The use of urea by lactating dairy cows when fed maize silage

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Maize silage is relatively high in energy but low in protein for the normal lactational requirements of dairy cows. Three trials were conducted to compare the use of urea as opposed to natural protein supplements in balancing the supply of energy and protein in maize silage for lactational requirements. Concentrates containing natural protein only were supplemented to meet the nutrient requirements above that supplied by the silage. Seventy-four Friesian cows between 8 and 14 weeks into lactation were used, 10 per treatment using a random block design in Trials A and B, whilst 24, six per treatment, were used in a crossover design in Trial C. The supplementation of maize silage by urea resulted in significantly lower ($P < 0,05$) dry matter intakes, resulting in significantly lower ($P < 0,05$) milk yields for the urea treatments.
S. Afr. J. Anim. Sci. 1986, 16: 87 – 89

Mieliekuilvoer is relatief hoog in energie maar te laag in proteïen vir die normale melkproduksie-behoeftes van melkkoeie. Proewe is uitgevoer om die benutting van ureum te vergelyk met dié van natuurlike proteïenaanvulling om mieliekuilvoer se energie en proteïen te balanseer om aan die voedingsbehoefte te voldoen. Kragvoere wat slegs natuurlike proteïen bevat is aangevul om te voldoen aan die koeie se voedingsbehoefte bokant dit voorsien deur die kuilvoer. Vier-en-sewentig Frieskoeie tussen 8 en 14 weke in laktasie is gebruik. In Proewe A en B is 10 koeie per behandeling in 'n omswaai-proefontwerp gebruik. Aanvulling van mieliekuilvoer met natuurlike proteïen het 'n betekenisvolle hoër ($P < 0,05$) melkopbrengs tot gevolg gehad as die ureumbehandelings. Die hoof bydraende faktor tot die betekenisvolle laer ($P < 0,05$) melkproduksie is skynbaar die betekenisvolle laer ($P < 0,05$) droëmateriaalinname van koeie wat onderwerp is aan die ureumbehandelings.
S.-Afr. Tydskr. Veek. 1986, 16: 87 – 89

Keywords: Maize silage, natural protein, urea, milk yield, dry matter intakes

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Received 10 July 1984

Introduction

The feeding of maize silage is the principal component of the winter feeding regime of many dairy farmers in Natal. This silage is relatively high in energy, but low in protein, necessitating the addition of a protein source if the energy potential of the silage is to be fully used. Sufficient supplementary protein to supply the requirements of approximately 10 kg milk production is required to balance the energy and protein levels.

The use of urea to correct the protein deficiency is normally more economical than the addition of natural proteins (Rys, 1967). However, research results on the use of urea by dairy cows conflict, with no difference found in milk yields of cows fed urea in place of a portion of the natural protein in the diet (van Horn, Foreman & Rodriquez, 1967; Holter, Colvos & Urban, 1968; Plummer, Miles & Montgomery, 1971) Other researchers found that the replacement of natural protein by urea reduced milk yields (Knott, Polan & Huber, 1972; Narasimhalu, Belzile, Brisson & Holtman, 1980; Polan, Miller & McGilliard, 1976; Wohlt & Clark, 1978).

The objective of this study was to investigate the effectiveness of supplementing maize silage with urea, as opposed to natural proteins, to balance the energy to protein ratio in maize silage and therefore save on the amount of natural protein required for efficient milk production.

Materials and Methods

Friesian cows between 8 and 14 weeks into lactation, with a minimum milk production of 98 l per week were selected and blocked into treatments according to milk production, butterfat percentage, bodymass, age, and stage of lactation. All cows were adapted to the treatments for 2 weeks prior to the experiments. Three experiments were conducted in successive seasons.

Experiment A

In this experiment 20 cows were used, blocked into two treatments of 10 cows each. Maize silage from the same source was available *ad lib.* to both treatments. Treatment I received sufficient supplementary natural protein, in the form of a commercial urea-free, high-protein concentrate (HPC) containing 38% CP 'as fed' to balance the energy in the silage for milk production. Treatment II was supplemented with urea and maize meal in such quantities as to ensure that both basal rations were isonitrogenous and isocaloric (Table 1).

