Nutrient Intake, Its Utilization, Rumen Fermentation Pattern and Blood Bio-Chemical Constituents of Sheep Fed Urea Treated Mustard (*Brassica campestris*) Straw

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ABSTRACT : A study was conducted to compare the feeding value of urea treated and untreated mustard straw (MS) for sheep. Treated MS was prepared by adding urea-N at 1.84% and followed by packing in a pit silo for 21 days. Two groups of six empty Avikaline ewes were fed untreated (UTMS) and treated (TMS) mustard straw along with 200 g concentrate per head daily for 90 days. Untreated MS had 0.41% N and the urea treatment increased its N value to 1.58 %. The cell wall constituents were decreased in the TMS except for cellulose which remained unaffected. Dry matter intake of TMS was consistently higher than that of UTMS. Digestibility of DM, OM and fibre fractions of MS improved by the urea treatment. Ewes in both groups were in positive N balance while % N retention was lower in UTMS (26.30%) than in TMS (52.14%). The TMS fed group on average consumed 30.2 g DM, 2.9 g digestible crude protein and 0.2 MJ DE per kg BW day^{-1} and maintained their weight whereas, the UTMS fed ewes lost weight. The VFA concentration in rumen liquor was higher in TMS than in UTMS. Total-N, ammonia-N and TCA-precipitable-N were also higher in TMS fed ewes. Blood glucose concentrations in the two groups were similar at initiation of the study. However the glucose concentration of UTMS fed group was significantly ($p<0.01$) lower than those fed UTMS at the termination of the study. Urea-N concentration was also higher in TMS fed group after 90 days of feeding period. It is concluded that urea treatment of MS improved N value of MS from 0.41% to 1.58% along with sizable improvement in nutritive value and in conjunction with 200 g concentrate, TMS can serve as maintenance ration for sheep. (ME_{lakt}/ME_m=1.46). *(Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 12 : 1674-1680)*

Key Words : Mustard Straw, Crop Residue, Urea Treatment, Sheep

INTRODUCTION

Mustard rapeseed is the second most important group of oil seed crop in the world. It is extensively grown as a cash crop in semi-arid and arid regions of India contributing over 6.72 million metric tones of rapeseed to gross national product (Virupakshappa and Kiresur, 1997). Considering average straw to seed ratio of the cultivar to be 3:1, it is estimated that over 20.2 m MT of MS is harvested annually in the region. The mustard straw after harvesting of the seed is either left in the field to decay in natural process or burnt without serving any purpose rather than adding to environmental pollution (Gupta, 1998). Shortage of dry and green roughases, and protein deficiency are the major constraints for animal production system in developing countries. In order to bridge the gap between demand (1,412.2 m MT) and supply (961.4 m MT) of dry roughages to sustain the existing livestock population of the country (Jain, 1996), it is essential that the unutilized crop residues like MS are to be used in livestock feeding.

Mustard straw is hard and woody, thus unpalatable to the animals. In addition, MS has very low CP content coupled with high cell wall constituents (Mishra et al., 1996). Hence fed alone can not support the maintenance requirements of sheep (Misra et al., 1995). The N content as well as the nutritive value of such poor quality crop residues could be improved by urea treatment (Williams et al., 1984; Dias-da-Silva and SundstΦl, 1986).

It is envisaged that urea treated MS in conjunction with limited concentrate supplementation could serve as maintenance ration for sheep during scarcity. This study was therefore, conducted to utilize MS, an abundantly available waste material of the region by urea treatment.

MATERIALS AND METHODS

The study was conducted at Central Sheep and Wool Research Institute, Avikanagar, located at 75°28'E latitude, 26°17'N longitude and 320 m above sea level. The climate is typically semi-arid with yearly mean minimum and maximum temperatures of 6℃ and 41℃, respectively. The dry bulb temperature and RH of the animal shed during the period of experiment ranged from 30.2 to 32.0℃ and 42.0 to 50.1% at 08:30 h and 40.5 to 40.8℃ and 20.9 to 26.8% at 14:30 h, respectively. The feeding trial was initiated in the month of May and continued for 90 days.

