OVERCOMING THE NUTRITIONAL LIMITATIONS OF RICE STRAW FOR RUMINANTS

1. UREA AMMONIA TREATMENT AND SUPPLEMENTATION WITH RICE BRAN AND GLIRICIDIA FOR LACTATING SURTI BUFFALOES

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Summary

Fifty-six lactating Surti buffaloes, fed rice straw, were allocated to seven treatment groups as follows:

1. Straw supplemented with 2% urea (SS) + 1.5kg rice bran (RB)
2. Straw treated with 4% urea in an open stack (TS open)
3. TS open + 1.5 kg RB
4. TS open + 3.0 kg RB
5. TS open + 1.5 kg RB + 3.0 kg Gliricidia (Gl)
6. Straw treated with 4% urea in a closed pit (TS closed)
7. TS closed + 1.5 kg RB + 3.0 kg Gl

Milk production, butterfat percentage and liveweight gain of cows and calves were measured and tested with analysis of variance. The results are:

- The animals on urea treated straw (group 2) had a higher milk production ($p < 0.05$), higher butterfat production ($p < 0.05$) and less liveweight gain loss ($p < 0.05$) than the animals on urea supplemented straw (group 1). Butterfat percentage also increased by treatment, although not significantly ($p > 0.05$).
- Increasing levels of rice bran (groups 3 and 4 compared to 2) increased total milk production and milked quantity of butterfat, while butterfat percentage decreased ($p < 0.05$).
  Milk production increased ($p < 0.05$) with extra rice bran added (group 4 compared to 3), but was not affected ($p > 0.05$) by Gliricidia addition (group 5 compared to 3). Butterfat percentage dropped with extra rice bran supplement ($p < 0.05$). The lack of response to Gliricidia indicated that protein is not limiting in treated straw, or that Gliricidia protein is partly insoluble.
- System of treatment had no effect on milk production ($p > 0.05$), while supplementation with 1.5 kg RB and 3.0 kg Gliricidia increased production and caused a lower butterfat percentage ($p < 0.05$) (groups 2, 5, 6 and 7 compared). A significant ($p < 0.05$) interaction treatment system x supplementation was present.

It was concluded, that both treatment and supplementation did affect milk production as well as milk composition. Gliricidia addition gave less effect than rice bran, indicating different requirements for starchy substances in the feed. Treatment of straw does not negatively affect butterfat production, it can increase butterfat production and even butterfat percentage.

(Key Words: Rice Straw, Urea Treatment, Supplementation, Lactating Buffaloes)

Introduction

Rice straw is widely used as a cattle feed, but is deficient as a source of nutrients (O'Donovan, 1983; Sundstøl and Owen, 1984; Doyle et al., 1986). There are different options to overcome these nutritional limitations, i.e. supplementation with specific nutrients or improvement of straw quality by chemical or physical treatment (Ibrahim, 1983). Urea ammonia treatment has been proven to be very practical, especially for the tropics (Ibrahim and Schiere, 1986; Perdok et al., 1982). Treatment with urea results in higher digestibility and a higher intake (Chesson and Ørskov, 1984; Saadullah et al., 1981, Ghebrehiwet et al.,

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1988) and has the advantage over other chemicals of supplying non-protein-nitrogen. Crude protein content of urea treated rice straw is at least 7% on dry matter basis (Jayasuriya and Perera, 1983), whereas untreated straw contains approx. 4% crude protein (Doyle et al., 1986). Furthermore, urea is a well-known chemical, generally used as fertilizer, harmless and easy to handle at farmer's level.

Shortage of specific nutrients may be corrected by supplementation. Many authors have reported positive effects of nitrogen, phosphorus, sulphur and carbohydrate supplementation on rumen fermentation and intake (Campling et al., 1962; Coombe and Tribe, 1962; Ernst et al., 1975; Leng, 1984). An efficient way of adding nitrogen is the use of urea, which can be sprayed on the straw directly, or made available in a mixture with other feeds, such as molasses (Kunju, 1986). Supplements can also consists of concentrates or green fodder (Creek et al., 1984; Schiere et al., 1985).

