REDUCING LACTATING COWS' DIETARY SODIUM TO REDUCE THE ENVIRONMENTAL COST OF DAIRY FARMS

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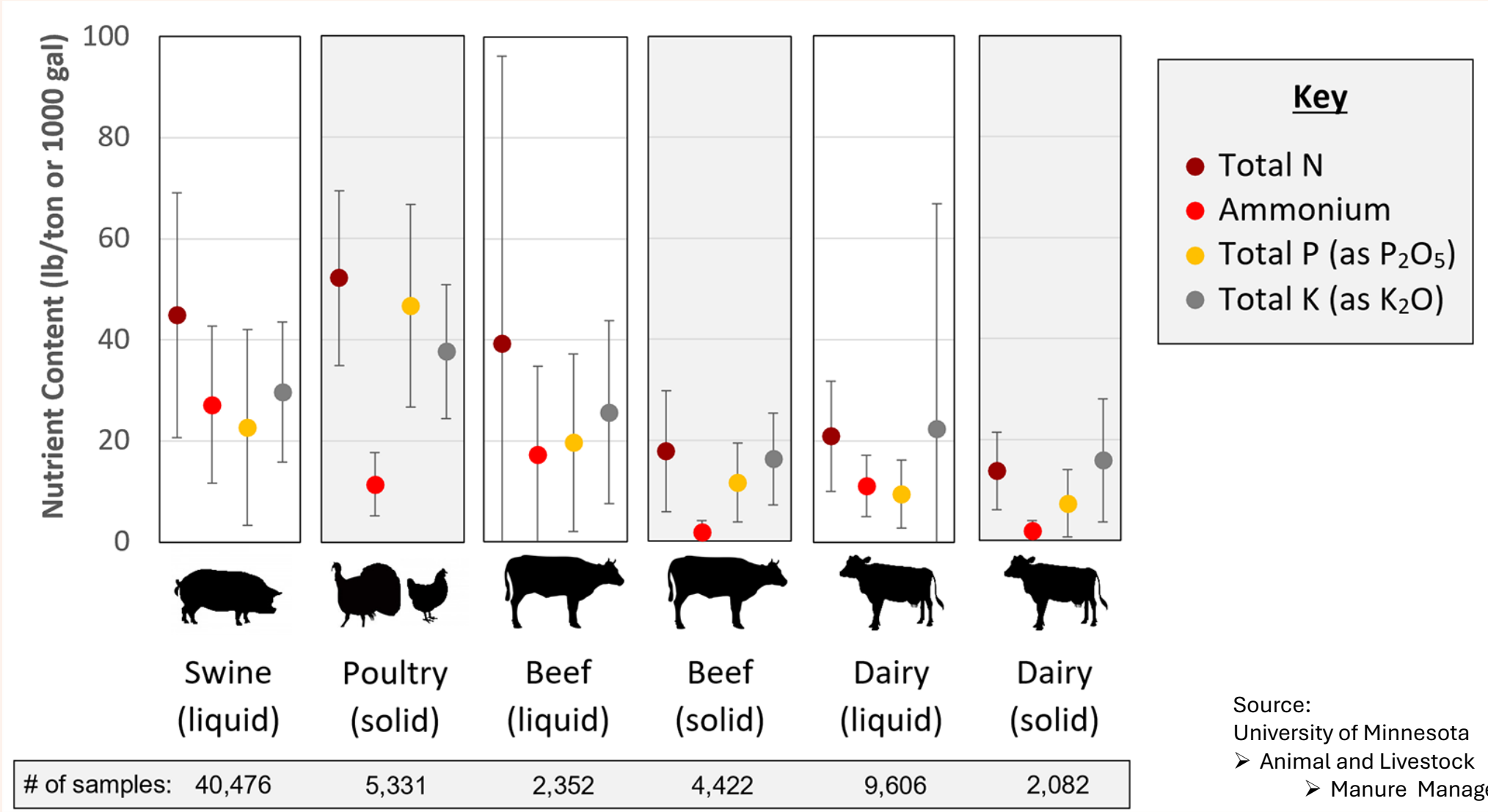
Introduction

- Sodium (**Na**) is vital for dairy cows
- **This mineral is absorbed from the diet with high efficiency (Schonewille &Beynen, 2005)**
- Excesses are excreted and needs replacing.