Animals and diets

Twelve adult Avikalin (Malpura×Rambouillet/

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Russian Merino half bred) empty ewes (2 to 3 years old) adopted from a flock previously maintained on mixed common pasture were randomly divided into two equal groups on the basis of body weight. During the experiment animals were housed in an asbestos-roofed open sided shed in individual pens. The first group was fed untreated ground MS (UTMS) and second group received urea treated MS (TMS). Straw was fed *ad libitum*. In addition, animals in both groups received 200 g concentrate mixture (table 1) in individual feeding troughs, daily. Weighed quantity of concentrate mixture and UTMS and TMS was offered daily at 08:00 h after discarding the residue of the previous day. Animals were offered clean drinking water free choice.

Urea treatment of mustard straw

Mustard straw was pulverized in a hammer mill to 1 to 2 cm particle size. One hundred kg of ground MS was then sprayed with a solution of 4 kg urea (fertilizer grade urea, N=46.0%) dissolved in 65 litres of water and mixed thoroughly. The treated material was tightly packed in a pit silo. The inner surface of the silo was lined with polyethylene sheet. After careful packing of the silo with treated material it was covered by polyethylene sheets followed by 12 cm earthen packing which was mud plastered. The pit was opened after 21 days curing period and the treated material was air dried in shed and used in the feeding experiment.

Table 1. Physical and chemical compositions of experimental feeds (%)

Attributes	Concentrate mixture	UTMS	TMS
Maize	53	-	-
Groundnut cake	45	-	-
Mineral mixture	1	-	-
Common salt	1	-	-
Chemical composition (% DM)			
DM	94.40	94.10	92.80
OM	96.50	92.40	92.80
CP (N×6.25)	21.20	2.56	9.85
EE	4.13	1.47	1.62
GE (MJ kg^{-1} DM)	15.10	13.30	13.40
TC	71.20	19.60	16.00
NDF	30.10	76.80	75.70
ADF	10.20	63.20	60.90
HC*	19.90	15.60	14.80
Cellulose	6.30	48.50	47.80
ADL	3.60	14.00	11.50
Calcium	0.22	1.95	2.12
Phosphorus	0.30	0.25	0.27

UTMS: Untreated mustard straw; TMS: Treated mustard straw. * NDF-ADF.

Metabolism trial

Towards the middle of the feeding trial a 7 day metabolism study was conducted on all animals in individual cages with facility for automatic and quantitative collection of faeces and urine. Samples of feed offered, residues, faeces, and urine of metabolic trial period were collected daily. Representative pooled samples were dried at 60℃ and ground for chemical analysis. A separate set of samples of faeces and urine from the daily collection were preserved in diluted sulfuric acid for nitrogen determination.

Simultaneously four ruminally cannulated ewes were assigned to the above feeding protocol following a switch over design. After a 5 week adjustment period on UTMS and TMS, samples of rumen liquor were collected for two consecutive days at weekly intervals for 3 weeks. The samples of rumen liquor were collected through a perforated probe attached to a vacuum pump from different sites and strained through six layers of muslin cloth. Just after collection, two drops of saturated mercuric chloride solution were added to stop microbial activity in the rumen liquor. The rumen liquor samples were then preserved at -5℃ for further chemical analysis.

Body weight of animals was recorded on two consecutive days at fortnightly intervals as well as before and after metabolism trial.

Chemical analysis

Dry matter, CP (N×6.25), ether extract (EE), ash, calcium and phosphorus contents were determined according to AOAC (1984). The NDF, ADF, hemicellulose (HC), cellulose ADL were estimated following the method of Goering and Van Soest (1970). Total carbohydrate (TC) content was determined by deducting CP and EE from OM. The GE content of feed, residue and faeces was determined by ballistic bomb calorimeter (Gallenkamp, UK).

Digestibility of nutrients and N retention

Digestibility of DM, OM, CP, TC, NDF, ADF, HC and cellulose were calculated from feed intake and faecal output data of metabolism trial. Nitrogen retention for each animal was calculated as total N intake minus total faecal N and urine N.

Rumen liquor and blood metabolites

Rumen liquor samples were analyzed for total-N (McKenzie and Wallace, 1954), ammonia-N (Conway, 1962), TCA-precipitable-N (Cline et al., 1958) and total VFA (Bernett and Reid, 1957). Blood samples were collected by jugular vein puncture in the morning hours before the meal, at initiation and the end of 90 days feeding period. Glucose was

determined in whole blood (Somogyi, 1945), while urea-nitrogen (Varley et al., 1980), total protein and albumin (Oser, 1971) were determined in separated blood plasma. The generated data were subjected to one and two way analysis of variance (Snedecor and Cochran, 1968).

