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UREA CONCENTRATION IN BULK MILK AS AN INDICATOR OF THE PROTEIN SUPPLY AT THE HERD LEVEL

By

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REFSDAL, A. O., L. BÆVRE and R. BRUFLOT: *Urea concentration in bulk milk as an indicator of the protein supply at the herd level.* Acta vet. scand. 1985, *26*, 153—163. — Levels of urea in bulk milk from 80 herds were analysed twice monthly during 1 year to study herd variations and effect of season (Experiment 1). The overall (mean ± s) was 4.7 ± 1.3 mmol/l ranging from 1.4 to 10.0 mmol/l. Generally, the urea levels were high in summer and early autumn and during this period there were 3 peaks, the first one at the beginning of June, the second one in the middle of July and the third one at the end of September. The peaks reflected feed changes and use of fertilizers commonly practized in the area.

In another study samples of bulk milk were obtained from 49 herds using single forage diets with fresh grass silage and standardized concentrate mixtures (Experiment 2). In these herds all feed components given on the day of urea sampling were weighed as accurately as possible and a sample of the silage was taken for chemical analyses and determination of in vitro digestibility. Mean level of crude protein (CP) in silage dry matter was 15.6 ± 2.2 % and average dietary digestible crude protein (DCP) per feed unit (FU) was 146 ± 16 g. In all herds the protein levels in the total daily ration were equal to or above recommended standards. Urea concentration in bulk milk was significantly affected by the CP content in silage, level of dietary DCP and amount of DCP/FU. In energy deficient herds relatively high urea values were obtained without any great surplus of protein. Yield did not significantly affect the urea concentration in bulk milk.

cow; protein/energy supply; season; yield.

Lack of information about the protein content in the feed may lead to nitrogen shortage or an inbalance in the ration resulting in low production, metabolic disorders or fertility problems. Control of the protein/energy balance is a problem in many herds. Variations in climatic conditions, stage of maturity at harvest, use of fertilizer and the botanic composition of the herbage may cause great variations in feed quality between herds and within herds.

The protein content in roughage is generally assessed from feed tables. Chemical analyses are rarely performed. When silage is used as the main roughage during winter, which is the case for many Norwegian herds, the content of protein in the silage is an important, usually unknown factor. Thus, there is a need for an indicator to reflect the protein content in the feed.

Urea concentration in milk is related to the protein/energy ratio in the diet (e.g. *Kaufmann* 1982, *Oltner et al.* 1983), and according to *Payne et al.* (1970) and *Hewett* (1974) serum urea-N is affected by the level of dietary protein. As shown by *Refsdal* (1983) there is a good correlation between herd means of urea in blood and urea in bulk milk, indicating that analyses of bulk milk can be used to reflect the status of the herd.

The present investigation was undertaken to study the urea levels in bulk milk from Norwegian herds and to study the relationship between the concentration of urea in bulk milk and the content of protein and energy in the feed ration at the herd level.

Another objective was to find out whether urea levels in bulk milk can be used to reflect the protein content in silage when using single forage diets combined with standardized concentrate mixtures.

MATERIAL AND METHODS

Urea in bulk milk was analysed in 2 experiments. In Experiment 1 bulk milk was obtained twice monthly from 80 herds in the eastern part of Norway from May 1983 to May 1984. During the winter, most of the herds were fed fresh grass silage and concentrates as the main ingredients of the ration. However, the diets varied between herds and with season and in some herds roots, hay and ammonia treated straw were given additionally. During the summer most of the cows were out at pasture but in some herds zero grazing was practized.

Experiment 2 was carried out in February 1984 and comprised 49 herds in the western part of Norway. These herds were fed single forage diets consisting of fresh grass silage. The concentrates mainly used were standardized concentrate mixtures with 12.5 % digestible crude protein (40 herds). Nine herds used concentrates with 15 or 30 % digestible crude protein (DCP) in addition, to increase the protein supply.

