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Sodium bicarbonate limited milk fat depression of lactating dairy ewes fed ryegrass herbage rich in water-soluble carbohydrates

M.A. Porcu, A. Ledda, D.Duras, E. Ruggiu, S. Pinna, A. Mazza, A. Fenu, R. Rubattu, A. Cannas

Department of Agricultural Sciences, University of Sassari
Sardinia, Italy

INTRODUCTION

Water-soluble carbohydrates (WSC) overload in grazing dairy ewes

Modern varieties of annual ryegrass (especially tetraploid types) can accumulate **high content of WSC (simple sugars+fructans)** during winter and spring with **low temperatures and sunny days**, which corresponded to **milk fat depression (MFD) in grazing dairy ewes in Sardinia**

A well studied issue in equine nutrition → **pasture-associated laminitis**

Little studied in ruminants, especially in dairy ewes

Pathogenesis of **oligofructose-induced acute laminitis** is similar in horses and cows, both consequent to **acidosis conditions**

(Thoefner et al., 2004; Filho et al., 2019)

INTRODUCTION

Recent studies on grazing dairy ewes in Sardinia

Negative correlation between **WSC intake and ruminal pH**

↑ WSC intake ↓ acetate:propionate ratio ↑ glucose and insuline in blood

(Molle et al., 2022)

Negative correlation between **WSC content in pasture and milk fat content (%)**

(Satta et al., 2023)

Negative correlation between **WSC intake (g DM/d) and milk fat content (%)** in milking 3 h after herbage supply (40-50% of total daily grass intake)

(Porcu et al., 2023)

Use of sodium bicarbonate ($NaHCO_3$) as a ruminal buffer to prevent the negative effects of carbohydrate overload

Studies on ruminants showed that sodium bicarbonate:

↑ DMI, nutrient digestibility, ruminal pH and TVFA

↑ acetate to propionate ratio

↑ milk yield, milk fat content (%)

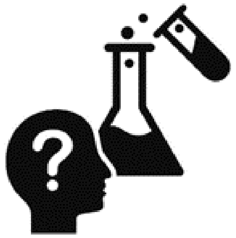
(Hart and Doyle, 1985; Calsamiglia et al., 2012; Farghaly et al., 2019; Nuhu et al., 2019; Vicente et al., 2023; Ameen et al., 2023)

❗ But the **response to the use of $NaHCO_3$** varies according to **supply method and diet type**

→ *greater effect at lower ruminal pH*

(Tripathi et al., 2004; Hu and Murphy, 2005; Calsamiglia et al., 2012)

Hypothesis



Sodium bicarbonate ($NaHCO_3$), supplied as a ruminal buffer**,**
could prevent subacidosis and milk fat depression from **WSC overload**
in lactating grazing ewes

Objectives

Test the effect of using **sodium bicarbonate on milk fat synthesis** by conducting a trial on lactating Sarda ewes fed **fresh herbage of tetraploid annual ryegrass** with **high concentrations of WSC** (mean 28% DM)

Materials and methods

Trial conducted at experimental farm of the Department of Agricultural Sciences of the University of Sassari

Experimental period: 12 d (6 April - 17 April 2023)

10 Sarda sheep in the third month of lactation, divided on the basis of BW (58.6 ± 6.7 kg), milk yield (2123 ± 254 g/ewe per day) and milk fat content (5.50 ± 0.46%) into **two homogeneous groups fed fresh grass indoors and concentrates:**

Control (CNT)

Sodium bicarbonate (BIC)

25 g/d of sodium bicarbonate supplied 30 min before grass supply

Materials and methods

Control (CNT) and **Sodium bicarbonate (BIC)**

The herbage was **mowed daily** from a field of
ryegrass (*Lolium multiflorum* var. westervoldicum, tetraploid type) rich in WSC,
sown in autumn 2023 within the same experimental farm

The grass was supplied in the barn **from 12:30 PM to 7:00 AM,** immediately after mowing,
with **automatic feeders of Biocontrol AS (Norway),**
which measure individual intake and daily DMI patterns

Materials and methods

Experimental diet sequence (per animal)

Integration:

Soybean meal fed individually at milking (7:30 AM, 4:30 PM)

