University of New Hampshire
College of Life Sciences and Agriculture

Kelp for Supplemental Feeding of Dairy Cows on Pasture

André F. Brito, Veterinarian, M.S., Ph.D.
Associate Professor of Dairy Cattle Nutrition and Management
Department of Agriculture, Nutrition, and Food Systems
University of New Hampshire
Email: andre.brito@unh.edu
Office phone: (603) 862-1341

Outline

- Supplementation of kelp meal
- Studies done at UNH
- Use of canola for grazing
- Final considerations

UNH Burley-Demeritt Organic Dairy Research Farm

Credit: Scott Ripley/UNH Communications and Public Affairs

UNH Burley-Demeritt Organic Dairy Research Farm

Kelp meal supplementation

Kelp meal nutritional properties

- Brown seaweed (*Ascophyllum nodosum*) rich in minerals, particularly iodine (Antaya et al., 2015)
- Contains a wide spectrum of nutritional compounds including polyunsaturated fatty acids (PUFA), polyphenols, bioactive peptides, and vitamins (Kumari et al., 2010; Tierney et al., 2010; Fitzgerald et al., 2011)
- Rich in phlorotannin, a polyphenol similar to terrestrial tannins known to affect carbohydrate and protein utilization, and to inhibit bacterial growth (Ragan and Glombitza,1986; Wang et al., 2008, 2009)
- High concentrations of antioxidants such as β-carotene and fucoxanthine, which may improve animal health (Haugan and Liaaen-Jensen, 1994; Allen et al., 2001)

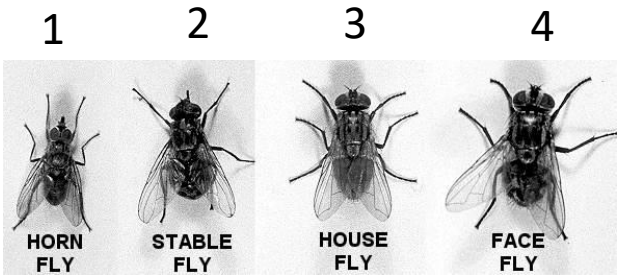
Use of kelp meal in organic dairy farms in the Northeast and Midwest US

- 59% of organic dairy farmers feed kelp meal in the Northeast (Antaya et al., 2015)
- 49% of organic dairy farmers feed kelp meal in Wisconsin (Hardie et al., 2014)
- 83% of organic dairy farmers feed kelp meal in Minnesota (Sorge et al., 2016)

Why organic dairy farmers feed kelp meal in the Northeast?

- It improves body condition and overall animal appearance
- It decreases milk somatic cell count, reproductive problems, and incidence of “pinkeye” (i.e., infectious bovine keratoconjunctivitis)
- It helps with control of nuisance flies during the grazing season

Source: Antaya et al. (2015)



1. *Haematobia irritans* L.,
2. *Stomoxys calcitrans* L.
3. *Musca domestica*
4. *Musca autumnalis*, De Geer

Source: Denning et al. 2014

Pasture vs. kelp meal nutritonal composition

Item	Feeds	
	Pasture	Kelp meal
	-----% of dry matter (unless otherwise noted)-----	
Crude protein	19.5	10.2
Neutral detergent fiber	51.0	53.9
Acid detergent fiber	31.4	39.9
Ca	0.76	1.31
P	0.36	0.25
Mg	0.28	0.69
K	2.68	3.53
S	0.28	2.84
I, ppm	0.62	820

Sources: Antaya et al. 2015; Hafla et al. (2016); Brito et al. (unpublished)

Nutritional comparison of kelp meal products

Item	Kelp meal products				
	Thorvin 1	Thorvin 2	TASCO 1	TASCO 2	Sealife
	--------% of dry matter (unless otherwise note)--------				
Ca	1.31	1.28	1.12	1.19	1.13
P	0.25	0.21	0.16	0.16	0.15
Mg	0.69	0.80	0.89	0.84	0.79
K	3.53	2.57	2.51	2.37	1.76
S	2.84	2.71	3.37	3.30	3.27
Na	3.90	3.59	3.42	3.39	3.14
Cl	4.70	4.73	3.18	3.30	2.95
Se	<0.041	-	-	0.025	-
I, ppm	820	727	356	775	-

Sources: Antaya et al. 2015; Brito et al. (unpublished)