RESULTS AND DISCUSSION

Chemical composition

The physical and chemical compositions of experimental diets are shown in table 1. The UTMS contained 0.41% N and 4% urea treatment increased the N value of TMS to 1.58%. It is evident that out of 1.84 kg N added from urea to each 100 kg MS, 1.17 kg N was retained in the TMS. Thus the efficiency of N retention in TMS in this experiment was 63.6%. This agrees with previous reports that approximately 58% NH_3 added to grasses and straws through urea treatment get irreversibly bound to treated material (Lawlor et al., 1981; Reddy et al., 1996). Other workers have reported that efficiency of N trapping in urea treated straw to be half of the present values (SundstΦl et al., 1978; Solaiman et al., 1979). The cell wall constituents viz. NDF, ADF and ADL decreased in the TMS. The observed decrease in ADL content by urea treatment could be ascribed to the breakdown of ligno-cellulosic bond through NH_4OH formation in the stack during treatment (Punj et al., 1977). This might have also been due to some ADL that would have got extracted out during ADF estimation of the TMS. This contention is also supported by a small increase in the hemicellulose content of treated straw, estimated by the difference of NDF and ADF. The cellulose content remained unaffected by urea treatment as it is resistant to alkali attack (Punj et al., 1977; Grotheer et al., 1986).

Intake and digestibility

Average BW, DMI and digestibility coefficient of nutrients are presented in table 2. Dry matter intake of TMS was consistently higher than untreated MS fed group throught the experiment (figure 1). Voluntary intake of both UTMS (350.7 g day^{-1}) and TMS (470.3 g day^{-1}) was lower ($p<0.01$) than prescribed requirements (ICAR, 1985) at the beginning of experiment which significantly ($p<0.01$) increased after 45 days of feeding trial. Conventionaly sheep require about two weeks time to adapt to a new feed source while it is evident from the results that for both UTMS and TMS, the animals required longer period of adaptation to the feed resource. The animals fed UTMS and TMS, on an average consumed 2.80 and 2.90% DM of their body weight during the entire period of experiment. Earlier studies utilizing untreated and urea treated conventional low grade roughages have also indicated that the DMI in sheep ranged between 2.6 to 2.8% of body weight (Rashiq, 1980; Hadjipanayiotou, 1984). Sheep fed UTMS and TMS with 200 g concentrate mixture had DMI 61.0 and 70.0 g/kg $W^{0.75}$, respectively, which is higher than the range of DMI reported in sheep fed low grade roughages (Prasad et at., 1993b). However, in the present study, the observed improvement in intake of TMS over UTMS was of lesser magnitude compared with observations of similarly treated wheat and rice straw fed to cattle (Jayasuriya and Pearce, 1983; Perdok et al., 1984; Wanapat et al., 1984).

Digestibility of DM increased by 16% units ($p<0.01$) in TMS compared with UTMS (table 2),

Table 2. Average body weight, DMI and digestibility coefficient of nutrients for ewes fed urea treated and untreated mustard straw

Particulars	UTMS	TMS	Significance
Initial BW (kg)	28.56±1.27	29.64±0.92	NS
Final BW (kg)	24.76±1.87	28.56±1.13	**
Average BW during metabolism trial (kg)	25.40±1.15	28.80±1.20	**
DMI from concentrate (kg/d)	0.19±0.00	0.19±0.00	NS
DMI from MS (kg/d)	0.50±0.03	0.68±0.04	**
Total DMI (kg/d)	0.69±0.10	0.87±0.08	**
DMI (g/kg BW)	27.16±1.85	30.21±1.34	*
DMI (g/kg $W^{0.075}$)	61.00±2.03	69.99±2.77	*
Digestibility coefficients (%)			
DM	30.90±2.46	46.80±2.83	**
OM	32.20±1.50	48.81±2.05	**
GE	45.59±2.43	48.44±3.46	NS
CP	54.51±2.56	77.86±1.59	**
TC	26.70±2.88	39.80±2.97	**
NDF	23.50±1.20	41.80±2.19	**
ADF	28.30±1.81	38.50±2.10	**
Cellulose	31.82±3.02	47.20±1.21	**
DCP intake (g/d)	28.92±2.35	84.41±3.20	**
DCP intake (g/kg BW)	1.13±0.08	2.93±0.06	**
DCP intake (g/kg $W^{0.75}$)	2.55±0.56	6.79±0.34	**
DE intake (MJ/d)	4.40±0.32	5.80±0.41	**
DE intake (MJ/kg BW)	0.17±0.02	0.20±0.02	*
DE intake (MJ/kg $W^{0.75}$)	0.38±0.03	0.47±0.02	*