Corn grains and **beet pulps** fed individually for 20 minutes

Hour	Control	Sodium bicarbonate
7:30 AM (morning milking)	200 g Soybean meal	200 g Soybean meal
8:00 AM	275 g Corn grains	275 g Corn grains
	150 g Beet pulps*	150 g Beet pulps*
12:00 AM	---	Sodium bicarbonate
From 12:30 PM to 7:00 AM	Ryegrass herbage supply	
4:30 PM (afternoon milking)	200 g Soybean meal	200 g Soybean meal
5:00 PM	275 g Corn grains	275 g Corn grains
	150 g Beet pulp*	150 g Beet pulp*

*Until 7 April (2nd experimental day)

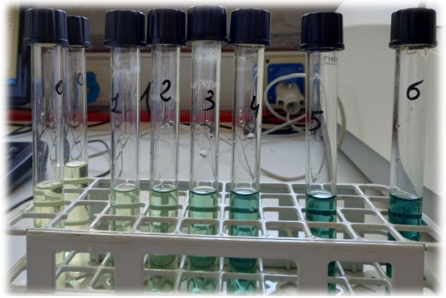
Materials and methods

Samplings and analyses

Intake and milk

- **Continuous:** individual intake of grass
- **Daily:** individual intake of concentrates at each meal
- **Daily:** milk yield at each milking (electronic and by weight)
- **2 times a week:** individual milk samples and analyses (fat, protein, lactose, urea, SCC)

Herbage



- **Daily:** samples of ryegrass herbage supplied to ewes
  - ➢ Lyophilization of grass samples
  - ➢ Complete chemical composition by **NIRS**
  - ➢ **WSC** by the **anthrone method** (Deriaz, 1961) in correspondence of milk sampling days

Statistical analyses

Data on intake, milk yield and composition were subjected to *General Linear Model (GLM)* using Minitab 21.4.1 (©2023 Minitab, LLC)

The model used was as follows:

$$Y_{ij} = \mu + bx_{ijk} + treat_i + day_j + treat_i \times day_j + anim_i + Error_{ijk}$$

where:

μ is the mean

b is the regression slope

$\boldsymbol{x_{ijk}}$ is the covariate (i.e. pre-experimental data)

$\boldsymbol{treat_i}$ is the treatment effect (*i* = CNT; BIC)

$\boldsymbol{day_j}$ is the day of data collection (j = 1; 2; 3; 4)

$\boldsymbol{treat_i \times day_j}$ is the interaction

$\boldsymbol{anim_k}$ is the random effect of animal

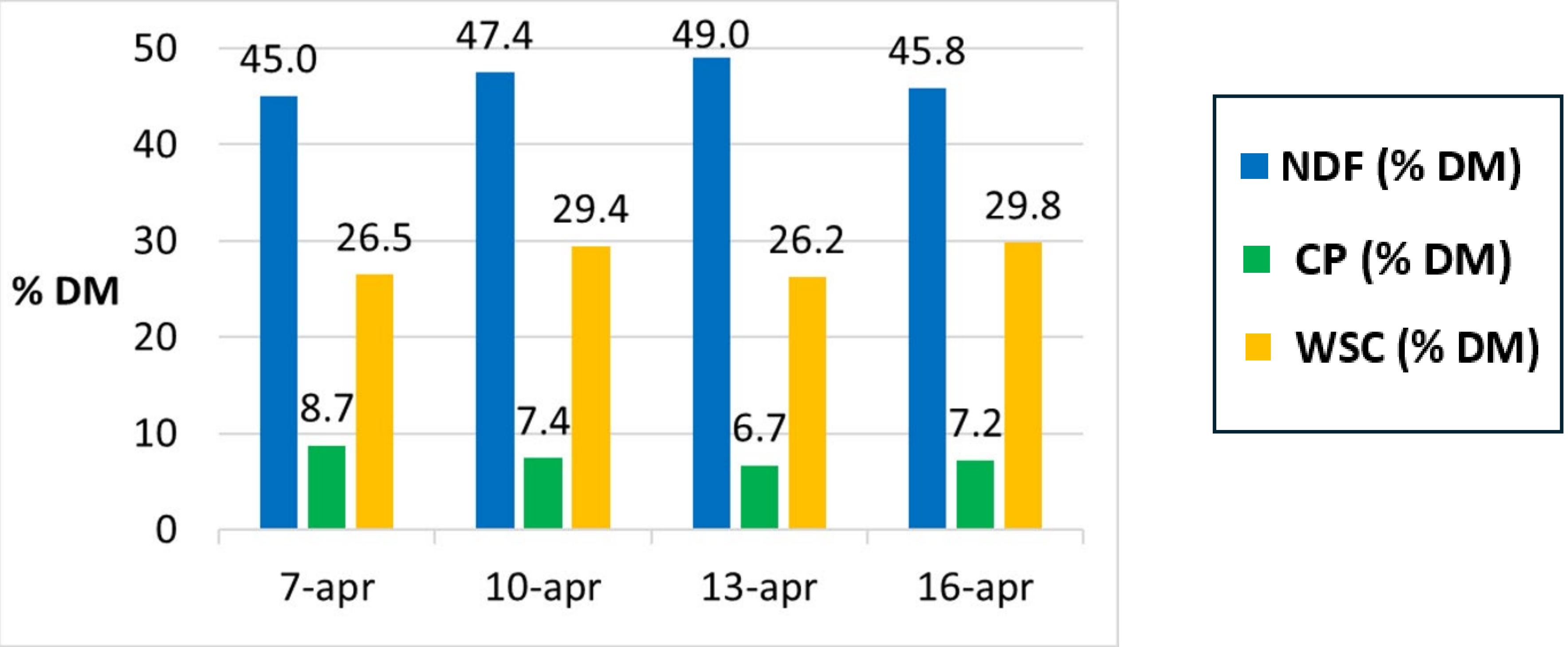
$\boldsymbol{Error_{ijk}}$ is the experimental error