Introduction – Livestock Manure

- Animal manures are a valuable source of nutrients for crop growth **(Kapkiyai et al., 1999; Jokela, 1992).**
- Each manure has unique characteristics based on the farm operation

Introduction – Livestock Manure



Source:
University of Minnesota
- Animal and Livestock
  - Manure Management

Introduction – Livestock Manure

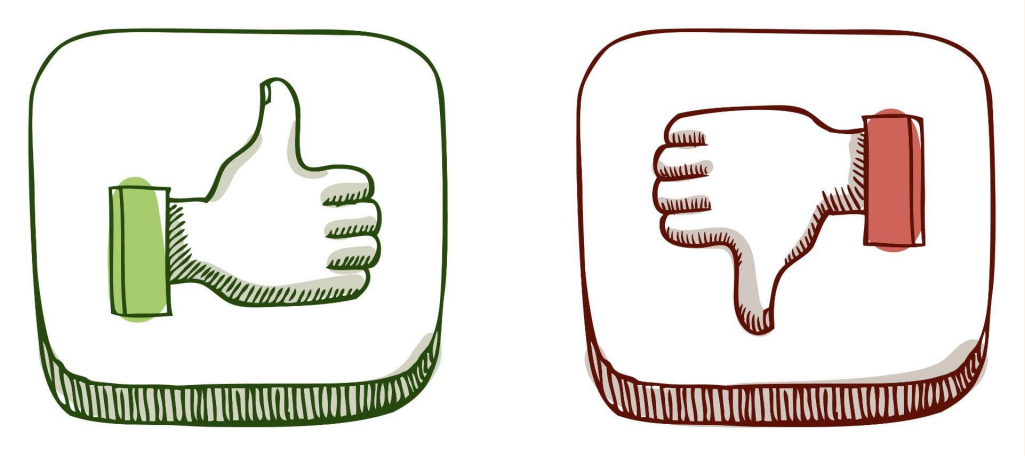
- The high salt content in cattle manure increase the risk of surface and groundwater contamination **(Jokela, 1992, Chang and Entz, 1996)**
- Overfeeding leads to increased excretion in feces and urine **(Norell & Chahine, 2014)**

Introduction – Are we overfeeding Na?

- Positive correlation between Na Intake and Na% in manure **(Norrel & Chahine, 2005)**
- Excessive manure application increase the risk of contamination of groundwater **(Chang et al., 1991,Peters and Basta, 1996)**
- Salt is can accumulate in the soil **(Liebhardt and Shortall, 1974, Pratt, 1984, Chang et al., 1991, Lu and Edwards, 1994)**

