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EFFECT OF TWO LEVELS OF UREA ON MILK PRODUCTION AND COMPOSITION OF MILK, BLOOD AND RUMEN FLUID IN LACTATING COWS[1]

M.S. Mostafavi, K. Ghorban and N. Sefidbakht[2]

ABSTRACT

To compare 3 levels of concentrate urea rations, two hybrid and one pure Brown Swiss cows were assigned to a 3 x 3 Latin Square design with 30 days experimental periods. Urea nitrogen in the concentrate was 7 and 14% of the total nitrogen. The daily milk yield and feed consumption were recorded. At the end of each week a composite of AM - PM milk samples from each cow was analyzed for percentages of fat, total solids, solids not fat, crude protein and non-protein nitrogen. Rumen fluid samples were obtained every other week and analyzed for pH, total nitrogen, urea nitrogen and non-protein nitrogen. On the 30th day of each period, samples of blood were withdrawn from the jagular vein and blood plasma was analyzed for total nitrogen, urea nitrogen, and non-protein nitrogen. Individual weight of the cows were recorded at the beginning and at the end of each period. The only significant differences observed were the increased amount of ammonia and non-protein nitrogen in rumen fluid and urea in the blood plasma of the cows receiving urea in their ration ($P < 0.05$).

INTRODUCTION

There are many countries in the world which are suffering from shortage of protein, particularly good quality animal protein. Animal protein is very expensive, because it is costly to convert grain to animal product. With this concept in mind, one may come to the question of how one can economically supply the protein need of animals by using feed materials which have little or no value to man.

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1. Contribution of the Department of Animal Science, College of Agriculture, Pahlavi University, Shiraz, Iran.

2. Instructor, and Associate Professors of Animal Science, respectively.

Continuous efforts in this subject made it clear that the rumen microorganisms could convert non-protein nitrogen compounds into true proteins of which urea is the most common form. The necessity of readily available carbohydrates as energy source for utilization of ammonia nitrogen and to improve urea utilization is well established (8). Effect of various sources of carbohydrate on urea utilization, on milk production (4) and nitrogen balance (3) confirms that the quantity of carbohydrates needed for maximum utilization of urea is about 1 kg of readily fermentable carbohydrate per 100 g of urea in an adapted cow.

The quantity and quality of true protein included in the ration affects urea utilization. Wegner *et al.* (22) reported the decrease of urea utilization and its conversion to microbial protein when there was a large quantity of true protein in the ration, but results differ with respect to quality of protein (12).

The recommended levels of urea which can replace the protein source in rations for lactating dairy cows are reported (12). However, there are some advantages in milk production for cows fed non-urea rations as compared with those receiving rations containing urea, although the differences often have not been statistically significant (6, 20).

Although extensive research has shown that urea can be fed to dairy cows, it is still not clear if urea can be fed without decreasing efficiency. The objective of the present work was to obtain further information on the use of urea in lactating cows.

MATERIALS AND METHODS

Two Brown Swiss X Native (F_4) and one Brown Swiss (Pure) cows, all aged between 5 and 6 years old were put in 3 x 3 Latin Square design. The cows were in the second month of their lactation. Individual weights of the cows were recorded at the beginning and at the end of each trial period. The body weights were obtained by weighing each cow twice daily and averaging the obtained values. The trial periods were 30 days preceeding by a two-week adjusting period.

Table 1 shows the proximate analysis of all the ingredients (2). Each ration consisted of alfalfa hay, corn silage and one of the 3 concentrate mixtures shown in Table 2. Table 2 also shows the amount of urea replaced by cotton seed meal and maize. The rations were designed to be isonitrogenous and approximately isocaloric. The proximate

Table 1. Average composition of feeds, based on 90% dry matter, fed to the experimental cows.

Feeding stuff	Dry matter %	Crude protein* %	Fat %	Crude Fiber %	Ash %
Beet pulp, molasses, dried	93.80	10.07	0.52	16.77	4.71
Alfalfa hay, all analysis	93.80	15.93	2.04	26.26	8.94
Corn silage	35.00	5.09	1.80	21.54	7.79
Barley	92.38	11.58	1.83	5.96	3.02
Wheat bran	92.54	14.14	3.18	12.40	4.57
Cotton seed meal	93.10	35.59	5.04	16.91	5.82
Maize	90.09	9.70	2.11	1.20	1.20
Bone meal	92.82	24.79	3.46	1.45	58.29

* Nitrogen X 6.25

analysis of the 3 concentrates, alfalfa hay, and corn silage are given in Table 3. The concentrates were fed to the cows according to their weight and their milk yield of the last two weeks.

Milk production of each cow was recorded twice per day. At the end of every week during the experimental periods, composites of AM - Pm milk samples were analyzed for milk fat (1), total solids (1), solids not fat, crude protein (2) and non-protein nitrogen (2).

Rumen fluid samples (approximately 50 ml) were obtained every other week, two hours after the morning feeding, by means of a stomach tube. Immediately after collection, pH was measured and samples were strained through cheesecloth to remove the suspended materials, and the supernatants were measured for total nitrogen (2), ammonia nitrogen (13), urea nitrogen (7) and non-protein nitrogen (2). On the 30th day of each

Table 2. Concentrate formulas.

