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Replacement of Para grass by urea-lime treated fresh rice straw in the lactating dairy cows diets in An Giang Province, Vietnam

Le Thi Thuy Hang Ngo Van Man * Hans Wiktorsson **

Animal Husbandry and Veterinary Department,

Agriculture and Natural Resources Faculty, An Giang University, Vietnam

**Animal Nutrition Department, Nong Lam University, Thu Duc district,*

Ho Chi Minh City, Vietnam

***Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences, P.O. Box 7024, 750 07 Uppsala, Sweden*

Abstract

Twelve tons of fresh rice straw from an early – maturing variety was preserved with 30g urea and 30g lime kg^{-1} dry mater (DM) straw in bales immediately after threshing. Four weeks after storage, the preserved straw was used to partially replace Para grass (*Brachiaria mutica*) for lactating cows. Eight crossbred Holstein lactating cows in their second to fourth lactation and in mid – lactation were arranged in a balanced design with two squares consisting of 4 periods x 4 treatments (100%grass *ad libitum* as a control; 75% grass + urea-lime treated fresh rice straw (ULTFRS) *ad libitum*; 50% grass + ULTFRS *ad libitum*, and 25% grass + ULTFRS *ad libitum* in one square. A concentrate supplement was given at a rate of 400g per day per kg of milk produced. Straw preserved for 4 – 5 months was in nearly all cases of good quality. Crude protein content was increased 1.75 fold. Para grass cultivated intensively was low in DM content compared to ULTFRS. Dry matter intake (DMI) tended to be higher for the mixture of ULTFRS and Para grass, particularly when half and one – third of roughage was ULTFRS, the mean daily DMI was 11.9 kg. Increasing substitution of Para grass with ULTFRS up to 75% of the roughage component increased milk fat content and had no significant effect on milk yield and other milk composition parameters, the mean daily milk yield was 10.0 kg. It is concluded that ULTFRS can partially replace Para grass in the diets of lactating cows in the dry season and in the flood season.

Key words: Urea – Lime Treated Fresh Rice Straw, Para Grass, Dry matter intake, Milk Yield, Milk Fat, Crude Protein Content of Milk.

1. Introduction

The Mekong Delta is called the rice bowl of Vietnam and accounts for more than half of the rice production area of the country (4 million ha, Vietnam Statistical Data, 2004). It is a typical lowland area, with rice – based farming systems and is flooded annually. Pig and poultry are the main species integrated in the systems and cattle, especially dairy cattle that have just been introduced to the region. Cattle are fed mainly on natural grasses and crop residues and small amount of concentrates. Increasing cultivated land and more intensive rice production limit the grazing land. Shortage of feed is common in the dry season (December – April) and in the flooding season (September – November) when the conditions for grass production are bad.

Rice straw is the most important feed resource that can replace scarce green grass. Rice straw is low in available energy, protein and vitamins and has an imbalance of essential minerals, but it contains a large pool of structural carbohydrates which can potentially be degraded by rumen microbes into volatile fatty acids, and thus is an energy source for ruminants (Wanapat, 1999).

In An Giang province, the total area of rice cultivated is more than five hundred thousand hectares from which 2.6 million tons of paddy rice can be harvested yearly (Statistical Yearbook, 2003) and it is estimated that a similar amount of rice straw is produced (Chowdhury *et al*., 1995). In fact, this straw is underutilized, being left to rot in the rainy season (flooding season) and burned in the dry season. Even with a small number of cattle in the province (52,800 heads: Statistical Yearbook, 2003) a sufficient supply of roughage is not easy to solve during the rainy season. The reason is difficulties in drying the straw in the rainy season and rice straw is an underutilized resource for feeding livestock.

