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Effects of different levels of urea supplementation on nutrient intake and growth performance in growing camels fed roughage based complete pellet diets

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ABSTRACT

The utilization of urea in camels has beneficial and negative effects. The aims of this study were to investigate the effects of different levels of urea supplementation on nutrients intake, digestibility, growth performance, feed efficiency and economics in growing camels fed roughage based complete pellet diets. In the present study, eighteen growing camels with an average live body weight of 306.17 ± 2.05 kg were randomly assigned in three treatments: T1 = roughage complete pellet diet without urea, T2 = T1 plus 1% urea, and T3 = T1 plus 2% urea. The results showed that the urea supplementation significantly affected average daily feed and nutrient intake of dry matter (DM), organic matter (OM), crude protein (CP), neutral detergent fiber (NDF), and acid detergent fiber (ADF) ($P < 0.05$). On the contrary, the average daily intake of nitrogen free extract (NFE) and water were not influenced by increasing urea supplementation ($P > 0.05$). Similarly, digestion coefficient of DM, CP, ether extract (EE), crude fiber (CF) and ADF was influenced by increasing urea level ($P < 0.05$), while the digestion coefficient of OM, NFE and NDF was not affected by increasing urea level ($P > 0.05$). The intake of digestive nutrients was similar among all treatment groups. Total body live weight gain and average daily gain were significantly higher in urea supplemented groups ($P < 0.05$) than in the control group. The supplementation of urea at 1% in low quality roughage complete pellet diets significantly improved ($P < 0.05$) the feed efficiency. In conclusion, these results indicated that the incorporation of urea at 1% in roughage based complete pellet diets could positively improve nutrients intake, digestibility, growth performance and feed conversion efficiency of growing camels.

1. Introduction

Potential production of the cereals in tropic areas is very important (Zhang et al., 2012). Thus, most ruminants are fed low-quality roughages, agricultural crop-residues and industrial byproducts (Wanapat et al., 2013). However, roughages are low in nutritive value, protein level, high content of ligno-cellulose and low digestibility (Freeman et al., 1992; Mawuenyegah et al., 1997), thus resulting in low voluntary feed intake (Wanapat et al., 2012). The improvement of low quality roughages can be fulfilled by

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supplementation of true protein sources (McCollum and Horn, 1990) and non-protein nitrogen (NPN) like urea (McAllen, 1991; Huntingto and Archibeque, 1999). In addition, the efficiency of protein utilization should always consider economical as well as environmental aspects (Yin et al., 2010).

Urea in rumen is converted to ammonia by urease and the ammonia released from urea has the capacity to weaken the lignified outer walls, allowing better penetration by rumen microorganisms to produce more effective fermentation and liberation of nutrients (Chenost, 1995). However, the addition of urea to animal diet should be done under limitations to avoid the risk of hyper ammonia. The hydrolysis of urea to NH_3 in the rumen by microbial enzymes is rapid and occurs at a faster rate than NH_3 utilization by the rumen bacteria (Highstreet et al., 2010). This results in the accumulation of NH_3 in the rumen and the transformation of this product in urea by liver cells (Golombeski et al., 2006). In normal conditions, ammonia is detoxified in the hepatocytes through urea cycle (Visek, 1968). But when its concentration is elevated in the rumen, blood, cerebrospinal fluid and other tissues, it is resulting in ammonia poisoning by overwhelm hepatocytes capacity of detoxification through inhibiting the Krebs cycle (Davidovich et al., 1977).

An effort to improve the low quality of straws and to slow down the ammonia release from urea has been initiated by making roughage based complete pellet diets. Therefore, a study was needed to generate reliable information of feeding complete pellet diet with supplemental nitrogen from urea in camels. This study was designed to measure the optimum level of urea that could be incorporated in the diets of growing camels.