The concentrate levels were based on recommended standards stipulated to meet the requirements for protein, energy and minerals. All feed components given in one day were weighed as accurately as possible and a sample of the silage was taken for dry matter (DM) determination and analyses of chemical components and in vitro digestibility.

Based on this information, the amount of DCP and energy (feed units*) fed to the lactating animals were calculated and related to the requirements for milk production and maintenance. Bulk mik samples for urea analyses were taken once at the time of feed control.

In both experiments the samples of bulk milk comprised both morning and afternoon milk. The samples were thoroughly mixed before processing. The urea analyses normally took place on the day following sample collection. If not, the samples were kept at 4°C and analysed the next day. All the samples were prosessed in a Technicon Auto-Analyser II according to a method described by the manufacturer.

RESULTS

The concentration of urea in bulk milk in Experiment 1 ranged from 1.4 to 10.0 mmol/l with an overall mean of 4.7 ± 1.3. There was a significant difference ($P < 0.005$) between the highest mean value obtained in June (5.4 ± 1.9 mmol/l) and the lowest mean in November (4.5 ± 0.9 mmol/l) (Fig. 1). Generally, the concentration of urea in bulk milk was high in the summer and early autumn and during this period there were 3 peaks, the first one at the beginning of June, the second one in the middle of July and the third one at the end of September. During the stall feeding period the monthly variation in the urea means was small. As indicated in Fig. 1, the herd differences were more pronounced during the summer and early autumn than in the stall feeding period.

In Experiment 2 the urea concentration in samples of bulk milk ranged from 3.5 to 7.0 mmol/l with an overall mean of 4.7 ± 0.8 mmol/l. The content of CP in silage DM ranged from 11.2 to 22.1 % and averaged 15.6 ± 2.2 %. The amount of CP in silage DM affected significantly the level of urea in bulk milk

* Feed unit (FU) = 1650 NK_F (Kcal, net energy for fattening).

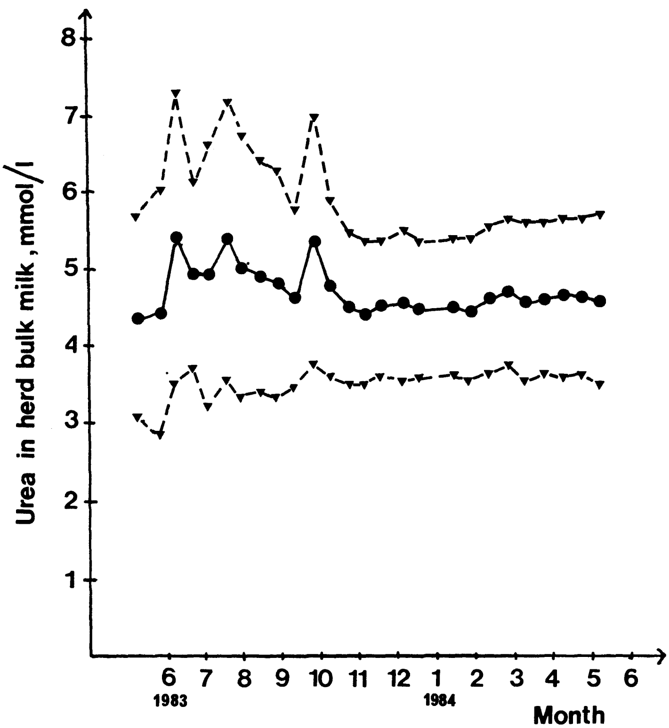


Figure 1. Seasonal variation in bulk milk urea (mean ± s) in 80 herds.