In this experiment, the effect of urea treatment versus supplementation with urea (sprayed on straw) on milk production of buffaloes was studied, as well as the effect of different levels of rice bran (mainly an energy source) and Gliricidia *maculata*, a promising legume tree with 22-23% crude protein (Chadhokar, 1982; Smith and van Houtert, 1987).

Materials and Methods

Treatments

A group of 56 lactating Surti buffaloes was divided at random into seven treatment groups as follows:

1. Straw supplemented with 2% urea (SS) + 1.5 kg rice bran (RB)
2. Straw treated with 4% urea in an open stack(TS open)
3. TS open + 1.5 kg RB
4. TS open + 3.0 kg RB
5. TS open + 1.5 kg RB + 3.0 kg Gliricidia (G1)
6. Straw treated with 4% urea in a closed pit (TS closed)
7. TS closed + 1.5 kg RB + 3.0 kg G1

Animals

Each treatment group consisted of eight lactating Surti buffaloes. The animals were allocated to the treatment groups at random, with the restriction that care was taken that the treatment groups were similar with regard to stage of lactation, average milk yield and body weight. The animals were randomized over the stables to avoid confounding stable and treatment effects. Before the experiment started, the animals were dewormed.

Feeds and feeding

The basal feed was rice straw. Straw was obtained from village farmers and was fed unchopped. The straw was either supplemented or treated with urea.

Sprayed straw (SS) was obtained by adding a solution of urea to the straw just prior to feeding without allowing time for reactions between urea and the straw. After putting straw in the feed trough, it was sprayed with 100 ℓ urea solution/100 kg airdry straw, resulting in 1.8 kg urea/100 kg straw dry matter).

Treatment involves a urea addition of 4 kg/100 kg airdry straw and 100 ℓ of water allowing one to two weeks of reaction (Schiere and Ibrahim, 1985). In this experiment the straw was treated in two different ways:

Open system: the straw was kept in unsealed stacks (3 x 1.5 x 2 m^3) under a roof. After being left for nine days, the product (TS open) was fed during three days (day 9, day 10 and day 11).

– Closed system: the straw was kept in cement pits (3 x 2 x 1.7 m^3) and sealed with polythene. After being left for approximately 18 days, the product (TS closed) was fed during four days.

Straw was fed *ad libitum*, i.e. the quantity offered was approximately 150% of the quantity consumed. The feed throughs were kept full day and night and refusals were removed every morning.

Rice bran, of a low quality as generally available in Sri Lanka, was obtained from a local mill and was fed separately in wooden boxes. Gliricidia sticks were stripped and only the composite leaves were fed and consumed without residue.

In addition to the experimental rations, all animals were fed 1 kg of fresh grass (cut in the field irrespective of maturity). The grass (unchopped) was offered on top of the straw in the feed troughs. All animals were fed 250 g of minerals (75g sodium sulphate, 75g dicalcium phosphate, 100g mineral mix). The animals had free access to drinking water.

Management of the herd

The buffaloes were milked twice a day. The calves suckled one minute before milking, to stimulate milk let down, and five minutes after. Feeding took place at regular intervals. After morning milking the animals were taken to a nearby pond to wallow for about one hour.

Measurements

The experiment lasted for 21 weeks, consisting of:

- preperiod of four weeks, in which body weights of calves and cows were measured weekly as well as daily milk and butterfat production; In this period the animals were given grass and coconut poonac;
  adaptation period of two weeks, in which the animals were introduced to their respective treatments;
- main period of 15 weeks, in which all measurements were recorded.

The milk yield was measured and weighed in a bucket. The milk consumption of the calf was measured by weighing the calf before and after suckling. The amounts of feces or urine voided by the calves were not recorded. To correct for this, all intakes lower than the average milk intake minus 2 x SD (standard deviation) were omitted. Milk butterfat percentage of each cow was determined daily. It was assumed to be the same both in the hand-milked quantity and in the quantity suckled by the calf. Body weights of buffalo cows were determined by weekly weighings (in the morning before feeding) on a cattle scale.