Urea treatment is the most suitable method for improving the quality of rice straw. Urea treatment of rice straw increases the crude protein concentration and rumen degradability compared to untreated rice straw (Hai *et al*., 1994; Chowdhury and Huque, 1996c). Urea treatment not only increases the potentially degradable fraction, but also its rate of degradation (Ibrahim *et al*., 1988). Urea treatment of fresh rice straw was applied successfully in studies reported by Chowdhury and Huque (1996b) and Man and Wiktorsson (2001). However, urea is expensive and a waste of resources when used at high levels to ammoniate straw. The amount of urea needed to effectively treat straw is considered to be more than the optimum amount of ammonia for microbial growth in the rumen. This has led scientists to examine the possibility of combining less expensive alkaline reagents with urea. Lime is one of the alternatives, and in An Giang province lime is easily available and cheap. Urea - lime treated rice straw gave higher NH_3-N concentration and total volatile fatty acids in the rumen than did untreated rice straw (Chaithai *et al*., 1987). Integrating lime with urea can reduce the urea level needed and supply calcium to the ration. By applying this treatment, we can introduce farmers in this region to a convenient and profitable method in storing and improving the quality of roughage.

2. Material and methods

2.1. Rice straw preservation method and sampling:

The experiment was carried out at Chau Thanh dairy farm in An Giang province in the Mekong Delta in the South of Vietnam. There are two seasons in the area: dry season (from November to March) and rainy season (from April to October). Mean temperature is 27 – 37^{o}C in the dry season, and 22 – 32^{o}C in the rainy season. In the rainy season there are periods of flooding from August to November. Rainfall is about 1500 – 2200 mm per year (Hydrometeorolstation in An Giang province, 2003).

Twelve tons of fresh rice straw (FRS) of an early maturing variety named Jasmine was collected in August, 2004, directly after threshing in the field. The fresh rice straw was packed in bales by machine after mixing thoroughly with lime. The straw bale was a rectangular block of 40, 50 and 60 cm in width, height and length, respectively. The weight of the straw bales varied from 50 – 65 kg and in total 200 bales was used. The mean DM of the FRS used in the preserving process was the mean of 5 samples measured by quick microwave dryer measurements (Undersander *et al.*,1993) one day before the preservation. Lime ($Ca(OH)_2$) was used at 30g kg^{-1} dry mater (DM) straw in mixing and urea level at 30g kg^{-1} DM straw was scattered on the surface of the bale after placing it in a plastic bag. After treating with urea the bags were bound by plastic string. The urea – lime treating was followed the same procedure described in the Paper I.

At the feeding time, commencing 4 weeks after preserving, 5 samples were taken for assessment of physical appearance and chemical parameters.

2.2. Feeds, feeding and performance recording

The urea-lime treated fresh rice straw (ULTFRS) was used in an experiment to evaluate in an experiment to evaluate its replacement of grass in the ration of milking cows. Eight lactating cows (75% of Holstein - Friesian blood) in the second lactation and in mid-lactation were arranged by the balanced design method. The experiment was conducted within two squares, consisting of 4 treatments * 4 periods per square. Each period was 20 days with a 10 day preliminary period and the last 10 days for data collection. Each of the experimental animals therefore received all 4 treatments:

Treatment 1: 100% Para grass *ad libitum* as a control

Treatment 2: 75% Para grass + ULTFRS *ad libitum*

Treatment 3: 50% Para grass + ULTFRS *ad libitum*

Treatment 4: 25% Para grass + ULTFRS *ad libitum*

The grass and ULTFRS was fed separately at the same time. At the beginning of the experiment a 20-day preliminary testing was done to measure the voluntary dry matter intake of Para grass in the diet of each animal in order to determine the amount of Para grass in the experimental diets. The animals were tethered in stalls and individually fed with free access to water. Milking was tethered in stalls and individually fed with free access to water. Milking was done twice a day at 06:00 h and 15:00 h by machine.

The concentrate supplement and roughage characteristics are described in the Table 1 and 2, respectively. The cows were supplied a fixed amount of Para grass in the mixed roughage treatments based on the ratio in DM of grass voluntary intake and the grass DM determined by a quick microwave drying method (Undersander *et al*., 1993) every day. Para grass was intensively cultivated in small plots and was harvested daily with a frequency cutting of 30 days, and supplied to cows in 2 – 5 cm chopped pieces. ULTFRS was taken out of the treated straw bale daily in the morning, weighed and placed in a plastic bag to supply feed in the whole day for each experimental cow. An additional amount of roughage of 25% was supplied for the *ad libitum* treatments. The concentrate supplement was based on the farm feeding regulation of 400g concentrate per 1 kg milk produced. In the concentrate, brewer's grain and molasses were fed in wet form in a DM ratio of 30 and 10% of the total concentrate as described in Table 1. The mean of the preliminary 10 days milk production was used in calculating the concentrate supplement for the next period. The concentrate ingredients and nutritional value were showed in Table 1.