(r = 0.46, P < 0.001). When selecting herds (n = 40) using only standardized concentrate mixtures with 12.5 % DCP together with the silage (Fig. 2), a good correlation was found between the amount of CP in silage and urea in bulk milk (r = 0.64, P < 0.001). Urea concentration in bulk milk was also significantly affected by the amount of DCP per FU in the daily ration (Table 1). Average dietary DCP per FU in the total feed ration was 146 ± 16 g ranging from 112 to 193 g for all the herds. The amount of DCP per FU in silage only, averaged 163 g with a range of 102 to 251 g.

The protein supply in the herds was equal to or in excess of recommended standards. On an average the excess was 389 ± 239 g DCP per cow. Mean concentrations of urea in bulk milk in herds fed a large excess of DCP (> 350 g) and in herds fed a low excess of DCP (< 350 g) were 5.2 ± 0.8 and 4.4 ± 0.8 mmol/l respectively, the difference being significant (P < 0.01).

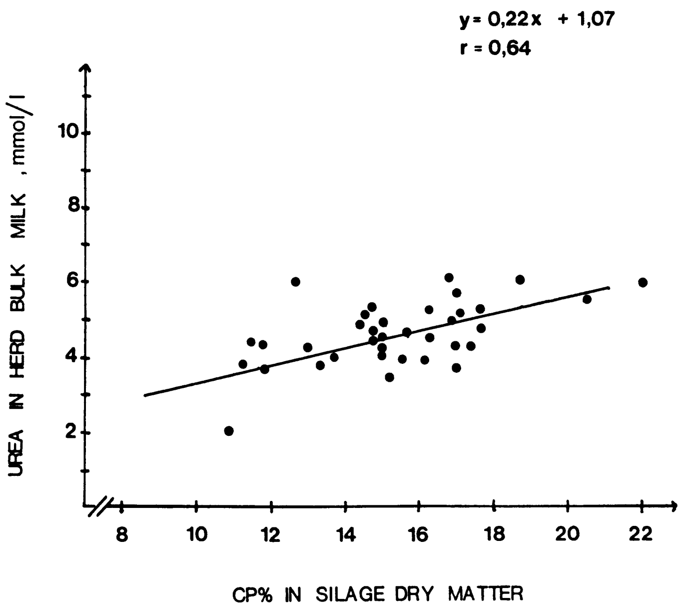


Figure 2. Effect of crude protein (CP) content in silage on urea levels in bulk milk from herds (n = 40) using single forage diets with standardized concentrate mixtures containing 12.5 % digestible crude protein.

Table 1. Effect of dietary digestible crude protein (DCP) per feed unit (FU) on urea levels (mean ± s) in herd bulk milk.

DCP (g)/FU	No. herds	Urea (mmol/l)	
≤ 140	16	4.26 ± 0.84	a_1
140—150	15	4.61 ± 0.71	a_2
≥ 150	18	5.28 ± 0.86	b
Mean ± s	49	4.70 ± 0.80	

b: vs a_1, $P < 0.01$
vs a_2, $P < 0.05$

In herds with negative energy balance (< — 0.5 FU), zero energy balance (± 0.5 FU) and positive energy balance (> + 0.5 FU) urea levels (mean ± s) in bulk milk were 5.1 ± 0.8, 4.5 ± 0.9 and 4.7 ± 1.0, respectively. The differences were not significant ($P > 0.05$). The average excesses of DCP fed in the three energy groups were 249 ± 150, 328 ± 147 and 560 ± 278 g per animal and day.