2. Material and methods

2.1. Animals and experimental diets

Three complete pellet diets with different levels of urea were prepared for eighteen growing camels. Animals were distributed equally in three groups (6 camels in each group, 3 males and 3 females), fed a complete pellet diet containing 0 (T1), 1 (T2) and 2% (T3) of urea, respectively. Composition analysis of the diets can be found in Table 1. The complete pellet diets were produced as following: crop residues (groundnut and wheat straws) were chaffed to 1 to 5 cm and concentrate ingredients (bajra grains and mustard cake) were coarsely ground separately. Urea was dissolved in hot water at 1 L to 1 kg urea and the solution of urea was then mixed with 5% molasses. The whole mass of urea-molasses and remaining ingredients were transferred into a vertical mixer in order to obtain homogenized total mixed ration. Care was taken for the mixture of ingredients to be uniform. Finally, the desired quantity of total mixed ration was pulled in a plate dye roughage based complete pellet making machine for densification of the ingredients.

The age of growing camels ranged between 18 and 24 months with an average live body weight of 306.17 ± 2.05 kg. Water and the diets based on complete pellet were offered ad libitum two times daily (at 0900 and 1500) during the experimental period of 120 days. Orts were weighed on the next day morning. Thus, the exact quantity of feed consumed during 24 h by the experimental animals was calculated by subtracting the weighed orts from the offered quantities. The water intake was recorded from the individual camels with 20 L graded buckets.

All diets were analyzed for chemical composition by the methods of the AOAC (1990; method ID 942.05) for dry matter (DM), organic matter (OM), ash, crude protein (CP), ether extract (EE), crude fiber (CF) and nitrogen free extract (NFE). Fiber content was tested using the procedures described by Goering and Van Soest (1970) for neutral detergent fiber (NDF) and acid detergent fiber (ADF).

Table 1
Composition and nutrient level of diets.

Item	Treatment[1]		
	T1	T2	T3
Ingredient, % (air-dry basis), %			
Groundnut straw	50.00	50.00	36.00
Wheat straw			14.00
Bajra grains	4.00	10.00	28.00
Rice bran	10.50	18.00	11.00
Soya churi	14.50	12.00	
Mustard cake	12.00		
Molasses	5.00	5.00	5.00
Mineral mixture[2]	2.00	2.00	2.00
Salt	2.00	2.00	2.00
Urea		1.00	2.00
Total	100.00	100.00	100.00
Nutrient level, % DM basis			
Dry matter	88.10	88.90	87.07
Organic matter	87.69	86.76	86.84
Crude protein	13.60	13.19	13.10
Ether extract	2.73	2.44	2.40
Crude fiber	22.02	25.01	25.32
Nitrogen free extract	51.02	46.27	45.95
Neutral-detergent fiber	41.32	40.77	40.30
Acid-detergent fiber	24.44	23.23	24.33
Energy (ME), Mcal/kg DM	0.98	0.95	0.96

[1] T1 = urea at 0, T2 = urea at 1% and T3 = urea at 2%.
[2] Containing 35% Ca; 27.4% P; 100 mg/kg of Co; 1,250 mg/kg of Cu; 1,795 mg/kg of Fe; 2,000 mg/kg of Mn; 15 mg/kg of Se; 5,270 mg/kg of Zn; and 90 mg/kg of I.

The body weights of all experimental animals were recorded by using a fixed electronic weighing balance in three consecutive days and the mean of the three observations was taken to represent the body weight during 120 days. Average daily gain (ADG) for individual growing camels was calculated by weekly total gain of experimental growing camels. Girth circumference (GC), hump girth (HG), height at withers (HW) and body length (BL) were measured monthly.

2.2. Sampling techniques

Feed and orts samples were taken from each camel during the digestion trial. To obtain a representative sample, 4 growing camels for each treatment were included in the experience. Fecal weight was recorded in the morning of the next day, mixed and stored at room temperature. The representative samples were pooled over the 7-day collection period for each treatment group. The digestion trial ran for 21 days and each experience period lasted for 7 days per each group after 30 days for adaption period.

2.3. Laboratory analyses

Feed, orts and fecal samples were dried at 105°C and ground through a 1 mm sieve before it was analyzed for DM, OM, CP, CF, EE, and NFE following AOAC (1990) procedures. Neutral detergent fiber and ADF fractions were determined with the procedure of Goering and Van Soest (1970).

2.4. Statistical analysis

All tests were performed using the computer package of the statistical analysis system (SSPS 16.0, Chicago, IL, USA). The data were analyzed by descriptive statistics and compared between groups by one way variance (ANOVA) and LSD method test. They were presented as mean ± standard error of mean (SEM).