Experiment B

Treatments I and II were the same as for Experiment A. An

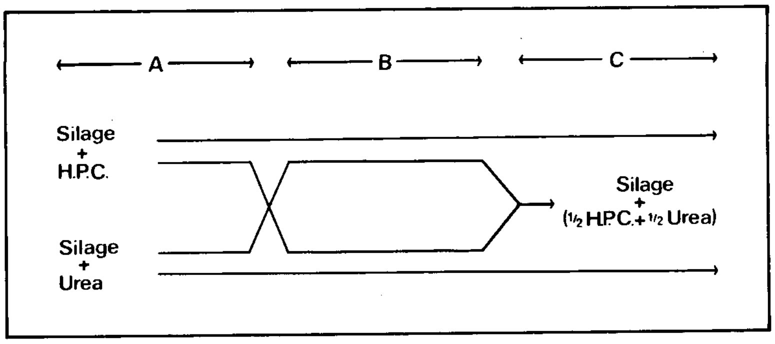

Figure 1 Crossover experimental design used in Experiment C (Magnification = 1,16).

extra treatment consisting of an HPC plus urea mixture (treatment III) was included. The HPC plus urea mixture was such that half the supplementary protein was derived from HPC and half from urea. Thirty cows, 10 per treatment were used.

Experiment C

Twenty-four cows were used, six per treatment, with half on a crossover design (Stokoe, 1983) which consisted of three periods (A,B,C) of 6 weeks each, with an adaptation period of 1 week between periods.

Treatments Ia and IIb were maintained on silage plus HPC and silage plus urea, respectively, for the duration of the experiment (Figure 1). Treatments Ib and IIa were on a crossover design for periods A and B. Treatment Ib received silage plus HPC in period A and silage plus urea in period B whilst treatment IIa received silage plus urea in period A and silage plus HPC in period B. Treatment Ib and IIa were combined for period C and received half their supplementary protein from HPC and half from urea as in Experiment B, treatment III. All diets were isonitrogenous and isocaloric as shown in Table 1.

Table 1 Levels of HPC, urea and maize meal allocated per treatment

	Treatment		
Ingredients	I HPC	III HPC + urea	II Urea
HPC (kg DM/day)	1,35	0,67	–
Urea (g)	–	74	148
Maize meal (kg DM/day)	–	0,585	1,17

In all experiments, supplementary concentrates (ME 11,1 MJ/kg, CP 15%) were fed on an individual basis according to their actual milk and butterfat production, following the Cedara system described by Bredon & Stewart (1978). The concentrates were adjusted weekly.

The cows were milked twice daily with the supplementary concentrates being fed after milking. Fresh silage, incorporating the additional protein sources, was distributed twice daily and the left-over silage weighed back every morning.

Biometrical analysis was done using analysis of variance.

Results

The milk yields for the different experiments and treatments are presented in Table 2. The chemical composition of the silage is presented in Table 3.

Cows in Experiment A subjected to treatment I (HPC) produced a slight but non-significantly higher production than treatment II (urea). In Experiment B, treatment I (HPC) had a significantly higher ($P < 0,01$) milk yield than treatments II and III

In Experiment C the milk production declined significantly ($P < 0,05$) during period A for the urea-supplemented animals (treatments IIa & b). During period B the milk production

Table 2 Milk production and butterfat percentage of cows fed maize silage supplemented with HPC, urea or HPC + urea

	Treatment				
Measurement	I		III		II
Experiment A					
Initial production/day (kg)	13,45				13,31
91-day cumulative production	1097				1052
BF (%)	4,30				4,25
Experiment B					
Initial production/day (kg)	16,02		15,00		15,63
12-week cumulative production	1210**		1084		1043
BF (%)	4,17		4,40		4,33
Experiment C	**Ia**	**Ib**		**IIa**	**IIb**
Initial production/day (kg)	14,62	15,19		14,78	14,20
Period A production (kg)	584	600		545*	554*
BF (%)	4,21	3,99		4,02	4,12
Period B production (kg)	542**	503*		514*	480
BF (%)	4,48	4,17		4,18	4,32
Period C production (kg)	475	–	461	–	429**
BF (%)	4,85	–	4,44	–	4,49
Total (Experiment C)	1600***				1462