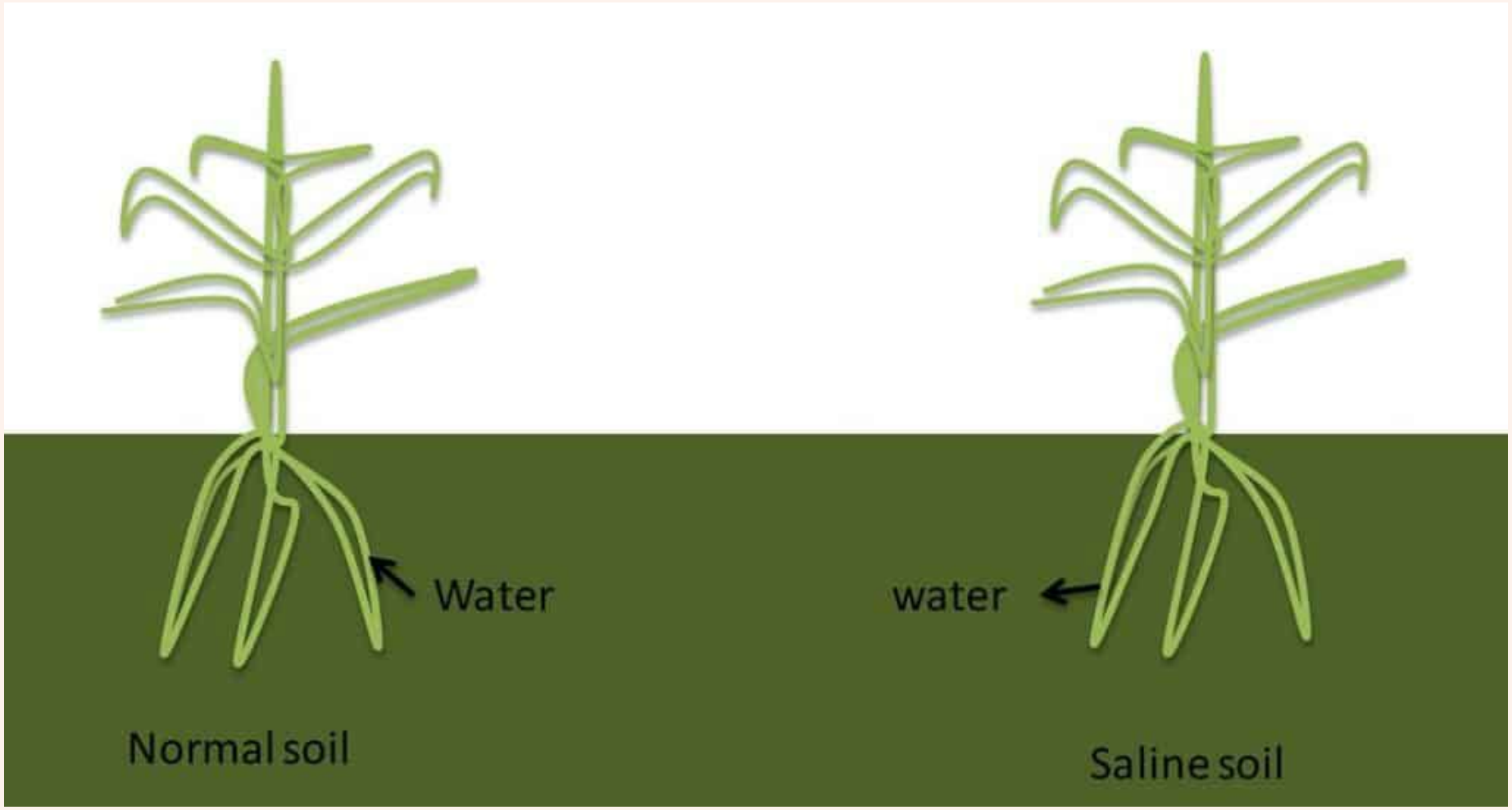
Introduction – Are we overfeeding Na?

- **Clark et al. (1998)** concluded that applying livestock manure did not increase salinity during the 8-year period of their study.