For all treatments, concentrate was given twice and roughage three times a day. Concentrate was fed at 06:00h and 15:00h (before milking), followed by roughage, and then the remaining roughage was fed at 18:00h. The residues of grass and ULTFRS were collected and weighed every morning the next day and the dry matter content measured. Body weight changes of the cows were calculated from the measurements of 3 consecutive days of initial and final weights in each period.

Concentrates were randomly sampled 2 times in each period, while grass and ULTFRS residues were sampled daily for DM measurement, and the pooled samples in each period were used for chemical analyses.

Table 1. Characteristics of the concentrate mixture used in the experiment

Ingredients	g/kg
Brewer's grain	300
Rapeseed meal	150
Molasses	100
Cassava chip	126
Coconut cake	117
Soybean cake	117
Rice bran	81
Vitamin + mineral	5.85
Common salt	3.15
Total	1000g
Nutritional value*	
ME (MJ/kg DM)	11.24
CP (g/kg DM)	219.08
Ca (g/kg DM)	4.27
P (g/kg DM)	5.08
Ash (%)	5.6

* Calculation from Feed Composition, NIAH (2002).

2.3. Chemical analysis

All samples of FRS, ULTFRS and Para grass were analyzed for DM, and crude protein (CP) using procedures described by AOAC (1990). ADF and NDF were analyzed according to Van Soest and Robertson (1980). All samples of milk were analyzed for fat content by The Gerber method, CP content and milk DM according to AOAC (1990).

2.4. Statistical analysis

The data were subjected to an analysis of variance (ANOVA) using the General Linear Model (GLM) procedure of Minitab 13.31. When the F test was significant ($p<0.05$), Tukey's test for paired comparisons was used (Minitab13.31)

3. Results

3.1. Chemical composition of feedstuffs

The chemical composition of the roughage used in the experiment is presented in Table 2. Four weeks after preserving all ULTFRS bales were in good condition, with a dark brown colour, strong ammonia smell and no mold and almost 100% were well preserved. The ULTFRS had a mean CP content increased of 1.75 fold of CP and a lower content of ADF and NDF compared to the FRS and all the differences were significant. The nutritional value ULTFRS was nearly the same as of Para grass, and slight higher in CP, ADF and NDF content but not significant difference was found.

Table 2. Characteristics of roughage used in the experiment

Chemical Composition	Roughage			
	FRS	ULTFRS	Para grass	p
DM g/kg	314.0	323.1	183.6	-
CP g/kgDM	42.2[b]	73.24[a]	68.14[a]	0.00
ADF (%)	44.00[a]	40.41[b]	38.54[b]	0.00
NDF (%)	69.19[a]	66.98[b]	64.63[b]	0.00
Ash (%)	12.51[b]	14.93[a]	10.71[c]	0.00

FRS: Fresh rice straw; ULTFRS: urea-lime treated fresh rice straw.

p: p value: Probability of a larger F value for the treatment

[abc] Mean within rows with differing superscript letters are significantly different ($p < 0.05$)

3.2. Total dry matter intake, substitution on Para grass by ULTFRS

The results of dry matter intake (DMI) are summarized in the Table 3. Daily dry matter intake was highest for 50% grass (12.3 kg) and lowest for the 100 % grass treatment, but no difference was found between these treatments. DMI per 100 kg live weight were in the same direction. The DMI of ULTFRS was 30.4, 46.8 and 66.4% of total roughage DM for the 75, 50 and 25% grass treatments, respectively. Crude protein intake was highest in treatment 50% grass and lowest in treatment 100% grass and no significant difference was found. The analysis of ME intake showed no significant difference between treatments either.

Table 3. Daily intake at 100% grass (Gr.) *ad libtum*, 75% grass + ULTFRS *ad libitum*, 50% grass + ULTFRS *ad libitum* and 25% grass + ULTFRS *ad libitum*.