3. Results and discussion

3.1. Feed, nutrients and water intake

Results of average daily feed, nutrients and water intake and relative nutrients intake are presented in Table 2. The average daily feed intakes were 6.44, 6.96 and 7.10 kg/d for T1, T2 and T3, respectively. By increasing the supplemental urea form 1% (T2) to 2% (T3), the average daily feed intakes increased from 8.07 to 11.02%, respectively. The average daily DM intakes were 5.70, 6.20 and 6.20 kg/d, and relative DM intakes were 76.38, 78.64 and 80.72 kg/$W^{0.75}$ for camels consumed T1, T2 and T3. Dry matter intake was increased by 9.07 and 9.07% for camels consumed T2 and T3, respectively, as compared with the control treatment. The supplemental urea significantly increased voluntary roughage based complete pellet diet intake when compared with the control group ($P < 0.05$).

The beneficial effects of urea supplement in complete pellet diets on feed intake are in agreement with the studies (Hannah et al., 1991; Mathis et al., 2000; Köster et al., 2002; Ortiz-Rubio et al., 2007), but abhorrent with studies showing negative effects (Del Curto et al., 1990a, 1990b; Sampaio, 2007). However, it is difficult to directly confirm this statement of nitrogen supplement from urea. Efficacy of the NPN application depends on many factors, such as a source of readily available carbohydrates, frequency and levels of feeding urea, proper mixing, solubility of proteins, adequate supply of minerals, etc. The observed effect of feed intake between urea supplemented groups (T2 and T3) and control may be due to the improvement of the feed passage through the digestive tract resulted from the higher digestibility coefficients of ADF for T2 and T3 ($P = 0.027$) as presented in Table 3.

The average daily intake of DM, OM, CP, ADF and NDF in T2 and T3 groups was greater ($P < 0.05$) than that in the control group, but neither T2 nor T3 affected NFE and NDF intake. The relative nutrients intake showed the same increasing trend as the daily intake with a variation of CP and NDF. The average daily intake of nutrients in T2 and T3 groups were greater without significant difference ($P > 0.05$). The effect of urea on nutrients intake has been variable in some studies. As observed in the current investigation and by other studies (Del Curto et al., 1990a; Köster et al., 1996; Lazzariri et al., 2009; McGuire et al., 2013), there was an increase of intake of nutrients in ruminants fed urea supplemented diets. Similarly, increase in DM intake in dairy cows was reported when straws were treated with 5.5% urea (Wanapat et al., 2009; Gunun et al., 2013). On the contrary, studies conducted by Köster et al. (2002) showed that intake of DM, ADF was not affected by urea treatment. In the present study, the increased intake of nutrients by camels might

Table 3
Nutrient digestibility and digestive nutrient intake.

Item	Treatment[1]						*P*-value
	T1		T2		T3		
	Mean	SEM	Mean	SEM	Mean	SEM	
Digestibility of nutrient, %							
DM	55.32[a]	1.15	58.38[a]	0.85	58.90[a]	0.77	0.050
OM	61.35[a]	1.13	63.62[a]	0.46	62.76[a]	1.70	0.441
CP	61.03[a]	0.75	66.66[b]	1.11	68.35[b]	1.57	0.025
EE	60.00[a]	2.09	68.75[b]	1.27	64.28[c]	1.40	0.014
CF	50.00[a]	0.93	59.17[b]	0.74	59.33[b]	0.71	0.000
NFE	67.80[a]	0.66	64.72[a]	1.47	66.18[a]	1.78	0.426
NDF	47.45	1.06	51.67	1.61	52.24	1.66	0.056
ADF	28.57[a]	1.05	35.18[b]	1.19	30.93[a]	1.88	0.027
Digestive nutrient and energy intake, %							
DDM	3.15	0.31	3.50	0.17	3.96	0.17	0.267
DOM	3.07	0.30	3.36	0.16	3.68	0.18	0.407
DCP	0.47	0.04	0.51	0.03	0.56	0.06	0.478
DEE	0.22	0.03	0.17	0.01	0.18	0.02	0.286
DCF	0.62	0.14	0.80	0.12	0.92	0.21	0.472
DNFE	1.39	0.14	1.44	0.14	1.61	0.21	0.759
DND	1.12	0.17	1.28	0.13	1.32	0.13	0.630
DADF	0.74	0.15	0.78	0.11	0.87	0.13	0.790
TDN	2.71	0.20	2.91	0.21	3.27	0.23	0.573
ME, Mcal/kg DM	0.98	0.13	1.05	0.11	1.18	0.22	0.576