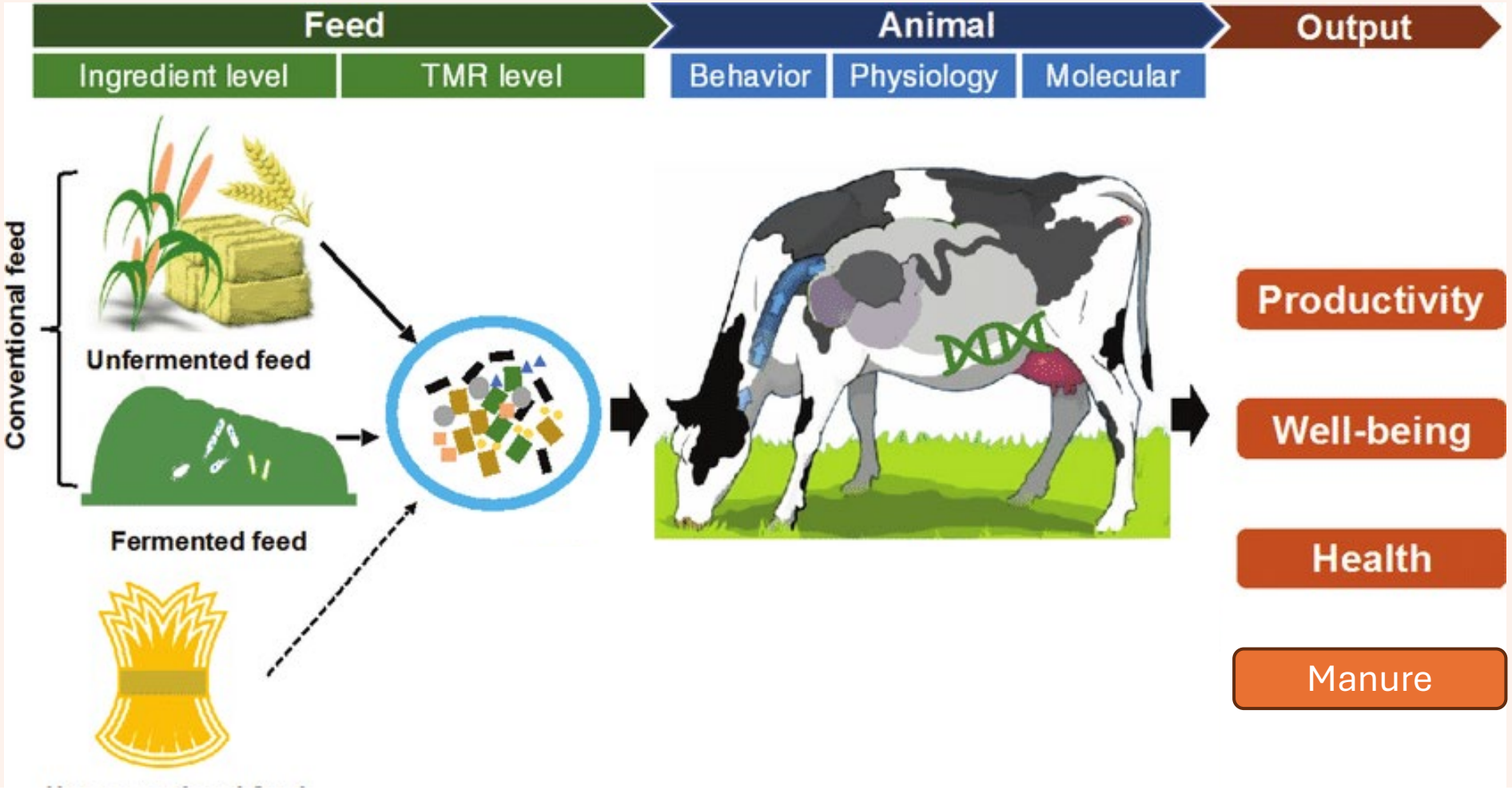


- **Pratt (1984)** found that after 4 years of livestock manure application, soil salinity levels increased significantly with the application rate. **Chang et al. (1991)** also reported similar results after 11 years of cattle manure application.

Introduction – Reducing fertilizer value



Introduction – Nutrient Intake



Reducing Na levels in dairy farms waste is great interest.

Introduction - Reducing dietary sodium

- In Israel the cows are feed with low roughage (30-35%) TMR
- Na Sources:
  - Sodium Bicarbonate
  - Sodium Chloride
- Up to 0.61% Na of TMR DM **(Y.A. Ben Meir, 2023)**

Introduction – Previous Studies

- **Sanchez et al 1994** – Curvilinear relationship between dietary sodium and intake and milk yield.
- **Bannink et al 1999** – Strong linear relationship between sodium in feed and its excretion in urine.
- **Spek et al 2012** – Reported an increase in DMI and a decrease in ECM yield.
- **Y.A. Ben Meir 2023** – Reported slightly changes in DMI but no effect in milk yield or its components.

Hypothesis

- Reducing dietary sodium from **~0.47%** to **0.31%** of diet dry matter (DM) by lowering $NaHCO_3$ and/or NaCl levels will maintain sufficient sodium for health and production in lactating cows, while decreasing sodium excretion in manure, thereby minimizing environmental cost in dairy farms in Israel, without negatively affecting feed intake, milk yield, milk components, or overall animal performance

Objective

- To examine the effect of reducing dietary sodium by reducing dietary $NaHCO_3$ or NaCl on feed intake, milk yield, milk components, or overall animal performance.

Materials and methods

- **Animal and Experimental Design**
  - Spring 2023 (Feb-April)
  - 42 multiparous mid-to late-lactating (>150 DIM)
- **Randomized block**
  - Parity
  - Days in Milk (DIM)
  - Milk Yield
  - Total 14 blocks

Materials and methods - Treatments

- **CON (N=14)**
  - the conventional lactation diet with 0.465% Na in dietary DM: 0.405% NaCl(0.16% Na in dietary DM); DCAD = ~250 mEq/kg
- **NHC (N=14)**
  - dietary Na of 0.306% in dietary DM: no NaCl, 0.6% $NaHCO_3$ (= 0.162% Na in dietary DM), and other ingredients (0.144% Na in dietary DM); DCAD = 250 mEq/kg
- **NC (N=14)**
  - dietary Na of 0.306% in dietary DM: no $NaHCO_3$, 0.412% NaCl (= 0.162% Na in dietary DM), and other ingredients (0.144% Na in dietary DM); DCAD = 250 mEq/kg