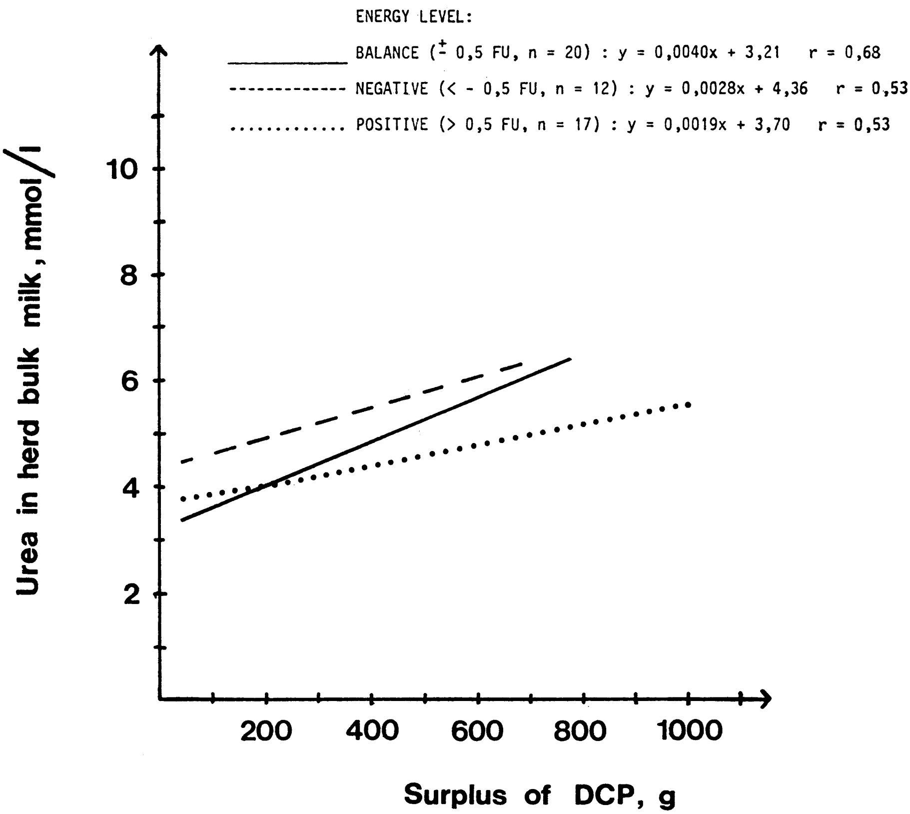
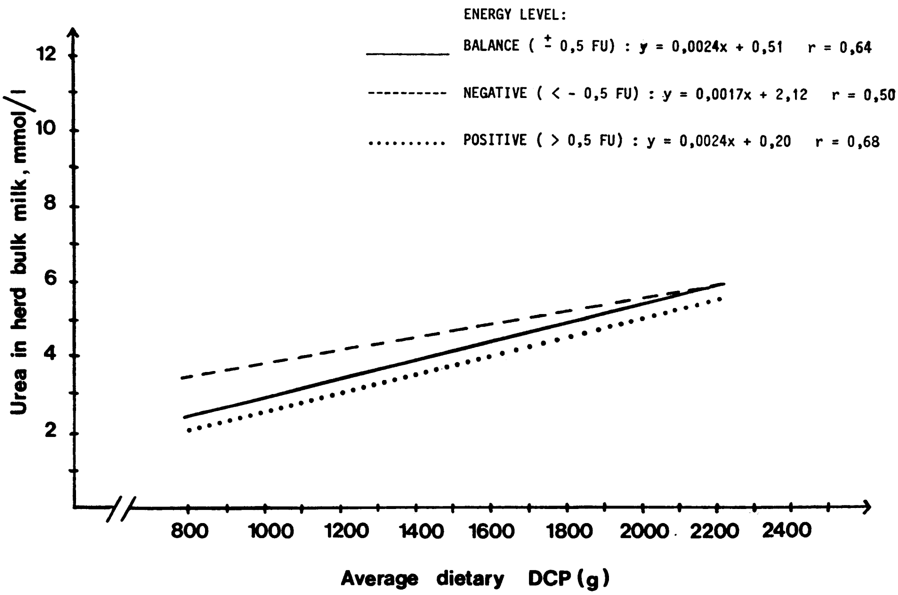


Figure 3. Effect of protein excess (per animal and day) on urea in bulk milk in herds on different dietary energy levels.