DM = dry matter; OM = organic matter; CP = crude fiber; EE = ether extract; NFE = nitrogen free extract; NDF = neutral detergent fiber; ADF = acid detergent fiber; DDM = digestive dry matter; DOM = digestive organic matter; DCP = digestive crude fiber; DNFE = digestive nitrogen free extract; DNDF = digestive neutral detergent fiber; DADF = digestive acid detergent fiber; SEM = standard error of mean.

[a,b,c] Means that do not share the same letter within each row are significantly different ($P < 0.05$).

[1] T1 = 0 urea, T2 = 1% urea and T3 = 2% urea.

Table 2
Average daily feed, nutrients and water intake and relative nutrients intake.

Item[1]	Treatment[2]						*P*-value
	T1		T2		T3		
	Mean	SEM	Mean	SEM	Mean	SEM	
Feed, kg/d	6.44[a]	0.13	6.96[ab]	0.16	7.10[b]	0.15	0.005
DM, kg/d	5.70[a]	0.12	6.20[b]	0.14	6.20[b]	0.09	0.003
Relative DM, g/kg $W^{0.75}$	76.38[a]	0.18	78.64[ab]	0.26	80.72[b]	0.27	0.026
OM, kg/d	4.99[a]	0.04	5.39[ab]	0.05	6.21[b]	0.03	0.004
Relative OM, g/kg $W^{0.75}$	63.00[a]	0.48	66.13[b]	0.40	68.15[b]	0.37	0.005
CP, kg/d	0.77[a]	0.01	0.82[b]	0.02	0.83[b]	0.01	0.024
Relative CP, g/kg $W^{0.75}$	9.63[a]	0.24	10.08[a]	0.25	10.24[a]	0.24	0.198
NFE, kg/d	2.89[a]	0.06	2.86[a]	0.07	2.85[a]	0.04	0.067
Relative NFE, g/kg $W^{0.75}$	36.18[a]	0.32	35.26[a]	0.31	35.68[a]	0.20	0.764
NDF, kg/d	2.34[a]	0.05	2.52[b]	0.06	2.52[b]	0.03	0.034
Relative NDF, g/kg $W^{0.75}$	29.70[a]	0.22	30.63[a]	0.25	31.84[a]	0.28	0.144
ADF, kg/d	1.39[a]	0.03	1.44[ab]	0.03	1.50[b]	0.02	0.024
Relative ADF, g/kg $W^{0.75}$	17.14[a]	0.44	17.57[ab]	0.44	18.84[b]	0.44	0.022
Water, L/d	20.60[a]	1.06	22.12[a]	1.10	21.38[a]	1.05	0.843
Water:feed, L/kg DM	3.64[a]	0.21	3.89[a]	0.20	3.45[a]	0.18	0.865

DM = dry matter; OM = organic matter; CP = crude fiber; NFE = nitrogen free extract; NDF = neutral detergent fiber; ADF = acid detergent fiber; SEM = standard error of mean.

[a,b] Means that do not share the same letter within each row are significantly different ($P < 0.05$).

[1] Relative nutrient intake (DM, OM, CP, NFE, NDF and ADF) was the ratio of nutrients intake to body weight.

[2] T1 = 0 urea, T2 = 1% urea and T3 = 2% urea.

have been associated with the higher digestibility coefficients affected by urea supplementation (Table 3).

The average daily water intake was 20.60, 22.12 and 21.38 L/d in T1, T2 and T3 groups, respectively. The ratios of daily water to feed intake were 3.64, 3.89 and 3.45 L/kg DM in T1, T2 and T3 groups, respectively. The daily water intake and ratio of water to feed intake were not different statistically between groups ($P > 0.05$). The results in the present study did not show the relationship between water and feed intake in camels. Similarly, ruminants fed dietary urea at different levels (Razdan et al., 1970) showed no adverse effect on the water intake. The findings indicated that camels could withstand long periods of time without any external source of water through a series of physiological adaptations (Roberts, 1986).