UTMS: Untreated mustard straw; TMS: Treated mustard straw. * $p<0.05$; ** $p<0.01$; NS: Non-significant.

which is in agreement with the observations of Trung (1986) and Dajajanegara and Doyle (1989) where sheep and goats were fed rice straw. Similar improvement in DM digestibility of wheat (Harrera-Saldana et al., 1982; Phukan and Singh, 1983; Singh and Gupta, 1987), barley (Horton, 1978; Mira et al., 1983) and oat (Horton, 1978, 1981) straws by urea treatment has also been observed in cattle. The OM digestibility followed a pattern similar to DM digestibility and an improvement ($p<0.01$) of 16% units due to urea treatment of MS was noticed. The findings are in close agreement with earlier reports indicating that urea treatment increased OM digestibility from 42 to 43% to 45 to 60% for wheat straw (Prasad et al., 1993a). Although the digestibility of GE was improved by about 3% units in TMS due to associated improvement in digestibility of DM and OM, still it did not reach statistical significance. Digestibility of fibre fractions was significantly ($p<0.01$) improved by urea treatment of MS which could be attributed to either incorporation of N in the N deficient MS or alteration of ligno-cellulosic complex or both (Dahiya et al., 1990; Rai and Gupta, 1990; Rai and Agrawal, 1991). Such changes were expected as 75 to 76% total content of MS was NDF. Urea treatment of MS significantly ($p<0.01$) improved CP intake as well as its digestibility by the ewes. Similar improvements in CP digestibility of urea treated cereal straws has been reported by Prasad et al. (1993b). In general, the improvement in digestibility of nutrients was of higher magnitude in the present study than those reported for similarly treated cereal straws and other low grade roughage fed to cattle and buffaloes (Prasad et al., 1993b). One of the possible reasons for the observed higher improvement in digestibility of TMS could be ascribed to comparatively lower magnitude of increase in DMI of TMS fed group as it is also a fact that DM digestibility is dependent on the level of DMI (i.e., the depression in digestibility might be observed when the DMI is increased beyond 80 g kg^{-1} $W^{0.75}$) (Gadre, 1979).

Both groups of animals, whether fed UTMS or TMS lost weight in 90 days feeding period (figure 2) whereas the loss in weight was higher ($p<0.01$) in UTMS (3.80 kg) compared with TMS (0.68 kg) fed group.

Nitrogen balance

The nitrogen balance data are presented in table 3. Although the N intake from concentrate was similar in the two groups (6.4 g day^{-1}), N intake of TMS (10.7 g day^{-1}) was significantly ($p<0.01$) higher compared with UTMS (2.0 g day^{-1}) fed group which led to higher ($p<0.01$) total daily N intake in the former than the later group. Despite of variable N intake, the N loss in faeces and urine was similar in the two groups resulting in significantly ($p<0.01$) higher N retention in TMS (10.5 g day^{-1} or 52.1% of intake N) compared to UTMS (2.2 g day^{-1} or 26.3% of intake N) fed group. Earlier reports also confirm that feeding ammonia treated straw in conjunction with medium to low CP containing concentrate maintains positive N balance in animals (Cottyn and DeBoever, 1988; Dias-Da-Silva et al., 1988).