Ingredients	Treatments		
	Control	$Urea_1$*	$Urea_2$*
	% on air dry basis		
Beet pulp, molasses, dried	35.00	35.00	35.00
Maize	41.40	46.60	51.70
Wheat bran	5.00	5.00	5.00
Barley	5.00	5.00	5.00
Cotton seed meal	11.40	5.60	—
Urea	—	.56	1.12
Bone meal	1.00	1.00	1.00
Salt	1.00	1.00	1.00
Vitamin and mineral supplement**	.20	.20	2.00

* $Urea_1$ and $urea_2$ supplied 7 and 14% of the total nitrogen in the concentrate, respectively.

** The vitamin and mineral supplement furnish the following quantities per kg of diet: Vitamin A, 5000000 I.U.; Vitamin D3, 1000000 I.U.; Vitamin E, 1250 I.U.; riboflavin, 1.5 g; pantothenic acid, 2.5 g; nicotinic acid, 4 g; Vitamin K3, 1 g; choline, 25 g; Vitamin B12, 2 g; manganese, 25 g; iron, 20 g; copper, 2 g; cobalt, 500 mg; zinc, 15 g; and iodine 250 mg.

experimental period, samples of blood (approximately 15 ml) were withdrawn from jugular vein, 3 hours after the morning feed, and collected into tubes containing E.D.T.A. and sodium fluoride as anticoagulants and preservatives. Immediately after blood collection, plasma was separated and stored frozen. The blood plasma was analyzed for total nitrogen (8), non-protein nitrogen and urea nitrogen (8).

Table 3. Analysis of the feeding stuffs fed to the cows.

	90 per cent dry matter basis			
	Crude protein	Ether extract	Crude fiber	Ash
Control concentrate	13.03	1.91	9.21	3.70
$Urea_1$ concentrate	13.03	1.74	8.35	3.50
$Urea_2$ concentrate	13.03	1.56	7.44	3.24

The experimental data were analyzed by the analysis of variance (16) and the means were compared by Tukey's test (19).

RESULTS AND DISCUSSION

Because of restricted offering of feeds there was no refusal of concentrate, hay or silage. This indicates that the food was quite palatable. The mean daily feed intake and body weight change of the cows are presented in Table 4. Statistical analysis showed no significant difference in feed consumption and body weight change for the 3 rations ($P > 0.05$).

The average production of milk throughout the experiment is shown in Table 5. There was no significant difference either as recorded or on the basis of 4% fat corrected milk ($P > 0.05$), although the milk production on urea ration was slightly lower than that of the control ration (10.58 and 10.33 *vs.* 11.69 kg). Similar results have been obtained by other workers (5, 20).

There was no significant difference among treatments in the percentages of all constituents which were measured in milk ($P > 0.05$), but the percentages of fat and protein were slightly higher in milk of the cows which received urea. It has been found that, in general, a rise in milk production lowers the over-all fat and protein percentages, but accompanies a rise in fat and protein production (10, 17). Little relationship between the nitrogen content of ration and milk protein is reported (9), whereas the other workers indicated there is such a relationship (14).

Table 4. Effect of urea added to the concentrate on feed consumption and body weight change of cows.

Cow no.	Treatment	Feed consumption, kg/day Alfalfa hay	Corn silage	Concen-trate	Body weight change, kg/day
104	Control	2.5	17	6.730	+ .25
	Urea $level_1$	2.5	17	6.649	+ .16
	Urea $level_2$	2.5	17	7.460	+ .10
105	Control	2.5	17	7.005	+ .15
	Urea $level_1$	2.5	17	7.112	+ .20
	Urea $level_2$	2.5	17	7.114	+ .10
110	Control	2.5	17	8.309	+ .33
	Urea $level_1$	2.5	17	7.682	+ .25
	Urea $level_2$	2.5	17	7.596	- .10
Means	Control	2.5	17	7.348	+ .243
	Urea $level_1$	2.5	17	7.148	+ .203
	Urea $level_2$	2.5	17	7.397	+ .033

Table 5. The yield and chemical composition of the milk.

		Milk yield, kg/cow/day		Milk composition, %				
Cow no.	Treatments	Actual	4% FCM	Fat	Total solids	Solids-not-fat	Crude* protein	NPN, mg/100g
104	Control	12.110	13.018	4.50	13.58	9.08	3.2559	24
	Urea level$_1$	12.218	12.859	4.35	13.80	9.45	3.5525	27
	Urea level$_2$	13.141	13.968	4.42	13.17	8.75	3.6818	24
105	Control	9.787	9.874	4.06	13.50	9.44	3.6056	26
	Urea level$_1$	11.408	11.921	4.30	13.24	8.94	3.5225	25
	Urea level$_2$	8.168	8.413	4.20	13.64	9.44	3.7609	28
110	Control	13.173	13.449	4.14	13.96	8.82	3.7785	26
	Urea level$_1$	8.112	8.370	4.21	13.30	9.09	3.6735	26
	Urea level$_2$	9.676	10.255	4.40	13.96	9.56	3.4231	28
Means	Control	11.690	12.113	4.23	13.34	9.11	3.5466	25.33
	Urea level$_1$	10.580	11.050	4.29	13.44	9.16	3.5828	26.00
	Urea level$_2$	10.330	10.878	4.34	13.59	9.25	3.6219	26.66

* Nitrogen x 6.38

Table 6. Effect of two levels of concentrate urea upon various traits of rumen fluid.