Daily intake	Treament				P	SE
	100% Gr	75% Gr.	50% Gr.	25% Gr		
DMI (kg/day)						
Total/cow	11.54	12.22	12.30	11.71	0.67	0.52
Roughage	7.31	8.02	8.01	7.36	0.26	0.33
Para grass	7.31[a]	5.58 [b]	4.26 [c]	2.48 [d]	0.00	0.21
ULTFRS	0.00 [a]	2.44 [b]	3.75 [c]	4.88 [d]	0.00	0.22
Concentrate	4.23	4.20	4.29	4.33	0.97	0.23
ULTRS/r*(%)	0.00[a]	30.42[b]	46.82[c]	66.40[d]	0.00	2.03
DMI/ LW**	2.77	2.93	2.95	2.81	0.86	0.17
ME intake (MJ/d)	114.46	116.84	115.76	108.67	0.64	4.83
CP intake (g/d)	1423	1480	1507	1482	0.82	65.37

SE: standard error of mean

p: p value: Probability of a larger F value for the treatment

[abc] Mean within rows with differing superscript letters are significantly different ($p < 0.05$)

r*: roughage

DMILW**: Dry matter intake per 100kg live weight

3.3. Milk yield and milk composition

The effects of partial replacement of Para grass with ULTFRS in milk yield and milk composition are presented in Table 4. The recorded milk yield and calculated 4% fat corrected milk (FCM) yield were close to 10kg milk per day and non significant differences were found between the treatments. The gradual increase of about 1 kg day $^{-1}$ of 4% FCM yield in relation to increase of ULTFRS up to 50% grass treatment could not be proved to be a treatment effect. The same trend was found in the milk fat yield; with the highest yield was in treatment 50% grass. The same applied to milk fat yield, although the milk fat content was lowest in treatment 100% grass, and gradually increased ($p<0.05$) with increased ratios of ULTFRS offered in the experimental diets. Relationship between ULTFRS offered and milk fat content was significant, increasing ratios of ULTFRS offered in the experimental diet increased milk fat content, but regression was low. Milk protein and dry matter contents varied from 3.20 – 3.33 and 12.18 - 12.38 %, respectively, and there was no tendency among treatments.

Table 4. Effect of partial replacement of Para grass (Gr.) with urea lime treated fresh rice straw (ULTFRS) on the milk yield, milk composition and live weight (LW)

Roughage based ration	100%Gr.	75%Gr.	50%Gr.	25%Gr.	p	SE
Milk production						
Milk yield, kg/day	9.8	9.9	10.8	9.6	0.48	0.63
0.04 FCM, kg/day	9.2	9.4	10.5	9.6	0.52	0.65
Milk fat yield, g/d	352.5	362.5	412.6	381.4	0.48	28.39
Milk CP yield, g/d	317.8	309.5	359.8	329.6	0.43	22.73
Milk composition						
Milk fat (%)	3.5^{b}	3.6^{ba}	3.8^{ba}	4.01^{a}	0.00	0.15
Milk protein (%)	3.20	3.22	3.32	3.33	0.65	0.09
Milk DM (%)	12.18	12.21	12.27	12.38	0.93	0.07
Mean LW (kg/cow)	419.1	421.9	420.7	421.1	0.99	15.26
Body weight change (kg)	14	10	15	- 5	-	-

SE: standard error of mean

p: p value: Probability of a larger F value for the treatment

[abc] Mean within rows with differing superscript letters are significantly different ($p < 0.05$)

FCM: Fat corrected milk

3.4. Body weight and nutritional balance

Results of the recordings of body weight change were shown in Table 4. Considering the whole period of 12 weeks, experimental cows gained 14, 10 and 15 kg for the treatments 100, 75 and 50% grass, respectively. Cows on 25% grass lost 5 kg during the same period.

In Table 5 the DM and nutritional intake are shown compared to nutritional requirements based on the NRC requirements (NRC, 1988) and NIAH feedstuff nutritive value (NIAH, 2002). The nutritive value of consumed feeds was similar or slightly higher than the requirements according to standards. The difference was greater for crude protein intake.