Frequency of pastures that did not meet minimum requirements

Item	Animal requirements according to Dairy NRC (2001), % of total diet, unless otherwise noted		Samples not meeting min animal requirements, %, unless otherwise noted	
	680-kg Holstein,[1] 25 kg/d milk	454-kg Jersey,[2] 25 kg/d milk	680-kg Holstein,[1] 25 kg/d milk	454-kg Jersey,[2] 25 kg/d milk
Forage quality				
CP	14.1	16.1	9.21	20.8
ADF	17–21 min	17–21 min	0.00	0.00
NDF	25–33 min	25–33 min	0.00	0.00
NE_l, Mcal/kg	1.37	1.54	35.5	85.8
Macrominerals				
Calcium	0.62	0.57	30.8	22.1
Phosphorus	0.32	0.33	19.2	26.1
Magnesium	0.18	0.18	2.89	2.89
Potassium	0.24	0.24	0.00	0.00
Sulfur	0.22	0.20	11.1	6.58

n = 380 pasture samples collected from 2012-1015 in organic dairies in NH, VT, ME, NY, and PA
Source: Hafla et al. (2016)

Minerals requirement in cows fed pasture supplemented with kelp meal

Item	Inputs				Net (+/-)
	Required[1]	Pasture	Kelp	Total provided	
Ca, g/day	130.2	111.6	1.37	138.2	-7.97
P, g/day	67.2	64.8	0.21	65.0	-2.19
Mg, g/day	37.8	50.4	0.91	51.3	+13.5
K, g/day	50.4	482.4	2.90	485.3	+434.9
S, g/day	46.2	50.4	3.53	53.9	+7.73
I, mg/day	10.5	11.2	76.3	87.5	+77

[1]Based on a 1,500-lb Holstein cow consuming 46 lb of dry matter and producing 55 lb of milk with 3.5% milk fat and 3% milk protein

[2]Assuming all pasture diet (40 lb of pasture intake/day)

[3]Assuming 4 oz of kelp meal consumed daily

Kelp meal studies objectives at UNH

- Investigate the impact of kelp meal supplementation on milk production, nutrient digestibility, animal health, and methane (CH_4) emissions during the grazing and winter seasons

- Improving the understanding of iodine metabolism in dairy cows fed kelp meal year-round

General study procedures

- Twenty lactating Jersey cows averaging 175 days in milk, 45 lb/d of milk production, and 972 lb of BW in the beginning of the study were used
- Cows were randomly assigned to 1 of 2 diets: **0 or 4 oz of kelp meal**
- Cows were milked twice daily and have access to a new strip of fresh pasture after every milking
- TMR was supplemented twice daily after milking
- Feeds, milk, blood, feces, and urine samples were collected monthly throughout the study
- Gaseous measurements were taken using the GreenFeed system

Pasture nutritional composition

Item	Pasture			
	July	August	September	October
Pre-grazing biomass, lb/acre	1,988	1,516	1,410	1,084
Crude protein, %	13.9	16.5	17.5	18.1
Neutral detergent fiber, %	59.0	59.6	66.0	63.7
Acid detergent fiber, %	33.0	35.1	34.1	33.3
Sugars, %	9.10	6.40	7.60	5.70
Starch, %	1.70	0.30	0.40	0.70
NEl, Mcal/kg	1.21	1.23	1.08	1.04
Iodine, ppm	0.39	0.43	0.52	0.63
Glucosinolates, ppm	105	63.3	102	88.0