Table 1. Chemical and Structural Composition of the TMR (% of TMR DM)			
	CON	NC	NHC
Composition			
DM, % of wet TMR	71.5	71.5	71.5
Ash	7.94	8.16	8.21
CP	16.5	16.5	16.5
Ether Extract Fat	6.16	6.16	6.16
aNDF	67.3	67.3	67.3
aNDFom	29.0	29.0	29.0
NFC	40.0	40.0	40.0
Sodium	0.47	0.31	0.31
Calcium	1.25	1.25	1.19
Chloride	0.50	0.55	0.45
Potassium	1.15	1.15	1.15
Phosphorus	0.54	0.54	0.54
Sulfur	0.32	0.32	0.32
Magnesium	0.23	0.23	0.23
DCAD, meq/kg	180	170	168
NE_L Mcal/kg	1.82	1.84	1.83

Materials and methods

- **Cows housing**
  - Agricultural Research Organization (ARO) experimental dairy barn (Rishon-Letzion, Israel)
  - Individual feeder
  - Single group
  - Ad Libitum access to water
  - Feed delivered daily (0900 to 1000)

Materials and methods

- **Management**
  - Milked twice a day 0530 and 1730
  - Milk component were recorded at each milking **(Afilab, Afimilk Ltd., Kibbuts Afikim, Israel)**
  - Milk sample collected 3 consecutive milking (15 days)
  - Daily record BW

Materials and methods

- **Sample Collection**
  - **TMR Sampled weekly**
  - **Urine and Fecal Samples**
    - **12 times over 3 days (0600, 1100, 1500, 1900)**
  - **Pooled TMR and Fecal Sample**
    - **Dairy One Laboratory (Ithaca, NY)**
    - OM, CP, ash-free amylase-treated NDF (aNDFom), crude fat, undigested NDF corrected for ash (uNDFom) 240 h and elements (Ca, P, Mg, K, S, Na, and Cl) concentrations

Materials and methods

- **Calculations**
  - **Yield ECM (kg/d) =** Milk yield (kg/d) × {[0.3887 × Milk fat (%)] + [0.2356 × (Milk protein (%)] + [0.1653 × Milk lactose (%)]}/3.1338.
  - **ADG =** Slope of the regression of daily weight against days in trail

Materials and methods

- **Statistical Analysis**
  - **Mix Model procedure in JMP v16**
  - **Fixed Effect = Treatment, Days in TRT and their Interaction**
  - **Random Effect = Cow**
  - **AR(1), Repeated by Days in TRT & Cow as Subject**