Table 5. Nutritional value of diet and nutritional requirement of cows

Composition	Nutritional value (actual)				Requirement*			
	T1	T2	T3	T4	T1	T2	T3	T4
DMI (kg/day)	11.54	12.22	12.30	11.71	11.46	11.55	11.491	1.55
CP (g/day)	1423.0	1480.0	1507.1	1481.5	1271	1267	1272	1267
ME (MJ/day)	114.46	116.84	115.76	108.67	109.1	109.6	109.2	109.6
Ca (%)	0.43	0.60	0.65	0.68	0.4	0.4	0.4	0.4
P (%)	0.58	0.50	0.55	0.56	0.26	0.26	0.26	0.26

* According to NRC 1988-2001

3.5. Economic aspects

The main costs in preservation of 1 ha (a typical rice farm area) of fresh rice straw with urea lime in plastic bags in a typical small scale farming systems in An Giang province, Vietnam, are shown in Table 6. The mean cost of 1 kg of ULTFRS is equal to the cost of 1 kg of Para grass (or baby corn stalk) bought in the dry season (or in the flooding season). On dry matter basis the cost of 1 kg ULTFRS is around half of the grass cost (0.053 vs. 0.114 US$). In the total cost of preservation, cost of rice straw and labor may be opportunity costs and in that case the expenditure cost in preserving straw may be lower.

Table 6. Urea lime treated preservation cost of fresh straw at Chau Thanh dairy farm (An Giang Province, Vietnam, March 2004, in US$)

Cost	Quantity	cost/kg	Expense (US$)	Para grass	Note
Fresh rice straw (1ha)*	# 5,000 kg		19.40		
Plastic: 80 bags			15.48		(1/3discount)
Urea	52.5 kg	0.1940	10.20		
Lime	52.5 kg	0.0052	0.27		
Packing			3.23		
Transportation			19.35		
Labor*			25.81		
Total cost			93.74		
Cost per 1 kg ULTFRS	(1 kg in fresh)		0.0187	0.019	
Cost in DM	(1 kg in DM)		0.0535	0.114	

* May be from farm resources.

4. Discussion

4.1. Chemical composition of feedstuffs

In this study urea - lime treatment was a good way to preserve straw. Ammonia, released from the urea hydrolysis, and trapped in the bag caused increase in straw pH>8 (mean pH: 8.3 in this present study), that inhibits oxidative and microbial fermentation (Wilkins, 1988) and maintained the treated straw in good condition with typical smell, colour and no fungi. The same results were reported by Man and Wiktorsson (2001) in fresh rice straw treated with 5% of urea a dome, or in rectangular heaps covered or not with polythene sheets.

Preservation of fresh rice straw with urea – lime improved the value of the straw by increasing the non-protein nitrogen (NPN) content by trapping NH_3 and supplying it to the rumen. The CP content increase in the treated straw was 1.74 fold compared to the untreated straw in the present study, which was slightly lower than the result of 2.1 fold reported by Man and Wiktorsson (2001). However, the CP content of untreated straw in our study was lower compared to their study (4.22 vs. 6.88), which might be part to the explanation for the magnitude of the increase. The quality of straw is one factor, which affects the result, as reported by Kernan *et al*. (1979). Other important factors that affect the magnitude of the CP increase are the urea level at treatment, the water content of the material and the temperature. CP content increased with urea lime concentration in the treatment and a level of 50g urea and 30g lime kg^{-1}DM straw was the highest as reported in Paper I.

Treating fresh rice straw with lime and urea made increase the ash content and decrease the ADF and NDF content (Table 2.).

4.2. Total dry matter intake, substitution on Para grass by ULTFRS

In the present study, there was a slightly higher in DMI compared to the results reported Man and Wiktorsson (2001), and a little lower compared to the information from the study of Wanapat *et al.*,(2000) and Prasad *et al.*, (1998). Several factors can contribute to differences in intake, such as breed, body size, feed quality, milk yield and level of concentrate.

Adding ULTFRS *ad libitum* to the ration after reduction of amount of grass by 25% and 50% tended to increase the total roughage intake in the present study. However more treated straw in the diet tended to reduce the total roughage intake. Feeding mixed roughage may improve DMI, as was reported by Wanapat *et al.* (2000) who studied the utilization of urea treated rice straw and whole sugarcane as roughage sources for dairy cattle. In our study the DMI tended to be lower in the control treatment, which used Para grass as the sole roughage. Para grass in the study had a low DM content, although at a normal level compared to the common content in the region (183.6 vs. 191.4g/kg in NIAH, 2002). When feeds are very succulent, the intake might be reduced because of the large amount of water that is ingested. Several authors eg. Dodsworth and Campbell (1953), Stoll and Jans (2000) have reported a reduction of DMI with lower DM content of the silage. That may be the reason for the tendencies to lower DMI in treatment 100% grass. Higher ratio of treated straw in the mixed roughage treatments resulted in higher indigestible parts in the diets because of low digestibility of treated straw in compared to grass, which may explain the result in treatment 4, 25% grass.

