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Effects of urea supplementation on nutrient digestibility, nitrogen utilisation and rumen fermentation in sheep fed diets containing dates

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ABSTRACT

Summary: The aim of the study was to determine the influence of increasing levels of urea (i.e., 0 (U0); 10 (U10); and 15 (U15) g kg^{-1} of concentrate) in sheep fed diets containing dates (local name: Azzawi), on nutrient intake and digestibility, N utilisation and ruminal fermentation. To maintain iso-nitrogenous and iso-metabolisable energy diets, the dates were added with increasing levels of urea. Sheep were fed a 400:600 (dry matter (DM) basis) concentrate:berseem hay (*Trifolium alexandrinum*) diet. Twelve Barki sheep (53.8 ± 1.95 kg body weight) with three/diet were used in a randomised block design to determine digestibility and N balance, while four ruminally cannulated Barki sheep (56.6 ± 2.15 kg body weight) were used in a 3×3 Latin square design to determine rumen function. Experimental periods were 22 days with the first 15 days for adaptation. The calculated metabolisable energy (MJ kg^{-1} DM) and actual crude protein (CP; g kg^{-1} DM) contents were 12.17 and 156.1, 12.69 and 158.2 and 12.60 and 154.8, for the U0, U10 and U15 diets, respectively. Increased urea feeding increased ($P < 0.05$) digestibility of DM, organic matter (OM) and CP. Rumen ammonia N concentrations, allantoin in urine and the resultant microbial N supply increased linearly ($P < 0.05$), as did the total ruminal volatile fatty acid concentrations. Results suggest that urea supplementation to sheep diets containing dates improved DM, OM and CP digestibility and substantially increased rumen microbial growth as well as ruminal fermentation function.

1. Introduction

As dates produced in the Siwa Oasis of Egypt are not edible by humans, farmers in the region use date by-products as ruminant feeds, intact or after grinding, as a source of energy to replace some dietary corn grain. El-Shaarawy et al. (1989) reported that dates are rich in carbohydrates (i.e., 800 g kg^{-1} dry matter (DM)) and they are an excellent source of sugars, minerals and vitamins, while the fibre specify type of fibre content of date is only about 80 g kg^{-1} DM (Lambiote, 1982).

A high content of readily soluble sugars in ruminant diets can interfere with rumen function (Bouabidi et al., 1996) as they are water-soluble carbohydrates which are readily available in the rumen. Sugars ferment faster than starch or fibre in the rumen, and the Cornell Net Carbohydrate and Protein System assumed a fermentation rate of 300% h^{-1} for sugars (Sniffen et al., 1992).

The digestive process of ruminants is affected by a variety of factors, among them the proportion of degradable dietary N

Abbreviations: ADF, acid detergent fibre; BW, body weight; CP, crude protein; DM, dry matter; EE, ether extract; ME, metabolisable energy; NDF, neutral detergent fibre; NPN, non-protein N; OM, organic matter; NFCs, non-fibre carbohydrates; VFAs, volatile fatty acids..

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Table 1
Dietary ingredients[1] and composition (g/kg) used in formulating the concentrate mixture as well as the composition of the roughage used.

	Level of urea (g/kg concentrate dry matter)			Berseem hay (*Trifolium alexandrinum*)	Dates
	U0	U10	U15		
Ingredient composition					
Soybean meal	170	90	50		
Cottonseed meal	150	150	150		
Dates	550	600	635		
Wheat, bran	110	130	130		
Urea	0	10	15		
Salt	7	7	7		
Limestone	10	10	10		
Vitamin mineral premix[2]	3	3	3		
Feed cost/ tonnes (US$)	284	263	251	200	167
Chemical composition					
Organic matter	881	878	881	847	948
Crude protein	156	158	155	140	73
Ether extract	49	43	43	37	41
Nonfiber carbohydrates[3]	410	411	417	143	649
Neutral detergent fiber	266	265	266	526	186
Acid detergent fiber	194	198	200	388	175

[1] Diets of sheep contained 400 g of concentrate kg of the diet DM with 0 (U0, no urea), 10 (U10) and 15 (U15) g of urea per kg of the total concentrate mixture, and 600 g of berseem hay (*Trifolium alexandrinum*) as the forage/kg of diet.
[2] Composition /kg: vit. A, 4,500,00 IU; vit. D3, 1,166,666 IU; vit. E, 333 mg; Mn, 2666 mg; Zn, 20000 mg; Se, 116 mg; Co, 333 mg; Fe, 16666 mg; Cu, 1000 mg.
[3] Nonfiber carbohydrates (NFC) determined by difference (100 - (% ash+% CP+% EE+% NDF)).

needed to support ruminal microbial activity. The rumen microorganisms ferment ingested organic matter (OM) to obtain energy for maintenance and growth and produce volatile fatty acids (VFAs) and ammonia. Russell et al. (1992) reported that microbial growth is proportional to the intake and extent of fermentation of carbohydrates as long as an adequate N source is available to the bacteria. Mehrez et al. (1977) observed that the optimum microbial growth depends on the maximum rate of fermentation, which depends on the maximum ammonia concentration and the minimal ammonia concentration for maximal rate of fermentation was estimated to be 23.5 mg dl^{-1} rumen fluid.

Urea is widely used as a dietary supplement for ruminants because it is an inexpensive nitrogenous compound and has long been accepted as a replacement for some of the degradable true protein in diets (Van Horn et al., 1969; Pinos-Rodríguez et al., 2010). Urea is rapidly and extensively degraded in the rumen yielding maximum ammonia concentrations within the first few hours of ingestion (Broderick and Wallace, 1988; Puga et al., 2001). Wallace et al. (1979) observed that addition of urea to the diet of sheep fed barley grain altered the rate of ruminal fermentation, quantities of some ruminal bacterial populations and activity of some enzymes. Leibholz (1980) evaluated variables of ruminal and total tract digestion in calves fed diets with different urea concentrations but, besides urea concentration, the experimental diets also varied in N content and the forage to concentrate ratio.

The aims of this study were to determine if there was a benefit to supplementation of urea to diets containing dates on nutrient digestibility, N balance and rumen function of sheep.

2. Materials and Methods

2.1. Feeds and diets

Three experimental diets were formulated to contain 400 g of concentrate kg^{-1} of diet DM with 0 (U0, no urea), 10 (U10) or 15 (U15) g of urea kg^{-1} of the total concentrate and 600 g of berseem hay (*Trifolium alexandrinum*) as the forage kg^{-1} of diet DM (Table 1). In the concentrate mixture, urea replacement was approximately iso-nitrogenous, and the resultant loss of volume was made up by adding dates to the concentrate. Thus, the concentrate mixture was iso-nitrogenous and iso-metabolisable energy to the control rations (U0). Sheep were fed restricted amounts of the diets to meet their requirements (NRC, 1985) twice daily in equal portions at 0800 and 1600 h and had continuous access to fresh water and a vitamin/mineral block.

2.2. Animals, samples and experimental design

2.2.1. Digestibility and nitrogen balance experiments

Digestibility and N balance experiments were conducted using twelve Barki sheep (53.8 ± 1.95 kg of body weight (BW)) with four sheep fed each diet. The sheep were housed individually in metabolism crates which allowed separate collection of urine and faeces. Sheep were allowed 15 days to adapt to the diets before a 7-days collection period. An aliquot (100 g kg^{-1}) of total faecal output was collected each day for digestibility determination and dried at 60 °C for 72 h to constant weight before analysis. Urine was collected into buckets containing 100 ml of 100 ml l^{-1} (v/v) sulphuric acid to keep the urine pH below 3.0 and prevent bacterial activity