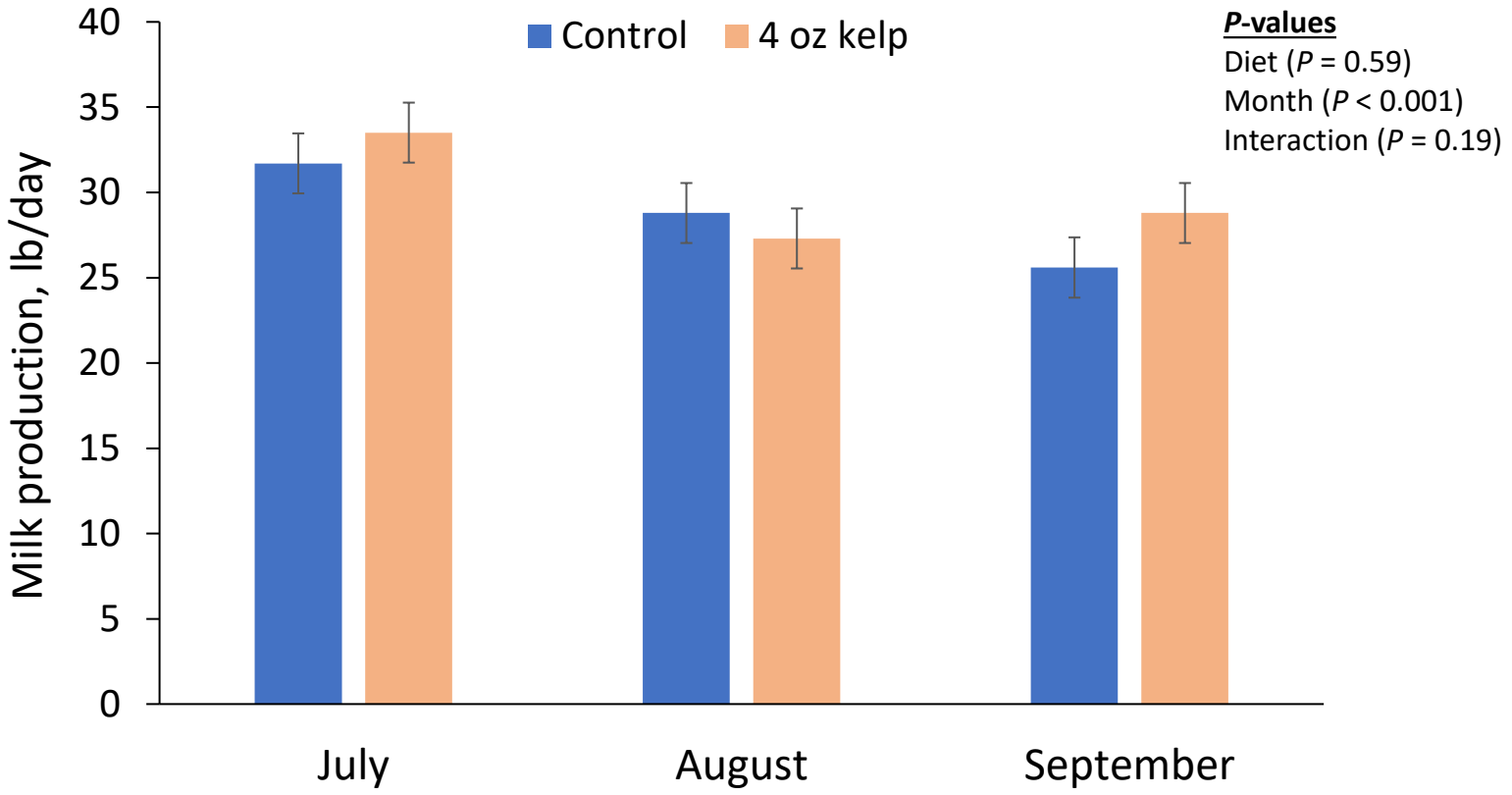
NEl = net energy of lactation
Source: Brito et al. (unpublished)

