12, 2005 report deadline to the Rice Research Board. They will submitted to next years report. Based on the data collected at this point, there is little difference in wet chemistry or animal response to "in field" maceration. It is assumed that it will take a much larger impact of treatment in the field to possibly change the physical properties enough to increase the utilization of rice forage by animals. It is hoped that the changes in macerator design (doubling the surface area of impact on the rollers) and the changes in the animal feeding design will provide a definetive answer on the value of "in field" maceration to increase rice forage quality.

Objective 2 - Coordinate with other researchers in other countries working on rice hay forage utilization.

We realized the power of a more diverse group of researchers studying the rice hay issue. We spent considerable time developing a collaborative team, which is discussed by the interaction with person below.

Dr. William Zinn

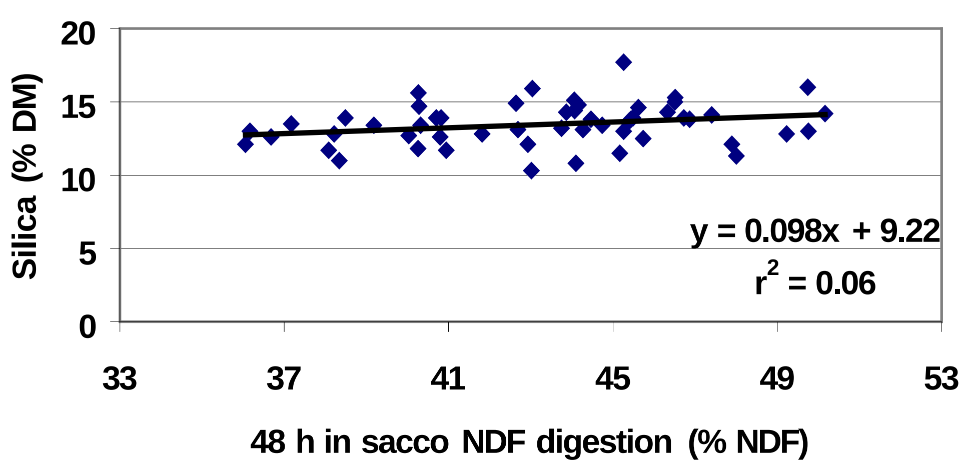
We met with Dr. William Zinn to discuss our research project. His work on maceration and rice hay created our interest in maceration. He recommended that we work with Agland Industries to change the design of the macerator. We worked with company engineers to implement a design that to incorporate his suggestions. We purchased steel rollers that doubled the surface area of impact with ¼ inch indentations. He also recommended that we use more concentrates in the diet to amplify the intake and performance differences of the macerated and unmacerated rice hay.

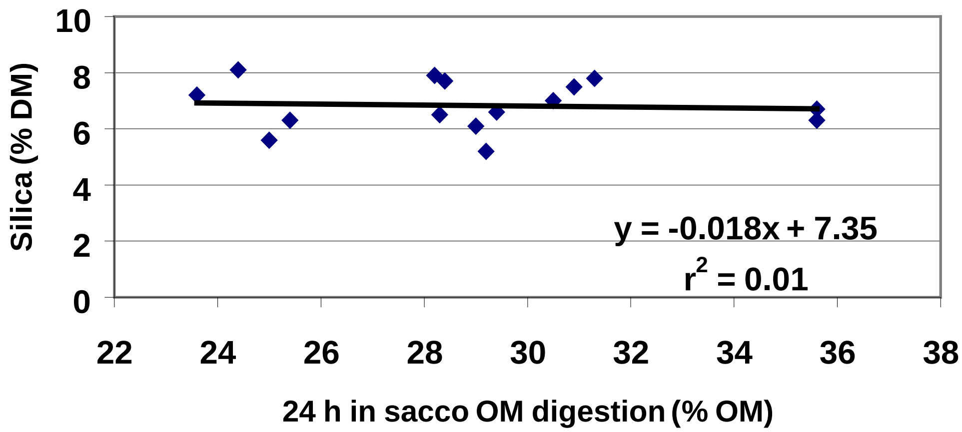
Dr. Peter J VanSoest

Dr. Peter Robinson also worked to get a complete scientific literature review of rice straw written by Peter J VanSoest, PhD Dairy Science; Cornell University published in the Animal Feed Science and Technology. An electronic copy of the paper will be provided to the Rice Research Board when it is published in 2006. This information illuminates all the different worldwide findings about the physical and chemical structure of rice hay and treatments that have been used to improve its forage quality. This allowed the team to focus on specific pieces of science that could be researched to understand the impacts of the drying process impacts on rice hay.