3.2. Digestibility and digestive nutrients intake

The results of apparent digestibility and digestive nutrients intake obtained during the digestion trial for 7 days are shown in Table 3. The DM digestibilities were 55.32, 58.38 and 59.90% in T1, T2 and T3 groups, respectively. The digestibilities of DM, CP, CF, EE, and ADF in camels fed dietary urea were significantly higher ($P < 0.05$) than those in camels fed the control diet. The digestibility of EE in T2 group was higher than that in T3 ($P = 0.014$) and the digestibility of ADF was similar between T1 and T3 groups, but significantly higher than that in T2 ($P = 0.027$). There was no significant ($P > 0.05$) difference between groups in OM and NFE digestibility. In the urea supplement treatments, the digestibilities of DM, CP, NDF and CF were increased but without significant difference ($P > 0.05$). The intake of digestive nutrients and energy were not affected by urea supplement ($P > 0.05$).

The results of the study were supported by the results from Lazzarini et al. (2009), while other studies did not confirm such positive effect of urea supplement (Chanjula and Ngampongsi, 2008; Köster et al., 1997, 2002). The positive effect of urea supplement in total mixed rations on the intake of digested CF and NDF by growing camels was reported by Bhattacharya and Pervez (1973). In the present study, the improvement of digestibility observed in Table 3 could be associated with the capacity of the ammonia released from urea to weaken the lignified outer walls, allowing better penetration by rumen microorganisms to produce more effective fermentation and liberation of nutrients (Chenost, 1995).

3.3. Growth performance and change of morphological characteristics

The results of growth performance and morphometric characteristics of camels during the experimental period of 120 days are presented in Table 4. The total body weight gain was 60.00, 88.80 and 72.83 kg for T1, T2 and T3 groups, respectively, and it increased significantly with incremental urea N ($P < 0.05$). The ADG in T1, T2 and T3 groups was 500.00, 740.00 and 606.00 g, respectively. Camels fed diet containing urea had higher ADG ($P < 0.05$) than camels fed the control diet. Average daily gain increased with the maximal gain at 1% (T2) urea. Growing camels fed urea supplemented complete pellet diets did not show influence on HW, GC or BL ($P > 0.05$). It indicated that dietary urea cannot affect the skeletal growth, but influence the development of hump positively.

The effect of incremental N from urea on total body weight gain and ADG has a variation in reports from different investigations. Urea up to 2.0% level in diet had positive influence (Zinn et al., 2003; Burque et al., 2008; Tan et al., 2011). On the contrary, the negative effect of urea inclusion in diets on performance was observed in other studies (Köster et al., 2002; Olson et al., 1999).

Table 4
Growth performance and morphometric traits.

Item	Treatment[1]						*P*-value
	T1		T2		T3		
	Mean	SEM	Mean	SEM	Mean	SEM	
Growth performance							
Initial BW, kg	314.00[a]	4.33	304.20[a]	6.44	300.33[a]	7.05	0.864
Final BW, kg	374.00[a]	3.98	393.00[b]	6.12	373.16[a]	7.28	0.768
BW gain, kg	60.00[a]	2.46	88.80[b]	2.20	72.83[c]	1.35	0.043
ADG, g/d	500.00[a]	2.82	740.00[b]	4.78	606.91[c]	3.63	0.010
Growth rate of morphometric traits, cm/d							
HW	0.55[a]	0.09	0.65[a]	0.03	0.30[a]	0.13	0.790
GC	1.65[a]	0.23	2.22[a]	0.51	1.68[a]	0.10	0.150
HC	1.61[a]	0.15	1.90[b]	0.36	1.85[b]	0.29	0.037
BL	0.73[a]	0.24	0.96[a]	0.22	0.68[a]	0.23	0.591

HW = height at the withers from the point of withers to ground level; GC = girth circumference at the mid sternum region or chest girth; HC = distance around the camel's body measured at its widest point from the top of the hump around the belly; BL = length from the point of shoulder to pin bone; SEM = standard error of mean.
[a,b,c] Means that do not share the same letter within each row are significantly different ($P < 0.05$).
[1] T1 = 0 urea, T2 = 1% urea and T3 = 2% urea.