Statistical analysis

The milk and butterfat productions (milked quantity, calf intake and total) and liveweight gain (of cows and calves) were tested in four separate analyses of variance (Snedecor and Cochran, 1980), of which the results are discussed separately. The first three were one-way ANOVA'S, the fourth a two-way ANOVA. The following comparisons were tested:

Urea treated straw compared to urea supplemented straw (group 1, 2).

- Rice bran supplemented to treated straw (2, 3, 4).
- Rice bran and Gliricidia supplemented to treated straw (3, 4, 5).

Straw treated in two treatment systems (open, closed) with and without supplementation of rice bran and Gliricidia (2, 5, 6, 7).

Differences between groups were analyzed by means of the LSD-method. Milk production, butterfat production and liveweight gain as measured before the adaptation period, were used as covariables to correct for differences at the onset of the experiment which could affect the subsequent production. Liveweight gain was calculated by means of linear regression analysis (Snedecor and Cochran, 1980).

Results and Discussion

The results are summarized in tables 1, 2, 3 and 4, concerning the four separate comparisons.

TABLE 1. MILK AND BUTTERFAT PRODUCTION, AND LIVEWEIGHT GAIN OF BUFFALOES, GIVEN RICE STRAW TREATED IN AN OPEN HEAP (TS OPEN), OR RICE STRAW, SPRAYED WITH UREA BEFORE FEEDING (SS).[1]

	Type of feed	
	TS open	SS
Milk production (kg/day)		
Consumption by calf	1.11[a]	0.83[b]
Quantity milked	1.78[a]	1.63[a]
Total	2.95[a]	2.40[b]
Butterfat production (g/day)		
Consumption by calf	86.9[a]	60.7[b]
Quantity milked	142.4[a]	114.2[b]
Total	231.1[a]	173.2[b]
Butterfat content (%)	7.83[a]	7.39[a]
Liveweight gain (g/day)		
Cow	−96[a]	−342[b]
Calf	149[a]	89[a]

[1] a,b: values with the same superscripts are not significantly different ($P > 0.05$).

Averages of treatment groups that were used in more than one comparison, differ slightly from one comparison to the other, due to the respective corrections for covariable effects.

Urea treated straw compared to urea supplemented straw

TABLE 2. EFFECT OF SUPPLEMENT WITH RICE-BRAN ON MILK AND BUTTERFAT PRODUCTION, AND LIVEWEIGHT GAIN OF BUFFALOES GIVEN STRAW TREATED IN AN OPEN HEAP[1]

	Level of rice bran supplement(kg)		
	0.0	1.5	3.0
Milk production(kg/day)			
Consumption by calf	0.93[a]	1.07[ab]	1.21[b]
Quantity milked	1.39[a]	1.66[a]	2.13[b]
Total	2.38[a]	2.70[ab]	3.30[b]
Butterfat production(g/day)			
Consumption by calf	81.2[a]	85.8[a]	86.6[a]
Quantity milked	116.2[a]	135.0[ab]	143.5[b]
Total	198.1[a]	220.8[a]	229.4[a]
Butterfat content (%)	8.69[b]	8.08[b]	6.96[a]
Liveweight gain(g/day)			
Cow	−126[a]	−96[a]	−71[a]
Calf	125[a]	149[a]	120[a]

[1]a,b: values with the same superscripts are not significantly different ($P > 0.05$).

The animals receiving treated straw had a higher total milk production, higher butterfat production and less liveweight loss ($P < 0.05$) than the animals receiving sprayed straw (table 1). The better performance on treated straw (open) compared to sprayed straw has to be explained from a better feed quality. Whether this is caused by the fact that treated straw has a higher digestibility (Hossain and Rahman, 1981; Karunaratne and Jayasuriya, 1984), a higher intake (Jaiswal et al., 1983; Karunaratne and Jayasuriya, 1984; Perdok et al., 1984) and probably a higher crude protein content (SUP, unpublished) than sprayed straw, is unclear from the design of the experiment.

Both butterfat and milk production were higher on treated straw than on sprayed straw, the difference in butterfat production between sprayed straw and treated straw was larger than the difference in milk production. An increasing butterfat percentage indicates, that volatile fatty acid(VFA) proportions change between urea supplemented straw and urea treated straw (Schmidt and van Vleck, 1974). In Sri Lanka, farmers also observed frequently, that feeding of urea treated straw increased both milk yield and butterfat percentage, when compared to the usual situation of relative underfeeding with grass. However, those effects were never quantified.