			Nitrogen, mg/100 ml fluid				N.P.N. as	Ammonia N as	Urea N as
Cow no.	Treatments	PH	Total	N.P.N.	Ammonia	Urea	% of total N	% of total N	% of total N
104	Control	6.97	50.5	16.4	10.5	1.30	32.47	20.79	2.57
	Urea $level_1$	6.68	61.3	20.2	13.1	2.00	32.95	31.37	3.26
	Urea $level_2$	6.05	70.2	23.4	15.2	1.52	33.33	21.65	2.16
105	Control	6.90	55.4	18.6	9.8	1.10	33.57	17.68	2.00
	Urea $level_1$	6.65	69.4	22.4	12.9	1.20	32.27	18.85	1.72
	Urea $level_2$	6.25	70.3	28.3	14.3	1.25	40.25	20.34	1.77
110	Control	6.90	63.7	15.3	10.7	.95	22.73	16.79	1.50
	Urea $level_1$	6.83	63.0	24.7	15.4	1.45	39.20	24.44	2.31
	Urea $level_2$	6.20	69.6	26.6	18.9	1.78	38.21	27.15	2.56
Means	Control	6.92^{a*}	56.33^{a}	16.76^{a}	10.33^{a}	1.12^{a}	29.58^{a}	18.42^{a}	2.02^{a}
	Urea $level_1$	6.72^{a}	64.56^{a}	22.43^{b}	13.80^{ab}	1.55^{a}	34.80^{b}	21.46^{ab}	2.43^{a}
	Urea $level_2$	6.16^{a}	70.03^{a}	26.10^{c}	16.13^{bc}	1.52^{a}	37.26^{c}	23.04^{bc}	2.18^{a}

* Means, in each column, followed by the same letter are not statistically different.

Table 7. Effect of two levels of concentrate urea upon various traits of blood plasma.

Cow no.	Treatments	Protein N, g/100 ml	Non-Protein N, mg/100 ml	Urea N, mg/100 ml
104	Control	2.55	24.80	9.01
	Urea $level_1$	2.43	23.95	11.93
	Urea $level_2$	2.52	22.92	14.11
105	Control	2.72	21.70	8.10
	Urea $level_1$	2.60	24.32	14.70
	Urea $level_2$	2.40	24.10	14.34
110	Control	2.66	23.01	8.45
	Urea $level_1$	2.62	24.85	14.83
	Urea $level_2$	2.38	23.70	14.42
Means	Control	2.64^{a*}	23.17^{a}	8.52^{a}
	Urea $level_1$	2.55^{a}	24.37^{a}	13.82^{b}
	Urea $level_2$	2.43^{a}	23.56^{a}	14.29^{b}

* Means in the same column bearing same letter are not statistically different.

Effects of urea on various characteristics of rumen fluid are shown in Table 6. Increased urea content of concentrate gave rise to appreciably greater amounts of ammonia and non-protein nitrogen ($P < 0.05$). Waite and Wilson (21) reported that the ammonia production resulting from urea feeding can be minimized by increasing the frequency of urea feeding in concentrates without change in the mean total nitrogen content. This would result in more efficient utilization of non-protein nitrogen. In addition to the actual concentrations of ammonia, urea and non-protein nitrogen in the rumen fluid, the proportions of these substances relative to the total nitrogen are also probably important. Considering the proportions, the same general trend was observed. The pH values varied within the narrow limits of 6.05 - 6.97. There was a slight tendency for the rumen pH to fall in cows given rations containing urea. This variation may be closely associated with the rise in total volatile fatty acids which was not determined in this study. However, the pH differences were not statistically significant ($P > 0.05$).

The levels of total nitrogen, urea nitrogen and non-protein nitrogen of blood plasma for the 3 rations are shown in Table 7. Of these, only blood plasma urea concentration was greater in the rations containing urea than the control ration ($P < 0.05$). Tagari *et al.* (18) found a significant correlation between blood urea concentration and nitrogen retention, and suggested that the former is a good index of protein utilization.

Tables 5 and 7 indicate that nearly in all instances there was a general parallelism between the concentration of non-protein nitrogen in the blood and that in the milk. This is confirmed by the study of Rye (15) which suggested that estimation of urea in milk is the simplest method of studying absorption of ammonia from the rumen by blood. Lewis (12) also indicated that there was a direct relationship between rumen ammonia concentration and plasma urea nitrogen. This relation tended to remain fairly constant on any particular diet unless it contained large quantities of soluble protein such as casein. In the latter case, high quantities of rumen ammonia levels were produced and hence resulted in elevated plasma urea nitrogen levels.

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