As shown in Fig. 3 the relationship between urea in bulk milk and excess DCP fed was more pronounced in herds with balanced energy levels (± 0.05 FU) than in herds low (< — 0.5 FU) or high (> + 0.5 FU) energy levels.

The relationships between total amount of DCP in the ration and urea in bulk milk in herds on different energy levels are shown in Fig. 4. In all groups there was an increase in concentration of urea in bulk milk with increasing levels of dietary DCP, but as shown in Fig. 3 the urea values may be high at relatively low protein levels in herds with energy deficit.

Table 2 shows the mean concentration of urea in bulk milk in high yielding (> 19.0 kg FCM) and in low yielding (< 19.0 kg FCM) herds. The difference in urea means is not significant ($P > 0.05$).



F i g u r e 4. Effect of amount DCP (per animal and day) on urea in bulk milk in herds on different dietary energy levels.

T a b l e 2. Urea in bulk milk as related to herd means of fat corrected milk (FCM).

FCM, kg Herd mean	No. herds	Urea (mmol/l) ± s	
> 19.0	25	4.98 ± 0.88	a
< 19.0	24	4.49 ± 0.88	b

a vs b: not significant (P > 0.05).

DISCUSSION

In agreement with *Payne et al.* (1970), using a metabolic profile test, the urea levels in bulk milk in Experiment 1 tended to be low on conventional indoor winter rations and high under grazing conditions. However, the urea levels were very variable and big herd differences were observed.

The urea peak occurring in early June seems to reflect the change from indoor winter ration to grazing on heavily fertilized pastures. The second urea peak, in the middle of July, probably reflects the use of grass well dressed after the first cut of grass for silage. The third urea peak, at the end of September, is probably caused by diets comprising green fodder like kale and annual rye grass, commonly used in relatively large amounts at this time of the year in the area. In Experiment 1 the ration varied between herds and with season. During the winter grass silage was the main roughage fed, but in periods some farmers used roots, hay, straw, etc. in addition. In individual herds urea in bulk milk very often reflected such changes in the composition of the diet.

In herds using a single forage diet, urea in bulk milk can be used to indicate crude protein content of the silage. In herds fed concentrates with 12.5 % digestible crude protein only, urea concentration in bulk milk seems to be a specially useful indicator of the crude protein content in the silage.

This would be expected, since relatively easily degradable protein in silage represents by far the greatest variation in dietary protein supply between these herds. In Norway single forage diets with fresh grass silage are commonly used. Therefore, these results could be of some practical value.

In many of the herds, excessive amounts of protein were given mainly because of high protein levels in the silage. Therefore, the use of single forage diets with grass silage, seems to involve a risk of feeding excessive amounts of protein, especially so far as low producing animals are concerned.

The urea concentration in bulk milk increased significantly with increasing excess of protein. However, energy levels have to be taken into account in the interpretation of the urea levels. As earlier shown by *Kaufmann* (1982) and *Oltner et al.* (1983), the milk urea concentration is to a great extent related to the protein/energy ratio. This is in agreement with our results based on one day feed control. In herds deficient in energy, relatively high levels of urea in bulk milk was found even though the excess of protein fed was moderate.

As regards the possibility of using urea analyses to reflect the dietary protein/energy ratio at the herd level, the results are promising. In herds fed 140—150 g DCP/FU, which is close to the recommended standard for milk production, the mean urea level in bulk milk was 4.6 mmol/l. In cases where the urea concentration in bulk milk deviates much from this value, it seems reasonable to initiate a control of the nutritional status of the herd.

Analyses of urea in bulk milk reflect the protein/energy ratio at the herd level only. Individual cows may to a great extent differ from the general pattern in the herd. Therefore, individual milk samples should be taken in order to obtain more exact information about the nutrional status of individual cows, although, according to *Oltner et al.* (1983), quite pronounced differences in urea concentration exist between individual cows at the same feeding level.

