Breeding and Feeding the High Genetic Merit Dairy Cow
Occasional Publication No. 19 — British Society of Animal Science 1995
edited by T. L. J. Lawrence, F. J. Gordon and A. Carson

Water, sodium, potassium and chlorine balance during late pregnancy and early lactation in high-yielding dairy cows under winter Mediterranean conditions

N. Silanikove[1], E. Maltz[2], A. Halevi[1] and D. Shinder[1]

[1]*Institute of Animal Science*
and
[2]*Institute of Agricultural Engineering, Agricultural Research Organization, Volcani Centre PO Box 6, Bet Dagan 50250, Israel*

Introduction

Water turn-over (WTO) rate in dairy cows is among the highest recorded in mammals (Shalit, Maltz, Silanikove and Berman, 1991). Likewise, secretion of sodium (Na), potassium (K) and chlorine (Cl) in milk markedly increases their output, so that in some cases the amount of Na and Cl secreted *via* milk is larger than that lost in urine (Shalit *et al.*, 1991). The balance of water, Na, K and Cl in dairy cows was studied under hot Mediterranean summer conditions (Shalit *et al.*, 1991). It was found that at initiation of lactation, when dry-matter intake (DMI) is still limited and hot weather obstructs its rapid increase, the current National Research Council (1989) recommendations for providing these ions as concentration in the diet were not met. The negative balance of Na, K and Cl was associated with marked reduction of their loss in excreta, particularly Na and Cl. The deficiency in Na, K and Cl might have limited sweat secretion, and hence reduced thermoregulation efficiency of the cows and perhaps even negatively affected milk production (Shalit *et al.*, 1991). As the increase in milk secretion in early lactation is faster than the increase in DMI, it was suggested that initiation of lactation probably is, in itself, a factor that may cause ion depletion (Shalit *et al.*, 1991); this assumption was examined in the present study.

Material and methods

During the winter, water, Na, K, and Cl balance was measured in six polyparous Israeli Holstein cows at 2 weeks before calving (period 1), 2 weeks *post partum* (period 2), and 7 weeks *post partum* (period 3) as described by Shalit *et al.* (1991). Average night and day temperatures were 12°C and 14·2°C respectively and relative humidity 0·85 to 0·93. Data were analysed with cow, period and their interaction as the independent terms in the model. Statistical significance ($P < 0·05$ or better) was assessed by the contrast routine.

Results

Live weight, DMI, milk yield and body temperature

Live weight was 654, 550, and 550 kg in periods 1, 2, and 3, respectively and milk yield was 29·4 and 41·5 l/day in periods 2 and 3 respectively. There were no notable fluctuations in rectal body temperature between the morning, noon and evening within each period; the temperature of the cows in the three experimental periods was approximately 38·6°C.

Water balance

WTO rate was 2·65 and 3·29 times greater in periods 2 and 3 than in the pre-partum period (Table 1). Drinking water accounted for proportionately about

Table 1 *Water balance (kg/day) in six cows two weeks before calving (period 1), 2 weeks* post partum *(period 2) and 7 weeks* post partum *(period 3)*

	Drinking	Within food†	Total intake	In milk	Urinary	Faecal	RCW‡
Period 1	36·2[a]	4·8[a]	41·0[a]		11·7[a]	18·7[a]	10·6[a]
Period 2	87·3[b]	21·4[b]	108·7[b]	34·9	11·8[a]	25·3[b]	36·9[b]
Period 3	106·6[b]	28·4[c]	135·0[c]	37·0	15·4[b]	36·1[c]	41·4[b]
MCV§	21·0	3·4	10·2	6·4	3·0	5·9	14·5

[a,b,c] Within rows, means having different superscript differ at $P < 0·05$.
† Moisture plus metabolic, metabolic water was calculated assuming 1 kg H_2O per 1 kg OM digested.
‡ RCW = Respiratory-cutaneous water output, calculated as total intake minus milk, urinary and faecal loss.
§ MCV = Mean critical value for differences between periods.

0·9 of the WTO rate during the pre-partum period and for 0·8 during periods 2 and 3. Loss of respiratory-cutaneous water (RCW) was the main component of the water output, accounting for proportionately 0·25 of the WTO rate pre-partum and about 0·34 in periods 2 and 3. Loss of RCW in the lactating cows was linearly and positively related to DMI (no. = 12, R^2 = –0·78, $P < 0·004$), WTO rate (no. = 12, R^2 = 0·97, $P < 0·0001$), and negatively to milk yield (no. = 12, R^2 = –0·75, $P < 0·006$).