Results

Average chemical composition of grass supplied during the experimental period

% DM	DM	CP	NDF	ADF	ADL	EE	WSC	NFC
Mean	22.7	7.5	46.8	27.0	5.7	1.9	28.0	33.8
Min	21.6	6.7	45.0	24.7	5.0	1.7	26.2	30.3
Max	25.5	8.7	49.0	29.4	6.3	2.1	29.8	36.2

Grass chemical composition in correspondence of milk sampling



Results

DM intake and milk yield

	Control	Sodium bicarbonate	SEM	*P-value cov. Adj mean*
Total intake, g DM/d	2178	**2319**	44.2	***0.03***
Grass intake, g DM/d	1340	**1488**	45.9	***0.03***
Concentrate intake, g DM/d	843	826	17	***NS***
WSC intake, g DM/d	377	**418**	12.8	***0.03***
NDF intake, g DM/d	791	**857**	21.8	***0.04***
CP intake, g DM/d	331	335	6.3	***NS***
Daily milk yield, g/d	1859	1838	28.6	***NS***
Milk yield afternoon, g/milking	649	647	16.1	***NS***
Milk yield morning, g/milking	1206	1194	24.5	***NS***

Covariated-adjusted means compared to the values of pre-experimental measurements (mean 2-5 April)

Results

Milk composition

	Control	Sodium bicarbonate	SEM	*P-value cov. Adj mean*
Daily milk fat content (%)	5.41	**5.79**	0.08	***0.002***
Milk fat content, afternoon (%)	6.01	**6.52**	0.09	< ***0.001***
Milk fat content, morning (%)	5.06	**5.39**	0.10	***0.03***
Daily fat yield (g/d)	99.7	**106.5**	2.34	***0.05***
Fat yield, afternoon (g/milking)	38.7	**42.2**	1.12	***0.03***
Fat yield, morning (g/milking)	60.6	64.7	2.03	***NS***
Daily milk protein content (%)	4.81	4.81	0.04	***NS***
Milk protein content, afternoon (%)	4.78	4.87	0.03	***NS***
Milk protein content, morning (%)	4.83	4.77	0.04	***NS***
Daily milk fat:protein ratio	1.13	**1.21**	0.01	< ***0.001***
Milk fat:protein ratio, afternoon	1.25	**1.35**	0.02	< ***0.001***
Milk fat:protein ratio, morning	1.06	**1.13**	0.02	***0.01***

Covariated-adjusted means compared to the values of pre-experimental measurements (mean 2-5 April)