As shown by *Hewett* (1974) serum urea-N values rise sharply from their nadir directly after calving up to the second month, following which values vary somewhat unpredictably. Therefore, in herds with a concentrated calving season, urea in bulk milk may be low shortly after this period, a fact that has to be taken into account in the interpretation of the results. Autumn was the main calving season in Experiment 2, which means that most of the animals were at a relatively late lactational stage at the time of investigation.

Yield did not significantly affect the concentration of urea in bulk milk ($P > 0.05$), but in agreement with *Kaufmann* (1982) and *Oltner et al.* (1983) the urea levels tended to be higher in high producing than in low producing herds.

Feeding excessive amounts of protein may cause detrimental effects on health and fertility (*Jordan & Swanson* 1979, *Lotthammer* 1979, *Piatkowski et al.* 1981 and *Kaim et al.* 1983).

In Norwegian herds, a high percentage of silage in the ration seems to be related to low fertility (*Refsdal* 1976). One reason for this may be that when silage is used as the main roughage, the protein/energy ratio tends to increase. Excessive amounts of relatively easily degradable silage protein will result in an accumulation of ammonia in the rumen, causing increased formation of urea in the liver. According to *Hewett* (1974) and *Depke* (1981) high urea levels are associated with fertility problems.

In conclusion, analyses of urea in bulk milk can be used to reflect the content of crude protein in silage in herds using single forage diets with standardized concentrate mixtures according to Norwegian recommendations.

Analyses of urea in bulk milk also seem to be a practical way of controlling the protein/energy ratio in the feed at the herd level.

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SAMMENDRAG

Ureanivå i gårdstankmelk som indikator på proteinforsyningen i besetningen.

Måling av urea i tankmelk ble foretatt for å studere årstidsvariasjoner og variasjoner mellom besetninger (Forsøk 1). Melkeprøver ble tatt hver 14. dag fra 80 besetninger i perioden mai 1983—mai 1984.

Ureamiddel ($\bar{x} \pm s$) for samtlige prøver var 4,7 ± 1,3 mmol/l og konsentrasjonen i enkeltprøver varierte fra 1,4 til 10,0 mmol/l. Ureanivået var generelt noe høgere i beitetiden enn i innefôringsperioden. I beitetiden ble det registrert tre ureamaksima (primo juni, medio juli og ultimo september). Disse maksima reflekterte gjødslingsrutiner og fôrforandringer som er vanlige i området.

I en annen undersøkelse ble ureanivået i tankmelk relatert til fôringa i besetninger (n = 49) med ensidig bruk av grassurfôr og standard kraftfôrblandinger (Forsøk 2). Daglig tilførsel av surfôr og kraftfôr ble kontrollert og surfôrprøver undersøkt ved hjelp av kjemiske analyser og bestemmelse av in vitro fordøyelighet. Gjennomsnittlig råproteininnhold pr. kg surfôrtørrstoff var 15,6 ± 2,2 %, og mengde fordøyelig råprotein pr. fôrenhet (FE) i den totale dagrasjon var 146 ± 16 g i middel for alle besetninger. Proteinforsyningen i besetningene var høgere enn anbefalte normer eller på linje med disse. Ureanivået i tankmelk var signifikant positivt korrelert til råproteininnholdet i surfôr, tilført mengde fordøyelig råprotein pr. ku og nivå av fordøyelig råprotein pr. FE i dagsrasjonen. Ved energiunderskudd var ureanivået ofte relativt høgt selv på moderate proteinrasjoner. Det ble ikke påvist noen signifikant sammenheng mellom ydelse og ureakonsentrasjonen i tankmelk.

Undersøkelsen viser at bestemmelse av urea i gårdstankmelk kan brukes til å avspeile forholdet mellom protein og energi i fôrrasjonen på besetningsnivå. Ved ensidig bruk av grassurfôr og standard kraftfôrblandinger etter norm, kan også ureamålinger i tankmelk brukes for å avspeile råproteininnholdet i surfôr.

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