***$P < 0,001$; **$P < 0,01$; *$P < 0,05$.

Table 3 Chemical composition of the maize silage used in the experiments expressed as percentage of dry matter

Experiment	Ash	CP	CF	EE
A	4,58	9,05	25,95	2,80
B	4,26	7,80	24,31	2,69
C	3,68	8,47	22,19	2,15

of treatment Ia (HPC) was greater than the two crossover treatments (Ib & IIa) ($P < 0,05$) whilst treatment IIb (urea) was significantly lower than treatment Ia (HPC) ($P < 0,01$) and the crossover treatments Ib & IIa ($P < 0,05$). In Experiment C, period C, treatment IIb (urea) had a significantly lower ($P < 0,01$) milk yield than treatment Ia (HPC) and III (HPC + urea). Over the entire trial cows on treatment Ia (HPC) produced significantly higher ($P < 0,001$) milk yields than treatment IIb (urea).

Bodymass changes over the three experiments for the different treatments did not differ significantly.

The total dry matter intakes for the different treatments are presented in Table 4.

Table 4 Total dry matter intakes of cows (as a percentage of bodymass) fed maize silage supplemented with HPC, HPC + urea or urea

	Treatment		
Experiment	I HPC	III HPC + urea	II Urea
Experiment A	2,46		2,47
Experiment B	2,63**	2,22	2,16
Experiment C — period A	2,93		2,72
— period B	2,93**		2,45
— period C	2,78	2,59	2,21*
Overall for Experiment C	2,88		2,46*

**$P < 0,01$; *$P < 0,05$.

Discussion

In view of the low dry matter intakes, as a percentage of bodymass (2,47 for the urea and 2,46 for the HPC), of both treatments in Experiment A, the results should be regarded with caution. The low intakes in Experiment A appear to be a reflection of the silage quality, which was initially coarse and long. The influence of physical form on voluntary intake in sheep (Deswysen, 1978) would appear to substantiate this.

As the milk production of cows subjected to the two treatments in Experiment A (when the dry matter intakes were comparable) did not differ significantly, the significant differences in the milk production obtained in Experiment B and Experiment C need not reflect significant differences in the use of urea as opposed to the natural protein, but can be ascribed to a reduced dry matter intake, caused by the inclusion of urea, in all the trials except period A of Experiment C.

The adverse effect of urea on dry matter intakes has been reported previously (van Horn, *et al.*, 1967; Holter, Colvos & Urban., 1968; Polan, *et al.* 1976; Narasimhalu, *et al.*, 1980). The mechanism of intake depression by urea is not as yet clearly understood (Huber & Kung, 1981).

The daily intake of urea in the present experiment was 0,29 g/kg bodymass, whereas Huber (1976) indicated that 0,39 g/kg bodymass is the maximum intake permissible before causing intake depression. The latest theory on non-protein nitrogen (NPN) supplementation recognizes that many natural feedstuffs, particularly silages, contribute NPN to the ration and these sources should be considered in calculating the overall NPN content of the diet (Huber, Jacobson, Allen & Hartman, 1961; Wohlt & Clark, 1978). Waldo (1968) found that up to 75% of the crude protein in maize silage may be in the form of non-protein nitrogen.

Conrad & Hibbs (1968) found that an intake of 0,4 – 0,5 g NPN/kg bodymass coincided with decreased feed intakes. The levels of NPN in the maize silage used in the experiment was 46% of the crude protein in Experiment B and 40% in Experiment C. At these levels the critical level of 0,40 g NPN/kg bodymass was exceeded for the urea-supplemented treatment when the total NPN level was calculated from both silage and urea. The NPN content of the diet may explain the difference in the dry matter intakes between the HPC and urea treatments in Experiment B and C. In Experiment C the NPN intake was 0,4 g NPN/kg bodymass, whilst in Experiment B (at the significantly reduced intakes) the intake was 0,41 g NPN/kg bodymass.

In conclusion it was found that cows on the HPC-supplemented treatments produced 11,2% more milk overall than the urea-supplemented treatments. The HPC plus urea combination produced variable results, dependant upon the NPN content of the maize silage. The economic advantage of using either urea or natural protein to balance maize silage for energy and protein will depend upon the relevant milk price and the urea:natural protein price ratio.

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