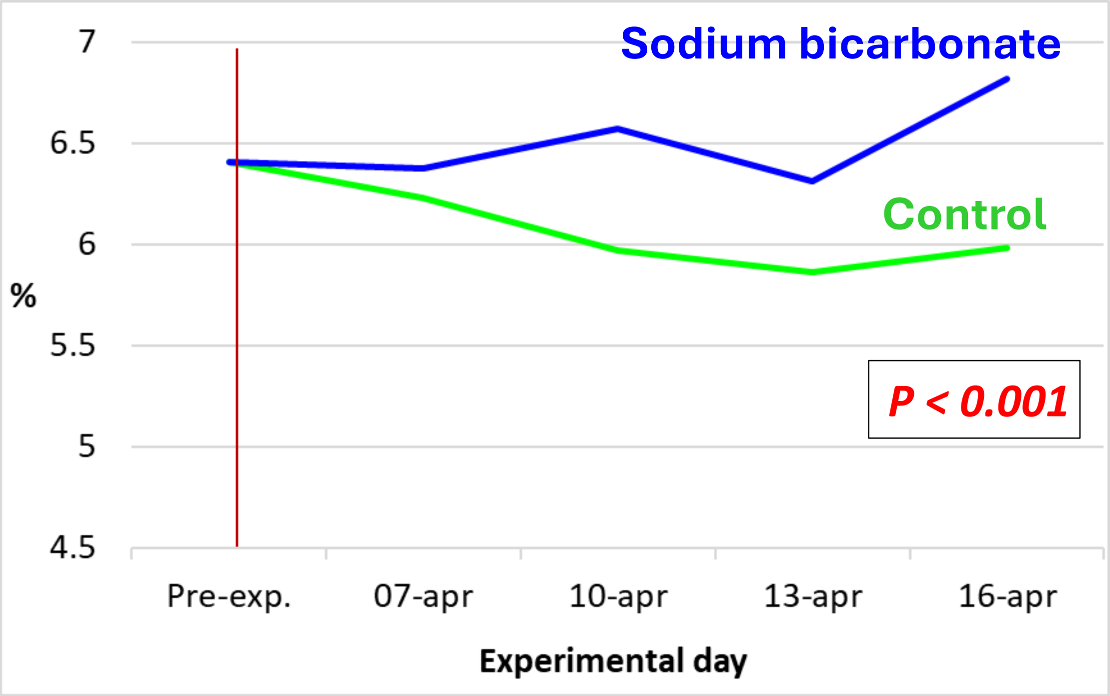
Results

Milk fat content (%)

Covariated-adjusted means compared to the values of pre-experimental measurements (mean 2-5 April)

AFTERNOON MILKING

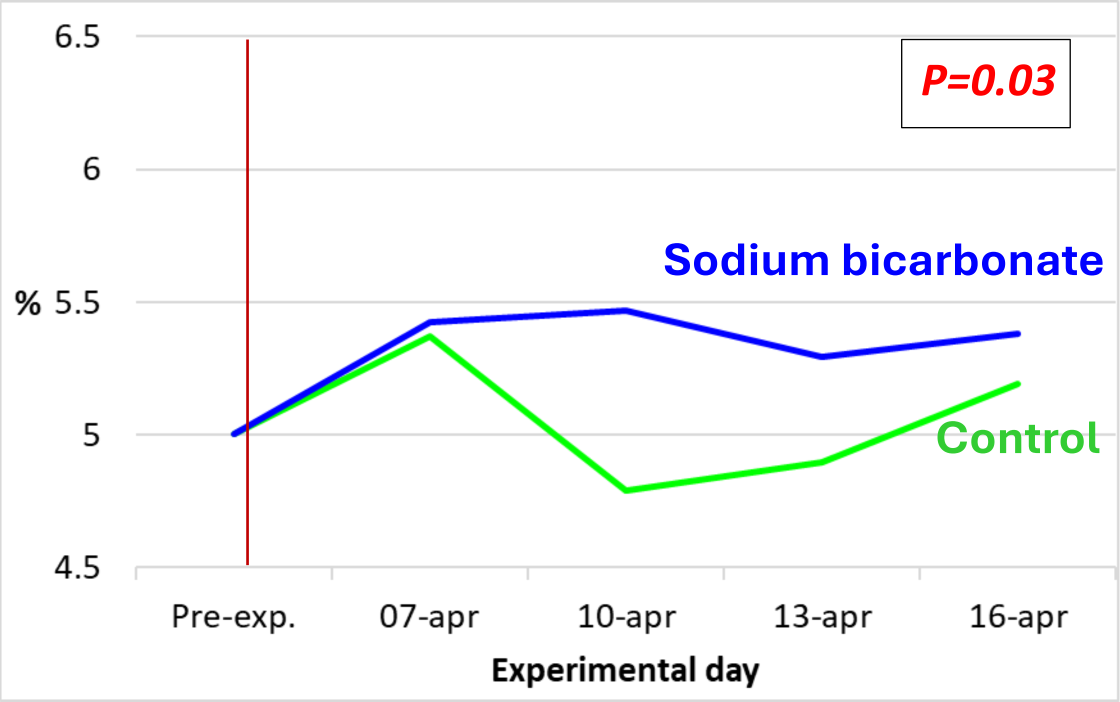
Pre-exp. mean: (CNT 6.36%, BIC 6.45%)