Rumen fermentation pattern

The average total VFA concentration in rumen liquor samples was higher ($p<0.01$) in TMS compared with UTMS fed group (table 4) which may be due to more efficient degradation of structural carbohydrates by the rumen microbes of TMS fed group, as reflected in improved digestibility of cell wall constituents. Givens and Moss (1995) also have

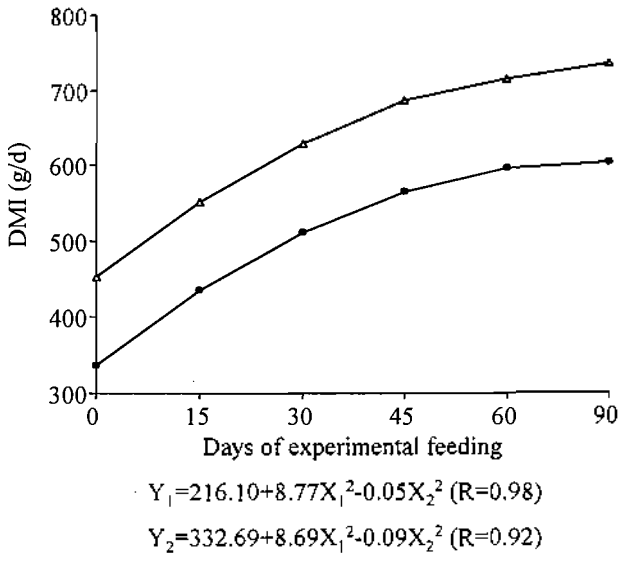

Figure 1. DM intake of ewes fed untreated (●) and treated (△) mustard straw

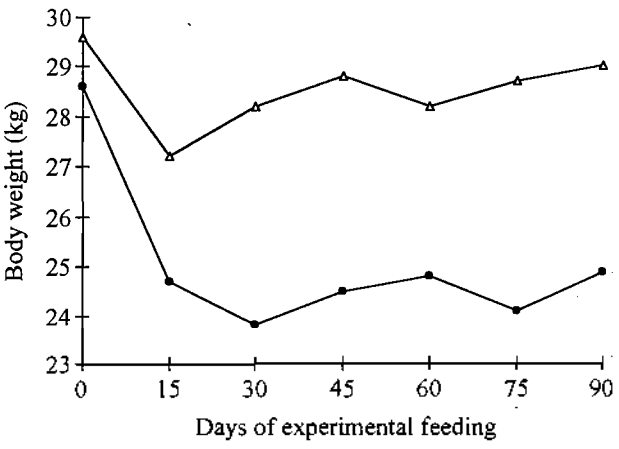

Figure 2. Body weight changes of ewes fed untreated (●) and treated (△) mustard straw

Table 3. Results of N balance for ewes fed urea treated and untreated mustard straw

Particulars	UTMS	TMS	Signifi-cance
N intake (g day^{-1})			
Concentrate	6.44±0.00	6.44±0.00	NS
Straw	2.05±0.07	10.72±0.36	**
Total	8.49±0.16	17.16±0.41	**
N excretion (g day^{-1})			
Faeces	4.17±0.06	3.80±0.05	NS
Urine	2.10±0.05	2.02±0.02	NS
Total	6.27±0.06	5.82±0.03	NS
N retained (g day^{-1})	2.22±0.04	10.48±0.06	**
N retention (% of total N intake)	26.30±5.23	52.14±6.41	**

UTMS: Untreated mustard straw; TMS: Treated mustard straw. ** p<0.01; NS: Non-significant.

reported that addition of nitrogen to N deficient low grade roughages improved rumen degradation of structural carbohydrates. Total VFA concentration of rumen liquor samples peaked at 4 h after feeding in the UTMS fed group which is in agreement with earlier reports on low grade roughages (Hadjipanayiotou and Antoniou, 1983; Santra et al., 1997). The peak total VFA value in rumen liquor of TMS fed group was however, recorded at 2 h after feeding indicating a lesser time lag in fermentation of UTMS. Total-N, NH_3-N and TCA-precipitable-N of rumen liquor were higher (p<0.01) in TMS compared with UTMS fed group (table 4). The ruminal ammonia-N in the UTMS fed group ranged from 4.4 to 5.8 mg dl^{-1} which would be considered adequate for optimum rumen microbial activity (Satter and Slyter, 1974). The higher (p<0.01) TCA-precipitable-N content observed in TMS fed group indicates more microbial protein synthesis in the TMS compared to UTMS fed ewes.