The animals on sprayed straw had a markedly higher loss of bodyweight. They clearly produced milk at the expense of their body reserves.

TABLE 3. EFFECT OF ISONITROGENOUS SUPPLEMENTATIONS WITH RICE BRAN(RB) AND GLIRICIDIA MACULATA(GL) ON MILK AND BUTTERFAT PRODUCTION, AND LIVEWEIGHT GAIN OF BUFFALOES, GIVEN STRAW TREATED IN AN OPEN HEAP[1]

	Level(kg) and type of supplement		
	1.5 RB	1.5 RB 1.5 RB	1.5 RB 3.0 GI
Milk production(kg/day)			
Consumption by calf	1.04[ab]	1.17[b]	0.85[a]
Quantity milked	1.72[a]	2.13[b]	1.80[a]
Total	2.75[a]	3.36[b]	2.61[a]
Butterfat production(g/day)			
Consumption by calf	84.1[a]	84.9[a]	68.5[a]
Quantity milked	138.1[a]	147.0[a]	141.6[a]
Total	223.0[a]	232.3[a]	209.0[a]
Butterfat content (%)	8.11[b]	7.04[a]	8.25[b]
Liveweight gain(g/day)			
Cow	−96[a]	−71[a]	−48[a]
Calf	149[a]	120[a]	124[a]

[1]a,b: values with the same superscripts are not significantly different ($P > 0.05$).

Supplementation of rice bran to urea treated straw

Increasing levels of ricebran supplement (table 2) significantly increased total milk production, milk consumption by the calf and milked quantity ($P<0.05$). In this case, the increased milk production (50%) was accompanied by a decrease in butterfat percentage ($P<0.05$). During lactation the requirements for both protein and glucogenic compounds is high (Preston and Leng, 1984). In a treated straw diet, sufficient nitrogen is supplied, while ready available carbohydrates (starches) may be limiting for milk production. Treating straw causes a higher production of volatile fatty acids (VFA) and a change in their composition. When rice bran (although of low quality) is added to the

TABLE 4. MILK AND BUTTERFAT PRODUCTION, AND LIVEWEIGHT GAIN OF BUFFALOES GIVEN STRAW, TREATED IN AN OPEN HEAP(TS OPEN) OR TREATED IN A CLOSED PIT(TS CLOSED), EITHER WITH OR WITHOUT A SUPPLEMENT OF 1.5 KG RICE BRAN AND 3.0 KG GLIRICIDIA MACULATA[1]

	without supplement		with supplement	
	TS open	TS closed	TS open	TS closed
Milk production(kg/day)				
Consumption by Calf	1.00^{a}	0.96^{a}	0.85^{a}	0.84^{a}
Quantity milked	1.39^{ab}	1.26^{a}	1.70^{bc}	2.11^{c}
Total	2.40^{ab}	2.12^{a}	2.67^{ab}	2.94^{b}
Butterfat production(g/day)				
Consumption by Calf	86.2^{b}	87.8^{b}	70.2^{ab}	65.8^{a}
Quantity milked	115.2^{a}	117.5^{a}	136.7^{ab}	165.0^{b}
Total	202.7^{a}	197.3^{a}	212.4^{a}	231.8^{a}
Butterfat Content (%)	9.61^{a}	9.35^{b}	7.98^{a}	8.30^{a}
Liveweight gain(g/day)				
Cow	-126^{a}	-15^{ab}	-48^{ab}	64^{b}
Calf	125^{a}	84^{a}	124^{a}	81^{a}

[1] a,b,c: values with the same superscripts are not significantly different ($P > 0.05$).

ration, butterfat percentage drops, indicating a shift in VFA production towards more propionic acid (Schmidt and van Vleck, 1974).

Liveweight losses of the lactating cows tended to decrease at increased supplementation, though not significantly ($P > 0.05$). The calf weight gains tended to increase with level of supplement (not significantly), as also shown by Perdok et al. (1982).