Experimental means
BIC 6.52%, **CNT** 6.01%

MORNING MILKING

Pre-exp. mean: (CNT 5.20%, BIC 4.81%)



Experimental means:
BIC 5.39%, **CNT** 5.06%

Discussion

- This trial was conducted **indoor.** The **feeding behaviour of grazing ewes will be different** (e.g. higher selection of plant species and plant parts, trampling, environmental effects)
  - on pasture there could be ↑ WSC intake (selection of WSC rich plant components and ↑ hourly intake rate) → negative effects on milk fat production

- The marked effect on milk fat content in the afternoon milking, 4 hours after treatment administration, is likely due to the **rapid action of $NaHCO_3$ at the ruminal level** (Russel and Chow, 1993)

- Considering that response to $NaHCO_3$ **depends on the type of diet** (greater at low ruminal pH), our results indirectly confirm that **grazing on WSC-rich grasses can cause a lowering of ruminal pH**. Thus, the use of **buffers that act at ruminal level is beneficial on milk fat content**

- **Combining buffers**, such as $NaHCO_3$ with rapidly rumen buffer action, and **alkalizers**, such as magnesium oxide (MgO), that have a slower action (relevant after 24 h) with a combined rumen and postabsorptive effect (Calsamiglia et al., 2012)

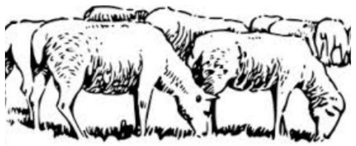
  → **additive effect on milk fat content in pasture fed sheep ?**

- Supply of **hay** (high NDF e peNDF) **before grazing WSC-rich grasses** can be beneficial → ↑ chewing time, rumination, salivation = rumen buffer action

Conclusions

In conclusion, **the use of sodium bicarbonate**, supplied as a ruminal buffer just before grass supply**, in diet of ewes fed ryegrass herbage rich in WSC (28% DM):**

- **Increases DMI** (grass intake)
- **Increases milk fat content** (%) and **milk fat yield** (g/d), especially in afternoon milking, probably due to its ***stronger short-term action***
- Can be used **to prevent ruminal subacidosis** and **milk fat depression from WSC overload**



Additionally, this study highlights that **WSC content** is an important **herbage quality parameter** to be considered when **formulating rations for pasture-fed dairy sheep**

Thank you
for the attention

Use of sodium bicarbonate ($NaHCO_3$) as a ruminal buffer to prevent the negative effects of carbohydrate overload

- One of the most common buffer salts used in ruminant rations (Nuhu et al., 2019)
- **Prevent ruminal pH reduction** and thus **ruminal acidosis** and **decrease in milk fat content** **(**Kalscheur et al., 1997; Calsamiglia et al., 2012; Jaramillo-López et al., 2017)
- **Fast buffer action** on ruminal fluid prevents post-prandial H^+ increases (Russel and Chow, 1993)
- Prevent **overgrowth of acid-tolerant lactobacilli** and pH decrease (Kleen et al., 2003)
- ↓ Production and flow to duodenum of ***trans C18:1 FA,*** a cause of MFD (Kalscheur et al., 1997)
- Can increase **passage and fluid dilution rate** of nutrients (Russel and Chow 1993; Vicente et al., 2023)
- Improve **outflow** of ruminal fluid (**< accumulation VFA and lactate**) (Vicente et al., 2023)