Vertical mixer

TMR mixer

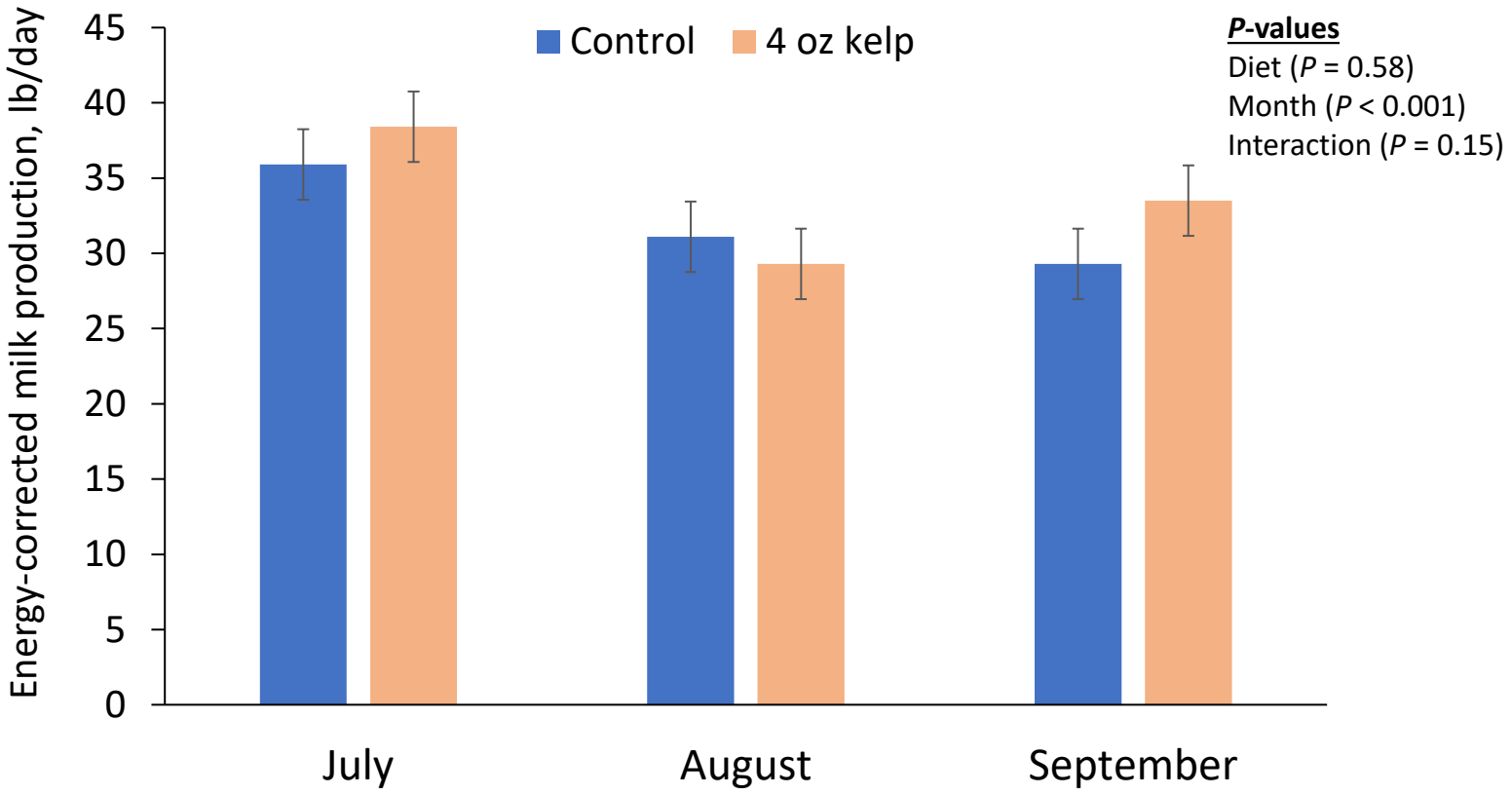
Calan doors system

Milk production in grazing cows fed kelp meal



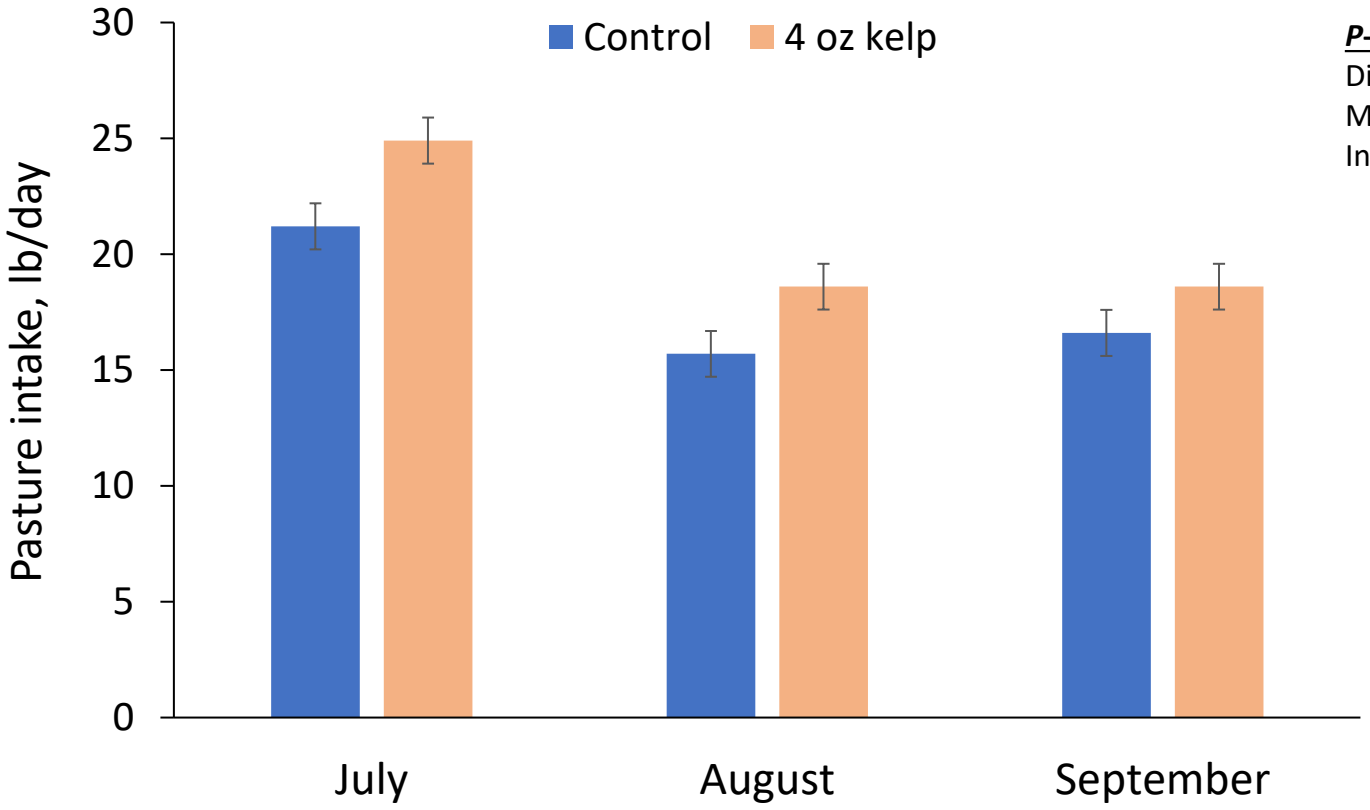
Source: Brito et al. (unpublished)