Blood metabolites

Concentrations of blood metabolites are given in table 5. Blood glucose concentration was similar in the two groups before starting the feeding trial (0 day) while on termination of the study it was lower (p<0.01) in UTMS and remained similar to that of pre experimental regimen in TMS fed group. These values are however within normal range of variation (Santra et al., 1997). Although it is realized that blood glucose concentration in ruminants do not clearly indicate their energy balance, still significantly (p<0.01) lower blood glucose concentration in UTMS fed ewes after 90 days of feeding period reflects their negative energy balance as also supported by lower intake of DM and nutrients. The plasma urea-N concentration was similar before the initiation of experiment in both the untreated and urea treated MS fed groups, while it was significantly (p<0.01) higher in TMS fed group after 90 days of experimental period. These values were also within the normal range of variation (More et al., 1980; Santra et al., 1997). Total protein ranged from 7.9 to 9.0 g% in the two groups which would be considered normal for empty ewes (More et al., 1980).

Overall the results indicate that *ad lib.* urea treated MS with 200 g concentrate was adequate to maintain adult empty ewes as evidenced by marginal loss in weight. Further, despite of higher N intake in TMS fed group, the faecal and urinary N voidence was similar in the two groups indicating that the excess N was retained in the body and incorporated in tissue synthesis rather than being excreted as waste. The

Table 4. Total VFA (mmol dl^{-1}), total-N, NH_3-N and TCA-precipitated-N concentrations (mg dl^{-1}) for ewes fed fed urea treated and untreated mustard straw

Parameters	Diets	Hours post feeding					Mean	Factorial analysis		
		0	2	4	6	8		T	H	T×H
TVFA	UTMS	3.01	6.96	8.89	8.01	6.56	6.68±0.54	**	**	**
	TMS	4.13	13.00	12.10	11.30	9.25	10.10±0.85			
Total-N	UTMS	91.20	107.60	105.00	102.00	96.60	100.50±1.73	**	**	*
	TMS	113.00	120.50	130.50	120.10	110.50	118.80±1.95			
NH_3-N	UTMS	4.79	5.85	4.81	4.75	4.44	4.93±0.13	**	**	*
	TMS	4.60	8.59	7.23	7.12	7.00	6.91±0.35			
TCA-N	UTMS	22.00	30.30	28.60	24.60	20.60	25.20±1.00	**	**	**
	TMS	28.90	45.10	48.40	55.20	52.60	46.00±2.47			

UTMS: Untreated mustard straw; TMS: Treated mustard straw.
T: Treatment effect; H: Sampling hour; * p<0.05; ** p<0.01.

Table 5. Concentrations of blood metabolites for ewes fed urea treated and untreated mustard straw

Blood metabolites	Diets	0 day	After 90 days	Factorial analysis		
				T	P	T×P
Glucose (mg %)	UTMS	41.10±1.96	36.22±0.45	*	*	*
	TMS	40.80±1.72	39.83±0.92			
Urea-N (mg %)	UTMS	28.41±2.12	27.22±0.89	**	*	**
	TMS	29.11±1.91	31.21±1.10			
Total protein (g %)	UTMS	8.89±0.35	7.92±0.95	NS	NS	NS
	TMS	9.01±0.67	8.96±1.01			
Albumin (g %)	UTMS	4.15±0.33	3.82±0.92	NS	NS	NS
	TMS	4.77±0.47	4.13±0.56			

UTMS: Untreated mustard straw; TMS: Treated mustard straw.
T: Treatment; P: Period; * p<0.05; ** p<0.01; NS: Non-significant.

TMS fed group consumed 30.2 g DM, 2.9 g DCP and 0.2 MJ DE kg^{-1} BW day^{-1} and apparently maintained their weight. The DM and nutrients intake of the TMS fed group were adequate as per the prescribed allowances for maintenance in Indian sheep (ICAR, 1985). However, in UTMS fed ewes, even with 200 g concentrate supplementation, the intake of DM and nutrient was lower than their allowances. As a result, the ewes in this group lost much weight indicating that such feeding regimen may not be sufficient to provide maintenance ration for sheep.

It is concluded that urea treatment of MS improved its N value from 0.41% to 1.58% along with sizable improvements in nutritive values, and in conjunction with 200 g concentrate, it can serve as maintenance ration for sheep.

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