Supplementation of rice bran and Gliricidia to urea treated straw (table 3)

Milk production increased with ricebran ($P < 0.05$), but not with gliricidia supplementation ($P > 0.05$). Butterfat production did not increase to the same extent, because butterfat percentage dropped ($P < 0.05$). Soluble carbohydrates supply seemed to be in a minimum because milk production responded better to the ricebran supplement, which was richer in starches than the gliricidia but approximately equal in crude protein amount.

These findings are in agreement with data of Perdok et al.(1984) on lactating buffaloes, who also found no effect on milk production of gliricidia addition to treated straw alone or to treated straw supplemented with coconut cake, while the addition of coconut cake to treated straw increased milk production. Rangkuti and Basya (1986) even found a lower digestibility and lower liveweight gain when animals on treated straw were given a supplement consisting of 65% gliricidia and 35% concentrates mixture, than when the supplement contained 40% gliricidia or 20% gliricidia.

Results of this experiment and of Perdok et al. (1984) and Rangkuti and Basya(1986) indicate, that protein does not seem to be limiting for production. Several authors found an indication for this also, reporting liveweight gains of growing animals on treated straw alone, ranging from 0 $g.d^{-1}$ (Tharmaraj et al., 1989) to 100 $g.d^{-1}$ (Ghebrehiwet et al., 1988; Schiere et al., 1989). Differences in response to treatment are possibly due to differences in type of treatment(ammonia gas versus urea-ammonia, open heaps versus closed heaps), the quality of straw and the type of animals (age, breed).

The low response to Gliricidia addition may also be caused by the presence of tannins in its leaves, which lowers the level of soluble protein (Marshall et al., 1979).

Treated straw (open) compared with treated straw (closed) with and without supplementation of rice bran and Gliricidia

System of treatment had no effect ($P > 0.05$) on the milked quantity and butterfat production but it was observed that the straw intake was substantially lower, when straw was treated in a closed pit, compared to treatment in an open stack. This may mean, that the palatability of treated straw (closed) is less than of treated straw (open). In another experiment, aeration per se did not affect intake and liveweight gain (SUP, unpublished). Liveweight gain was increased by airtight treatment, although not significantly ($P > 0.05$). So the nutritional quality of treated straw is different for the open nine days system compared to the closed 18 days system. Unfortunately, duration of treatment was confounded

with system of treatment (airtight versus open). Kumarasuntharam et al.(1984) fed rice straw treated for nine days in both open and closed systems. They found a significantly ($P < 0.01$) higher LWG for the closed treatment system (300 versus 200 g/d). Perdok et al. (1984) however, did not find any difference between both systems. Whether treatment system (open versus closed) does affect intake and performance, is very dependent of the size of the open heap and the type of straw used. *e.g.* a large heap has a relatively small surface, so losses by evaporation are less than for a small heap. When the straw, treated in a closed pit, is not easily compactible, the treatment process is not completely airtight and losses of gaseous NH_3 will occur, even in a cement pit sealed with polythene.

Supplementation of 1.5 kg rice bran and 3.0 kg Gliricidia increased milk and butterfat production, but did not affect liveweight gain of cow and calf. The lower butterfat content and the higher production indicate that shortages of specific nutrients on the glucose or protein precursor side were supplemented. Supplementation significantly ($P < 0.05$) increased the difference in the milked quantities of milk and butterfat between treated straw (open) and treated straw (closed).

Conclusion

Urea treatment of straw with 4% urea caused a higher milk and butterfat production and liveweight gain, compared with supplementation with 2% urea (sprayed straw). This is probably not only caused by the treatment effect per se, but also by the extra nitrogen supplemented.

Supplementation with rice bran, increased milk production, but not butterfat production. Urea treatment and rice bran supplementation caused, besides an increase in milk production, a change in composition of the milk: butterfat percentage seemed to increase by straw treatment, while it decreased by supplementation with rice bran.

Supplementation with *Gliricidia maculata* to a ration of treated straw plus rice bran did not increase milk or butterfat production, indicating that protein is not limiting in treated straw containing at least 7% crude protein, or that the level of soluble protein is low in Gliricidia.

Airtightness of treatment had no effect on production, while treatment system and supplementation showed significant interaction.

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