Energy-corrected milk production in grazing cows fed kelp meal



Source: Brito et al. (unpublished)

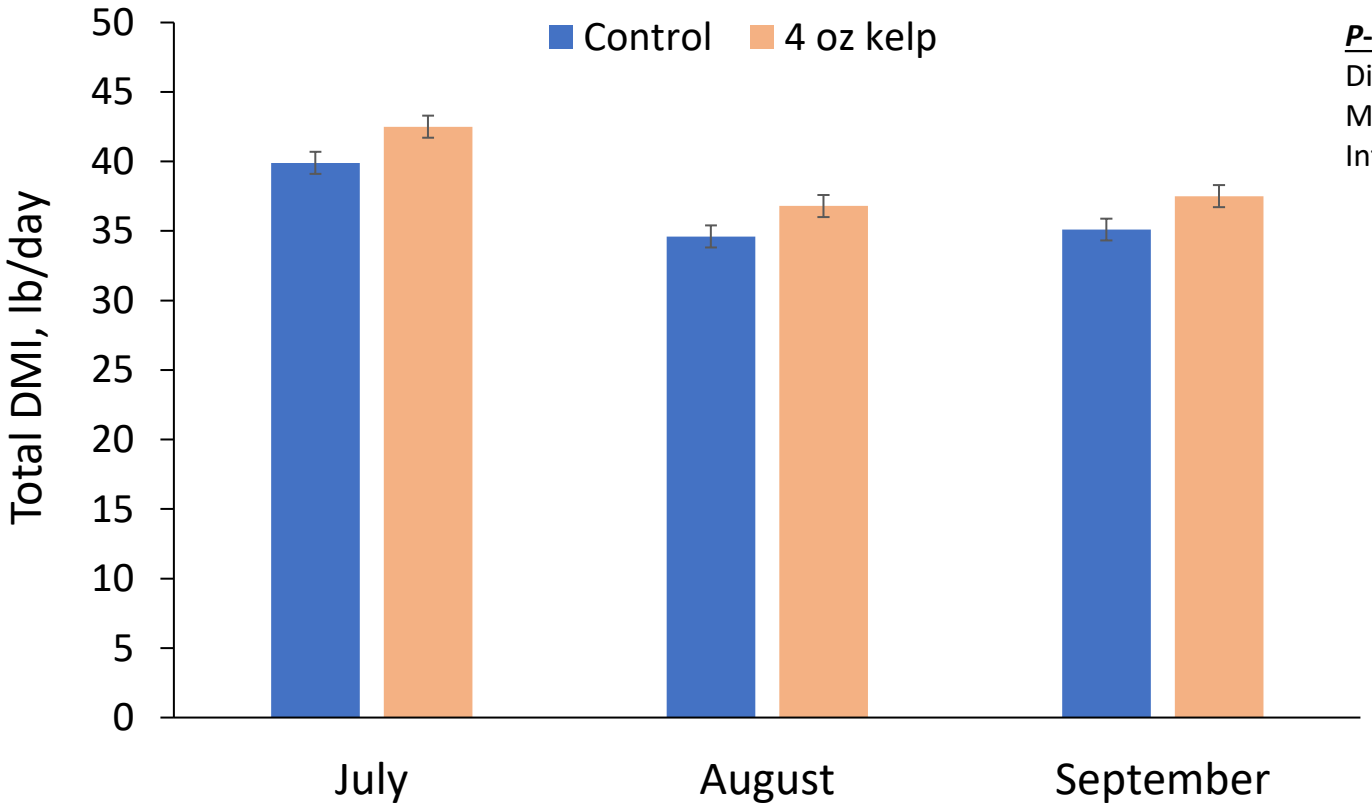
Pasture intake in grazing cows fed kelp meal