In the present study, the amounts of concentrate offered were almost the same on all experimental treatments, and with the fixed ratio of Para grass the roughage intake and its components ratios may indicate differences in palatability of the roughage. It could be concluded that the introduction of treated straw in the grass diet at the low level of 25% the total diet roughage can increase the feed intake and at a higher ratio the treated straw intake was reduced, corresponding to the increase ratio. The results were similar to the report by Man and Wiktorsson (2001) that mixed roughage of UTFRS and elephant grass in the ratio of 1:3 has highest DMI.

4.3. Milk yield and milk composition

Increased use of ULTFRS in lactating cow diets up to a ratio of 75% roughage did not result in differences in milk yield and milk composition, expect for milk fat content. Milk fat content positively related to higher proportion of acetate and butyrate in the rumen volatile fatty acids (VFA). It is known that acetate predominates with the increasing proportion of fibrous diets (Jorgensen *et al*., 1965; Gordon and Forbes, 1971). Beauchemin (1991) found similar result when increasing of VFA and acetate/ propionate (A/P) ratio with dietary NDF. In the present study there was a positive response in milk fat content to the increase of treated straw in the diet but not to the content of dietary NDF. The calculation of NDF intake of the treatments showed that the daily intake roughage NDF was lowest in the control treatment 100% grass and increased to the highest level in the next two treatments (75 and 50% grass) and decreased in treatment 4 (25 % grass). The reaction of the milk fat content to the NDF intake was not the same direction as in the report of Man and Wiktorsson (2001) of the replacement of Elephant grass with urea treated fresh rice straw.

4.4. Body weight and nutritional balance

A body weight gain of 3 – 5 kg/ months for the treatments 100, 75 and 50%grass is reasonable after peak production when cows have to regain what they generally have lost weight during the very first part of lactation. Cows on treatment 25% grass showed constant or slight loss in weight because the DMI and ME intake (Table 5.) of this treatment were low but milk yield was not different.

Based on the calculation of daily requirements (NRC, 1988) of lactating cows in this experiment, the daily ME intakes (Table 5) were slight higher than required on 100% grass, 75% and 50% grass, and sufficient for additional milk or weight gain. However, with the short period for each treatment, milk yield and live weight change (Table 4.) can not expected to show full response to difference in ME intakes, although the measured nutrient intake, milk yield and live weight changes agree well with the recommended nutrient supply. In the same comparison (Table 5), the daily ME intake was satisfied even on the lowest ME intake treatment (25% grass).

4.5. Economic aspects

The cost of ULTFRS was less than half of the cost grass on DM basis. Compared with the results of Man and Wiktorsson (2001) the cost of treated straw in our study was a little higher, although our cost for chemical agent and plastic bags were lower. The contribution in cost increase came from the payment for machine packing and the transportation. Of course machine packing can reduce the storage area and plastic bag cost. In the study 1 tonne of treated straw needs 2.4 m^3 in storage and this is a reduction of nearly half of the space in the manual method reported by Man and Wiktorsson (2001).

The cost of preservation on farm can be reduced by using the farmer's resources, such as rice straw, which usually be wasted. Adding to this reduction, the cost of plastic bags will decrease when using polythene sheets to cover the urea treated straw bales, as proposed by Chowdhury and Huque (1996a), Man and Wiktorsson (2001).

5. Conclusions

The present data indicate that fresh rice straw can be safely prevented with improved nutritional value by urea - lime treatment (Urea: lime: 30: 30g kg^{-1} DM rice straw). Substitution of Para grass with ULTFRS up to 75% of the roughage in lactating cow diets improved the milk fat content and had no effect on milk production and milk composition. Urea - lime preservation of fresh rice straw for dairy cattle can reduce the cost of buying grass in the dry season and in the flood season, which is a common practice in dairy production in Vietnam. Further, the treated straw bale heap can reduce the cost and be applicable to the dairy farming systems of the Mekong delta.

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