One of the key points that was illuminated by the paper is the role of silica (Si). During drying of the plant, silicic acid is converted to silicon dioxide, a chemically inert form of silica that historically was considered to be indigestible by the animal, and have no impact (either positive or negative) on digestibility of plant OM components. Van Soest later suggested that, during the conversion of silicic acid to silicon dioxide, it was likely that silica created some sort of bond with some part of the structural fiber that inhibited its digestion by ruminal microorganisms. Details of the chemistry are not clear. However, if true, it seems clear that higher levels of silica in rice hay should be associated with lower OM digestibility (see figure 1 below).

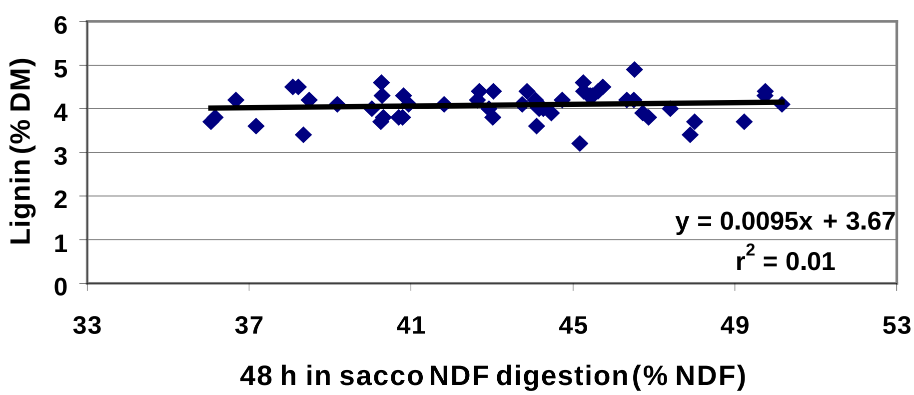
Figure 1. Relationship between silica and NDF (upper) or OM (lower) digestion.

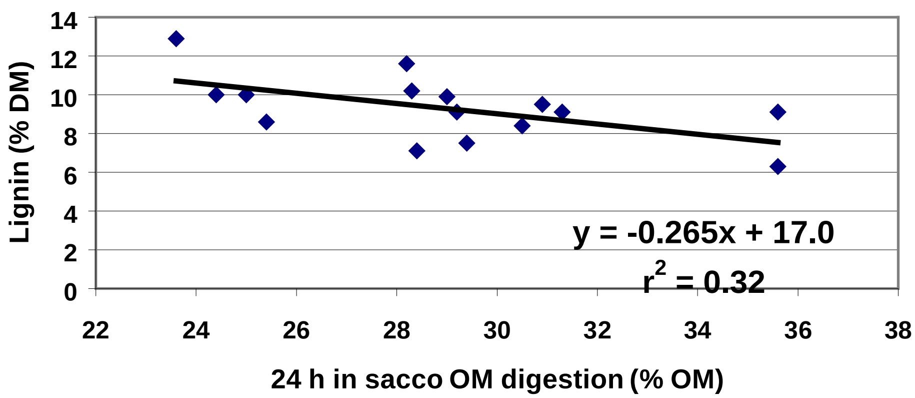




The other nutritive constraint that is discussed is lignin. Re-analysis of individual sample data published on 53 California rice straws and 15 European rice straws (Figure 2) provide little support for a negative effect of plant lignin level on either NDF or OM digestion.

Figure 2. Relationship between lignin and NDF (upper) or OM (lower) digestion.