***P*-values**
Diet ($P = 0.05$)
Month ($P < 0.001$)
Interaction ($P = 0.73$)

Source: Brito et al. (unpublished)

Total diet DMI in grazing cows fed kelp meal



***P*-values**
Diet ($P = 0.07$)
Month ($P < 0.001$)
Interaction ($P = 0.95$)

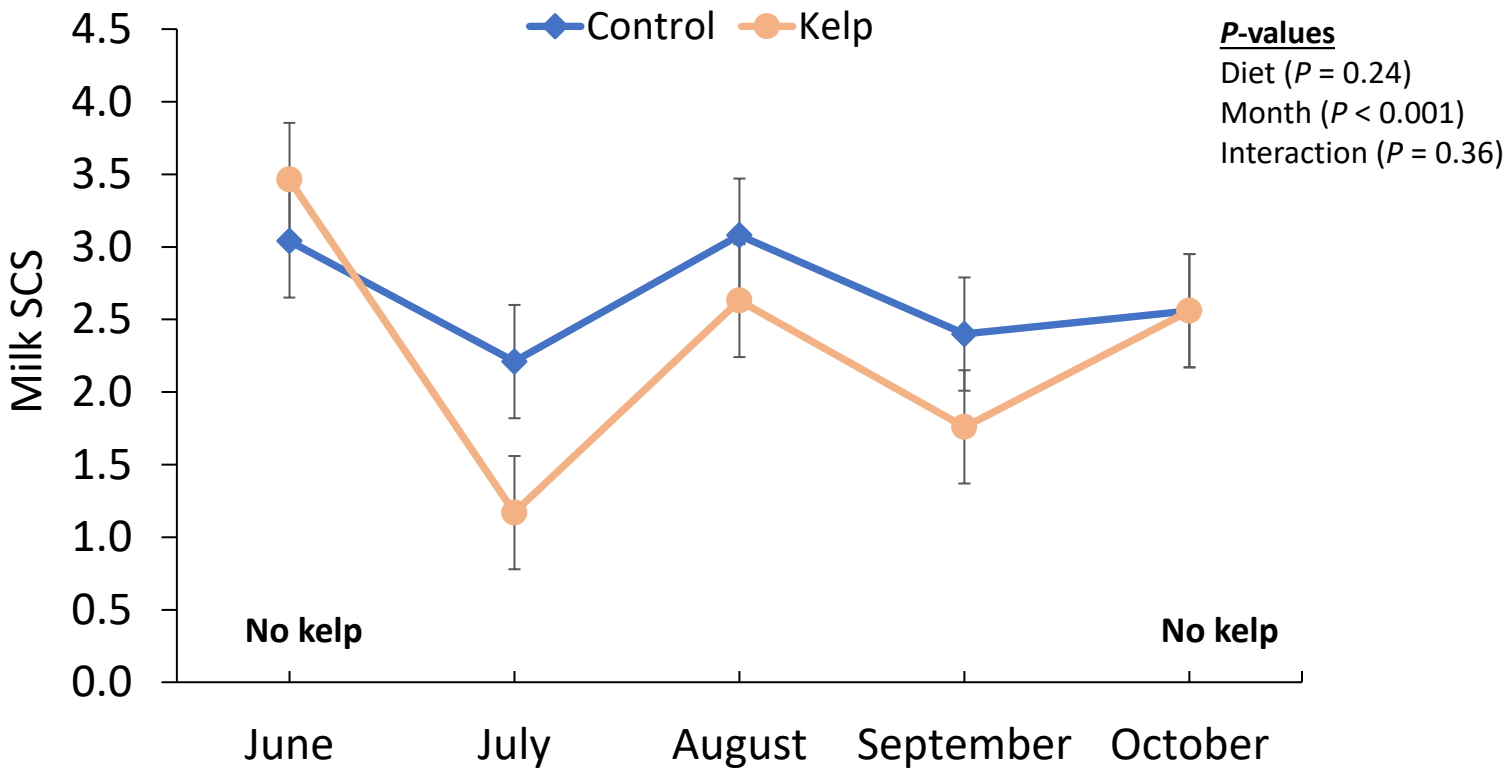
DMI = dry matter intake
Source: Brito et al. (unpublished)