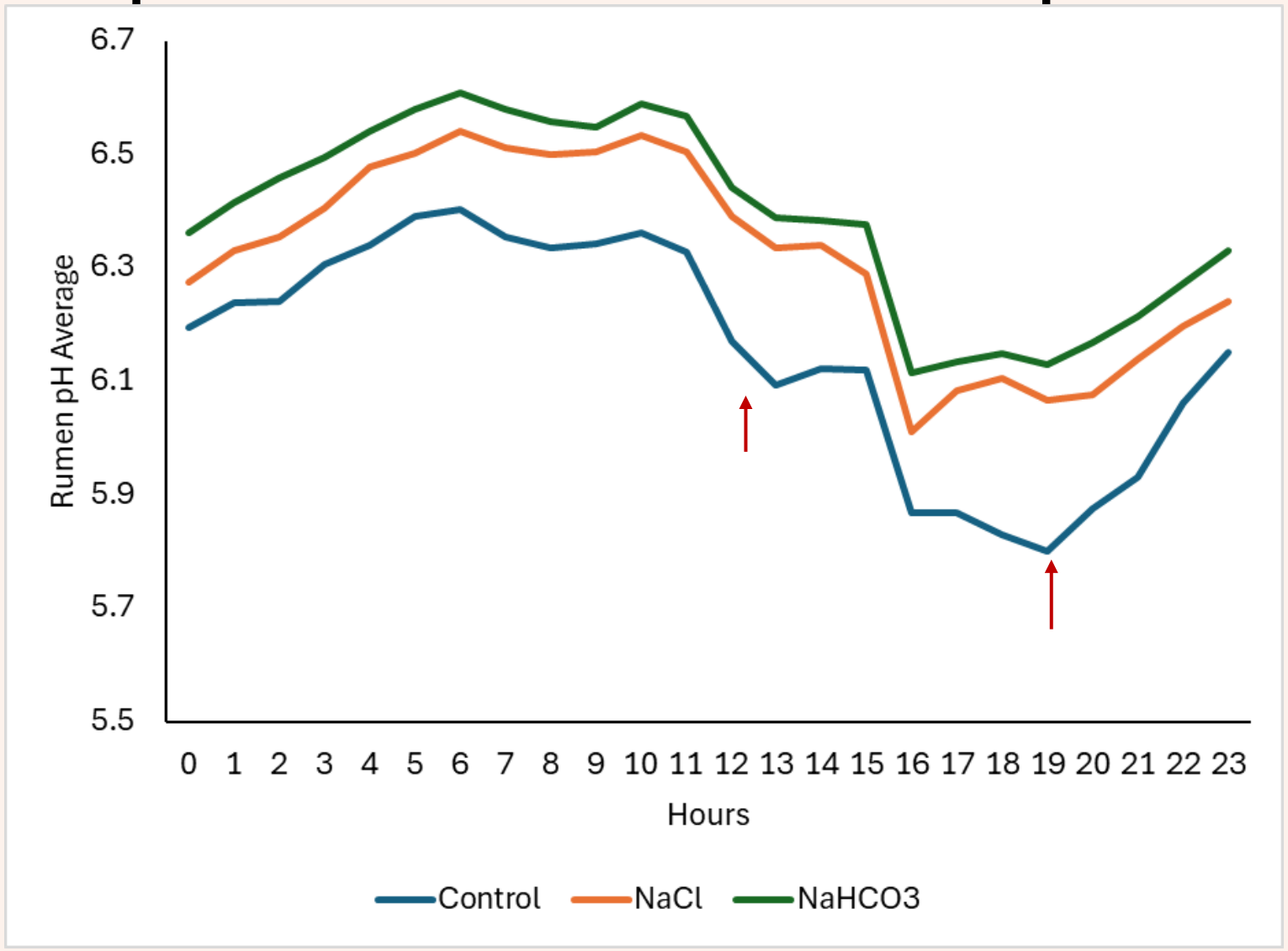
Result – DMI, ECM, BW, and ADG

		Dietary Sodium			SEM	P
Trait	Units	CON	NC	NHC		
n		14	14	14		
DMI	kg/d	30.5	31.7	32.0	1.80	0.70
ECM	kg/d	42.0	41.3	41.4	2.77	0.98
ECM/DMI		1.43	1.37	1.31	0.11	0.74
Milk Yield	kg/d	44.1	45.0	45.1	3.07	0.10
Milk Fat	%	3.82	3.67	3.60	0.08	0.06
Milk Protein*	%	3.34^{a}	3.27^{b}	3.24^{b}	0.04	0.04
Milk Lactose	%	4.31	4.31	4.31	0.04	0.61
Body Weight	kg	694	689	689	25.8	0.98
ADG*	kg/d	0.36^{a}	0.18^{b}	0.25^{ab}	0.03	0.009