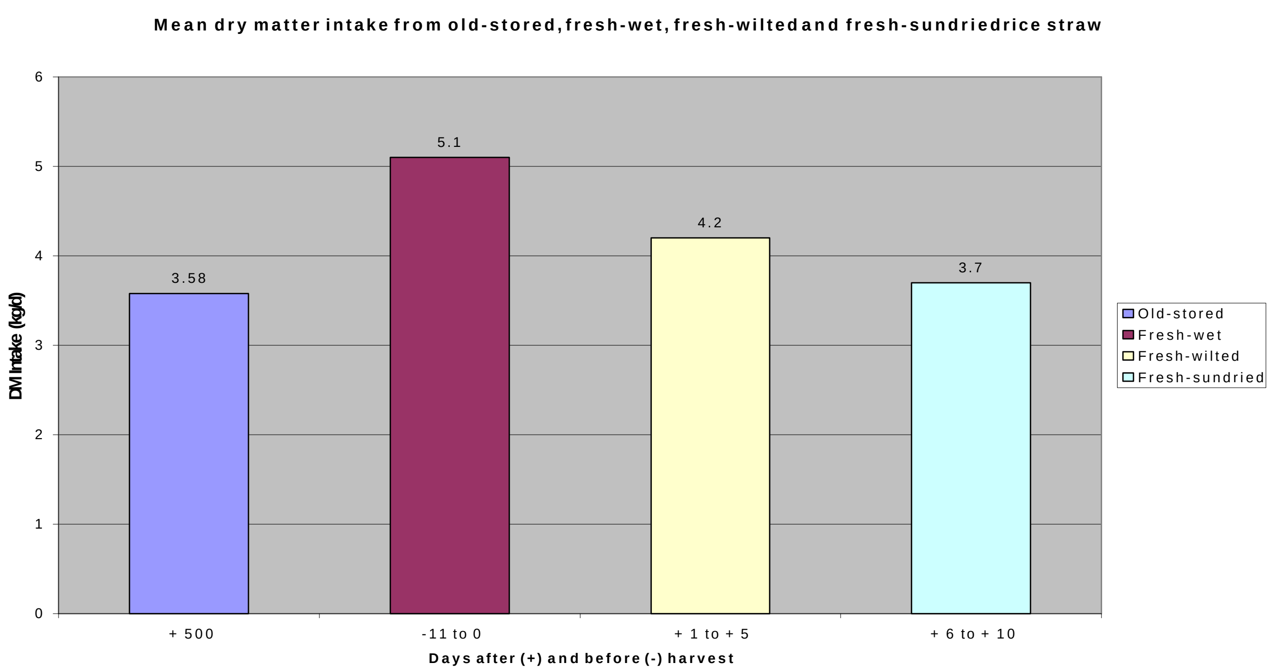




Dr. Uppoor Krishnamoorthy

Dr. Peter Robinson established a working relationship with Dr. Uppoor Krishnamoorthy at the University of Agricultural Sciences, Bangalore, India. He traveled to India to discuss and develop collaborative research on rice hay. In a cooperative effort, a research project was conducted in India that documented a 40% intake difference between fresh green rice forage at harvest and forage dried in the field. Eight crossbred heifers (Bos indicus x Holstein Friesian or Jersey) were offered 0.75 kg of concentrate mixture (Crude protein 24% and crude fiber 8%) at 9:00 A.M followed by ad lib dry rice straw that ranged from fresh cut to rice forage that was stored from the harvest of November 2003. The results in Figure 3 focused the team to study the change in plant structure with drying that limits animal feeding of rice hay.

Figure 3



Dr. Kevin Holtman

We contacted the USDA Ag Research Service (ARS) laboratory at Albany, California. They requested that we come to their research laboratory and make a presentation on our rice hay research. Through this action we were able to meet Dr. Bill Ort and his team that are working on utilization of different agricultural biomass. They were in the processing of hiring a scientist that would have a portion of their time specifically devoted to rice straw utilization research. We were asked and participated in the selection committee in the hiring process. ARS hired an outstanding scientist, Kevin Holtman to the position. We brought him out to see our field research. His comments and suggestions on our research have been very helpful. He now also has a very good understanding of the rice harvest and cattle feeding processes due to this field exposure. This will assist in development of suggested treatments that will fit within the standard production process. We collaboratively studied the physical impact of the 2004 maceration with ARS researcher Delilah Wood. We developed more in depth collaborative study procedures for the 2005 macerated hay using the powerful laboratory and researcher at the Albany ARS research laboratory. Dr. Holtman has proposed extensive research for the next year based on collaborative research in India, our previous Rice Research Board funded work, and the VanSoest literature review. The ARS addition to our team has been a very powerful action. I t has increased the critical thinking capabilities and provides non animal science expertise to study the physical and chemical properties of rice hay.

We are emboldened that the synergy of the diverse group that has the common goal of using rice forage will greatly increase our chances for success in what has proved in the past 40 years to be a very elusive solution to improving the nutritional quality of rice hay that will allow for wider feed utilization.