Milk composition and body condition score (BCS) in grazing cows fed kelp meal

Item	Diets		SEM	*P*-values		
	Control	Kelp meal		Diet	Month	Interaction
Milk fat, %	4.19	4.38	0.19	0.52	<0.01	0.84
Milk fat, lb/day	1.21	1.30	0.08	0.56	<0.001	0.21
Milk protein, %	3.41	3.40	0.07	0.99	<0.001	0.98
Milk protein, lb/day	0.97	1.01	0.07	0.67	0.01	0.07
MUN, mg/dL	12.5	13.1	0.46	0.39	0.06	0.07
BCS, point/28 days	3.33	3.30	0.11	0.83	<0.001	0.13

Source: Brito et al. (unpublished)

Milk somatic cell score (SCS) in grazing cows fed kelp meal



***P*-values**
Diet ($P = 0.24$)
Month ($P < 0.001$)
Interaction ($P = 0.36$)

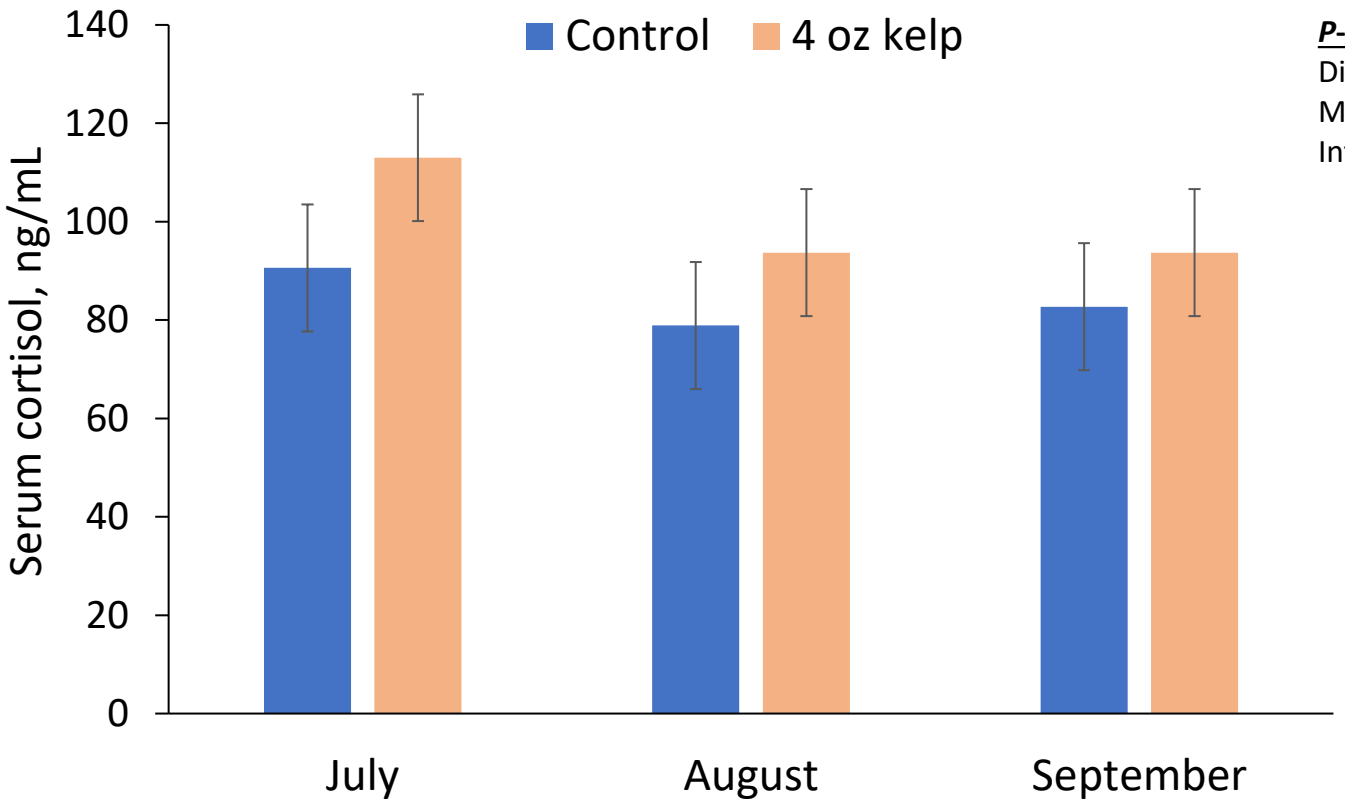
Milk SCS = log base 2 (SCC/100)
Source: Brito et al. (unpublished)