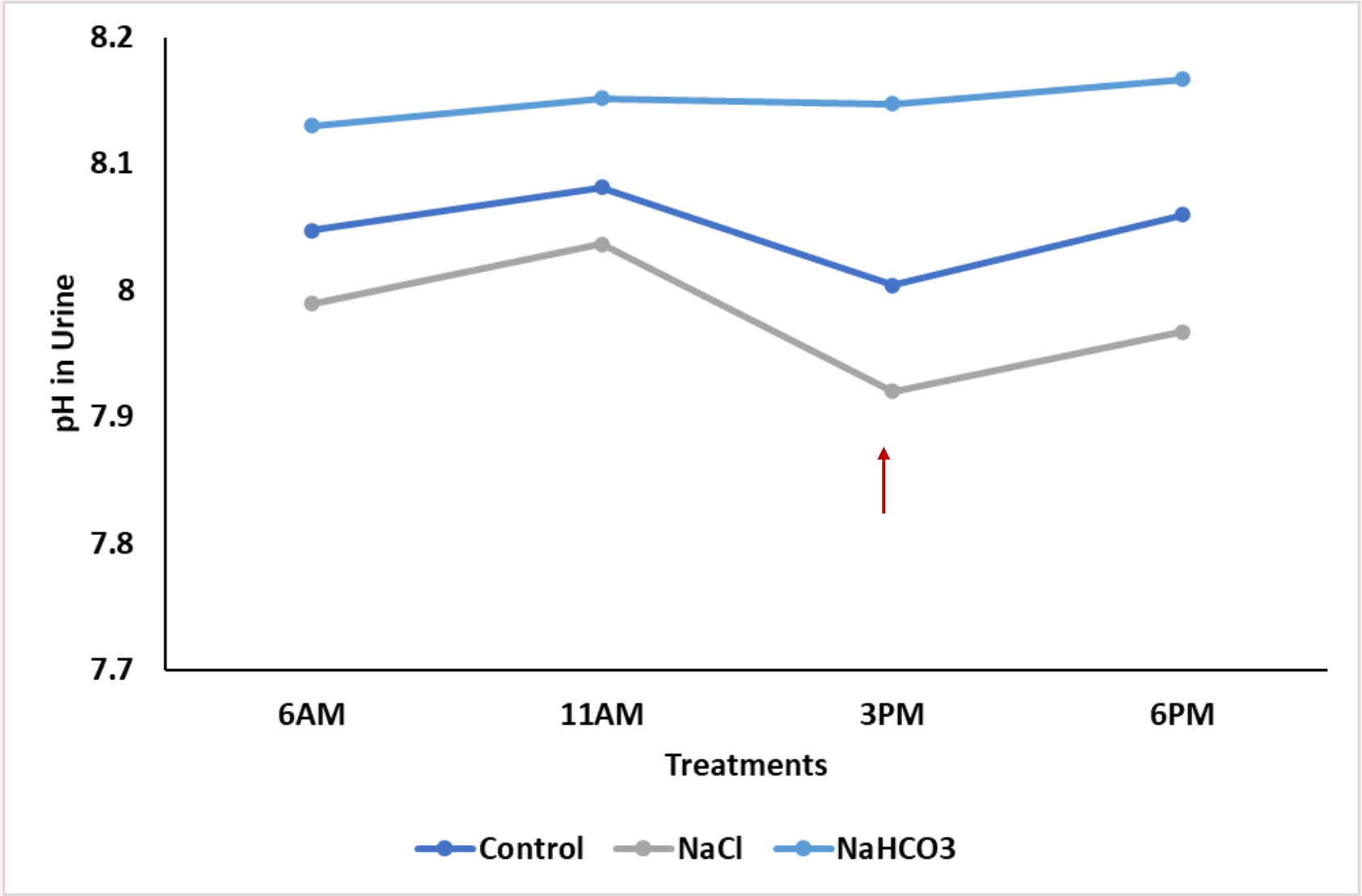
Result – Na discharge in feces

Fecal Concentration, %									
Element			CON	NC	NHC			p-value	
n			7	7	7				
Calcium			3.26	3.26	3.40			0.67	
Phosphorus			1.00	0.99	0.97			0.99	
Magnesium			0.51	0.51	0.51			0.99	
Potassium			0.56	0.56	0.54			0.89	
Sodium*			0.53^{a}	0.34^{b}	0.32^{b}			0.02	
Sulfur			0.33	0.33	0.32			0.98	
Chloride*			0.50^{a}	0.48^{ab}	0.39^{b}			0.04	

Result – pH variation Urine Sample



Result – pH variation Urine Sample



Discussion

- We hypothesize that dietary Na can be reduced from ~0.47% to 0.31% of diet DM while supplying sufficient Na for health and production. Indeed, we found that the amount of Na and its source can be reduce without affecting Milk or ECM Yield, as **Ben Meir, 2023** reported with a study in High Sodium vs Low Sodium diets.

Discussion

- Sodium’s Role in Dairy Cow Nutrition. **(NRC 2021)**
- Effect on Milk Yield and ECM**. (Hu et al 2004)**
- Impact on Milk Protein. **(Block, E 1984)**
- Tendency to Reduce Milk Fat. **(Bauman & Griinari 2003)**
- Effect in ADG. **(Loor et al., 2005)**

Conclusion

- **Reducing dietary to 0.31% will minimize environmental cost of dairy farms without impairing production. Additional study is warren before lowering dietary Na concentration below this.**

Conclusion

- Reducing sodium in the TMR for dairy cows can be a viable strategy to maintain milk yield and ECM, but it must be approached cautiously. The observed reductions in milk protein, milk fat, and ADG highlight the need for a balanced approach that considers the intricate roles of sodium in overall cow health and production.

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