Water loss in faeces was the third largest avenue of loss, accounting for proportionately 0·23 and 0·27 of the WTO rate during lactation (periods 2 and 3, respectively) and for 0·46 *pre-partum*. Faecal water excretion was linearly related to DMI (no. = 18, R^2 = 0·97, $P < 0·0001$), WTO rate, and free water intake (FWI) (no. = 18, R^2 = 0·93, $P < 0·0001$).

The water excreted *via* urine had the smallest contribution to total water loss, accounting for proportionately 0·29 of the WTO rate in period 1, and 0·11 in periods 2 and 3. Urinary water excretion was linearly and positively related to DMI (no. = 18, R^2 = 0·55, $P < 0·01$), WTO rate (no. = 18, R^2 = 0·47, $P < 0·05$), Na, K and Cl intakes (no. = 18, R^2 = 0·68 to 0·70, $P < 0·001$ to 0·002), and excretions of urea, Na, K and Cl in urine (no. = 18, R^2 = 0·48 to 0·54, $P < 0·05$ to 0·01).

The milk free-water balance (MFWB) (WTO rate minus water excreted in milk) can be very efficiently predicted during summer and winter in lactating and non-lactating cows by the following equation: MFWB = 12·7 + digestible energy intake (MJ/day) × 0·13 + RCW loss (kg/day) × 0·97 (no. = 33, R^2 = 0·96, $P < 0·0001$).

Ion balance
Ion balance is represented by K balance (Table 2), the balance of Na and Cl showed a similar trend (data not presented). As a result of the increase in DMI in period 3, total K intake in this period became significantly higher ($P < 0·05$) than in periods 1 and 2. Urine K excretion accounted for proportionately 0·96, 0·56, and 0·46 of total K intake in periods 1, 2, and 3, respectively.

Table 2 *Potassium balance (meq/day) in six cows two weeks before calving (period 1), two weeks* post partum *(period 2) and seven weeks* post partum *(period 3)*

	Total intake	In milk	Urinary	Faecal	Retention
Period 1	2693[a]		2583[a]	397[a]	–288
Period 2	3219[a]	1746	1796[b]	611[a]	–925
Period 3	4763[b]	1847	2176[ab]	1201[b]	–461
MCV†	619	360	596	299	630

[a,b,c] Within rows, means having different superscript differ at $P < 0·05$.
† MCV = Mean critical value for differences between periods.

The ratio between milk K excretion and total K intake was similar to that of urine K excretion, and accounted for proportionately 0·54, and 0·34 in periods 2 and 3, respectively. The amount of K excreted *via* milk was similar in periods 2 and 3. Faecal K excretion accounted for proportionately 0·15, 0·19, and 0·25 of total K intake in periods 1, 2, and 3, respectively. The amount of K excreted during lactation (periods 2 and 3) was significantly ($P < 0·05$) higher than that *pre-partum* (period 1).

K balances ranked in the order period 3 > 2 > 1 ($P < 0·05$), being negative in periods 1 (–0·11 of the total intake), 2 (–0·29 of the total intake, and –0·62 of the milk free intake), and 3 (–0·10 of the total intake. There were relatively large differences between the three periods in the average value; however, due to the large standard deviations these differences were not statistically significant.

Conclusions

The present study indicated that in addition to the two well known factors that dictate FWI and WTO rate in dairy cows, namely DMI and milk yield. RCW loss also becomes a significant factor in cows yielding 40 l/day, even under temperate environmental conditions. This is most likely a result of activation of sweating in response to the large increment in the internal heat production. The present results also support the conclusion that DMI is the major limiting factor in the ability of the cows to satisfy their needs for Na, K, and Cl in early lactation. The cow's demand for Na, Cl, and, particularly, K, cannot be satisfied completely by the current NRC (1989) recommendations. A deficiency in these ions may limit the ability of cows to produce maximal amounts of milk and may be involved in complications typical to the early stages of lactation.

References

National Research Council. 1989. *6th rev. ed., updated 1989.* National Academy of Science, Washington, DC.

Shalit, U., Maltz, E., Silanikove, N. and Berman, A. 1991. Water, sodium, potassium and chlorine metabolism of dairy cows at the onset of lactation in hot weather. *Journal of Dairy Science* **74:** 1874.