These researchers reported that relatively high percentage of the supplemental NPN failed to be as effective as true protein in supporting maintenance of beef cows on low-quality. More than 3% urea in diet reduced feed intake and decreased body weight gain. Asynchronous release of ammonia and insufficient undegradable intake protein supply are two factors often considered when discussing reduced performance observed with NPN-based supplements (NRC, 1996). The positive effect of urea supplement in roughage based diets on total body weight and ADG may be relative to the higher nutrients intake and enhancement of digestibility.

3.4. Feed efficiency and economics of feeding roughage based complete pellet diet with urea

The results of feed efficiency and economics of feeding roughage based complete pellet diet with urea in growing camels are presented in Table 5. The total dry matter intake was 699.82 kg for T2 group and 679.86 kg for T3 group versus 638.40 kg for control (T1). The DMI were 10.64, 7.88 and 9.33 kg/BW gain for T1, T2 and T3 groups, respectively. The total organic matter intake of the growing camels fed the urea supplemented complete diets was lower

Table 5
Feed efficiency and economics of feeding roughage based complete pellet diet with urea.

Item	Treatment[1]						*P*-value
	T1		T2		T3		
	Mean	SEM	Mean	SEM	Mean	SEM	
TFI, kg	724.60[a]	4.52	787.20[b]	5.48	779.58[b]	8.10	0.030
Total DMI, kg	638.40[a]	4.22	699.82[b]	5.44	679.86[b]	8.42	0.028
DMI, kg/BW gain	10.64[b]	1.45	7.88[a]	1.22	9.33[ab]	1.13	0.026
Total OMI, kg	561.77[a]	3.98	608.80[b]	4.86	590.80[c]	7.92	0.025
OMI, kg/BW gain	9.36[a]	0.98	6.85[b]	0.76	8.11[c]	0.12	0.045
Total CPI, kg	300.04[a]	3.12	377.90[b]	4.46	373.50[b]	4.32	0.036
CPI, kg/BW gain	5.00[a]	0.88	4.25[a]	0.74	5.12[a]	0.65	0.198
EFE, Rs/kg gain	193.22[a]	2.44	141.83[b]	3.26	171.26[c]	3.87	0.010

SEM = standard error of mean; TFI = total feed intake; DMI = dry matter intake; OMI = organic matter intake; CPI = crude protein intake; EFE = economic feed efficiency; Rs = Indian Rupees.
[a,b,c] Means that do not share the same letter within each row are significantly different ($P < 0.05$).
[1] T1 = 0 urea, T2 = 1% urea and T3 = 2% urea.

($P = 0.025$) than that of the control group. Similarly, the economic feed efficiency calculated on basis of Rs feed conversion ratio was the lowest for growing camels fed urea supplemented complete pellet diets with 1% of urea. Significant difference in economic feed efficiency were observed among the three experimental rations ($P < 0.01$).

The results were in close proximity with those reported by Milton et al. (1997), Zinn et al. (2003), and Burque et al. (2008) who stated that feed efficiencies were apparently improved with different urea levels up to a certain percent level. Once the content of urea is beyond that level in diet, a significant depression of intakes, digestibility, ADG and feed efficiencies are expressed in camels. Roughage based rations containing urea had no effect on feed efficiency values (Barque et al., 1982; Köster et al., 1997). Other researchers have observed a reduction of the feed efficiency of the growing ruminants fed urea supplemented roughage based diets (Bhattacharya and Pervez, 1973). Improvements in the efficiency of urea supplemented pellet diets utilization by growing camels were of course the nutrients intake, growth performance and the quantity of feed consumed per kg weight gain.

4. Conclusions

Results of the present study indicated that the incorporation of urea at 1% in roughage based complete pellet diets positively improved nutrients intake, digestibility, growth performance and feed conversion efficiency of growing camels. This is a potential approach to exploit the use of crop residues for growing camels. However, it would be desirable to conduct further research on the use of urea in practical rations for camel feeding systems before it can be implemented at region or national level.

Conflict of interest

The authors declare that they have no conflict of interests.

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