Apparent total-tract digestibility of nutrients in grazing cows fed kelp meal

Item	Diets		SEM	*P*-values		
	Control	Kelp meal		Diet	Month	Interaction
Dry matter, %	69.7	69.2	0.22	0.13	<0.001	0.39
Organic matter, %	71.2	70.5	0.25	0.11	<0.001	0.20
NDF, %	61.6	61.7	0.53	0.85	<0.001	0.76
ADF, %	55.8	56.1	0.89	0.83	<0.001	0.05
Crude protein, %	64.7	63.7	0.59	0.13	<0.001	0.05

NDF = neutral detergent fiber
ADF = acid detergent fiber
Source: Brito et al. (unpublished)

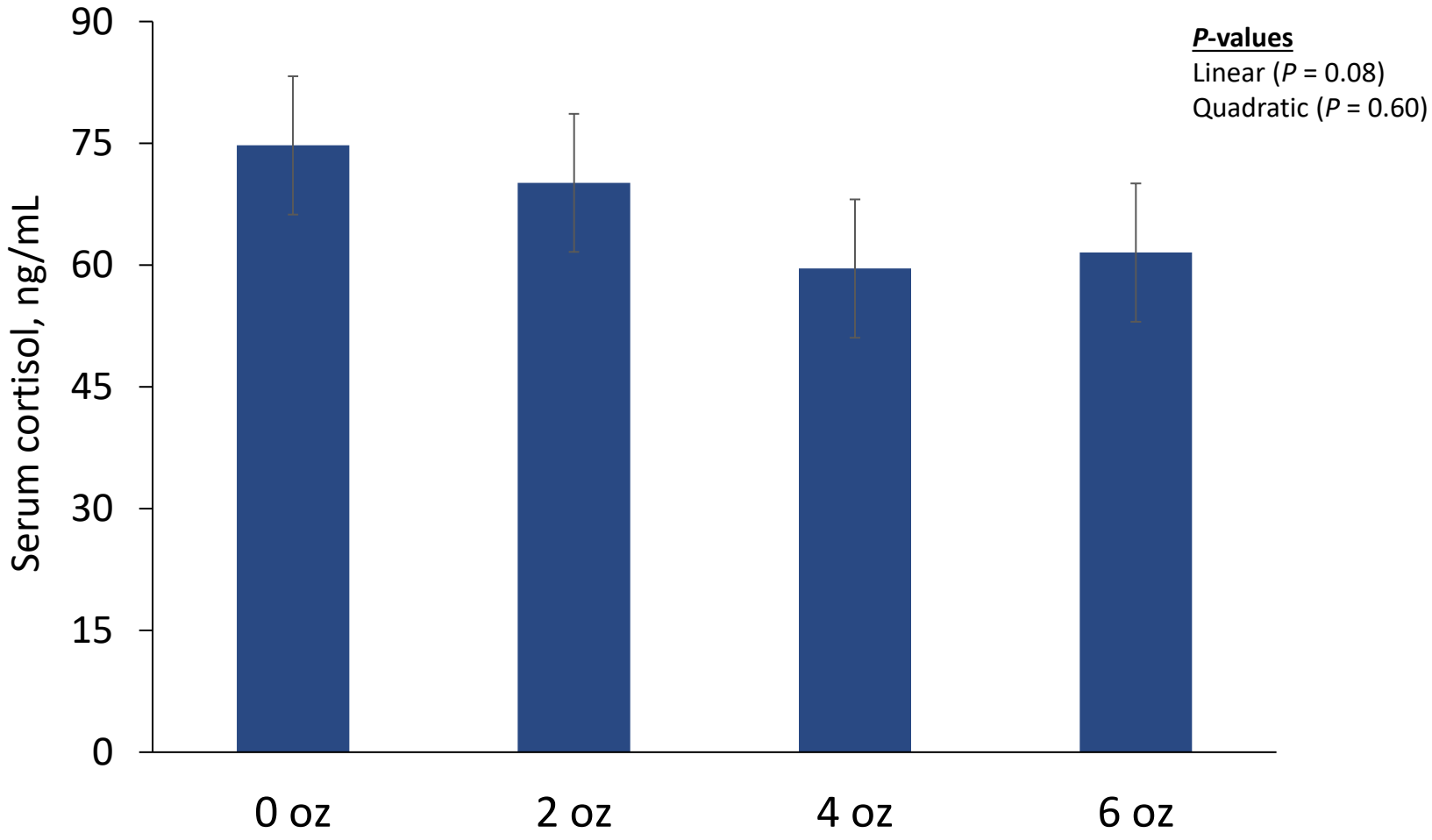
Serum cortisol in grazing dairy cows fed kelp meal



***P*-values**
Diet ($P = 0.32$)
Month ($P = 0.16$)
Interaction ($P = 0.82$)

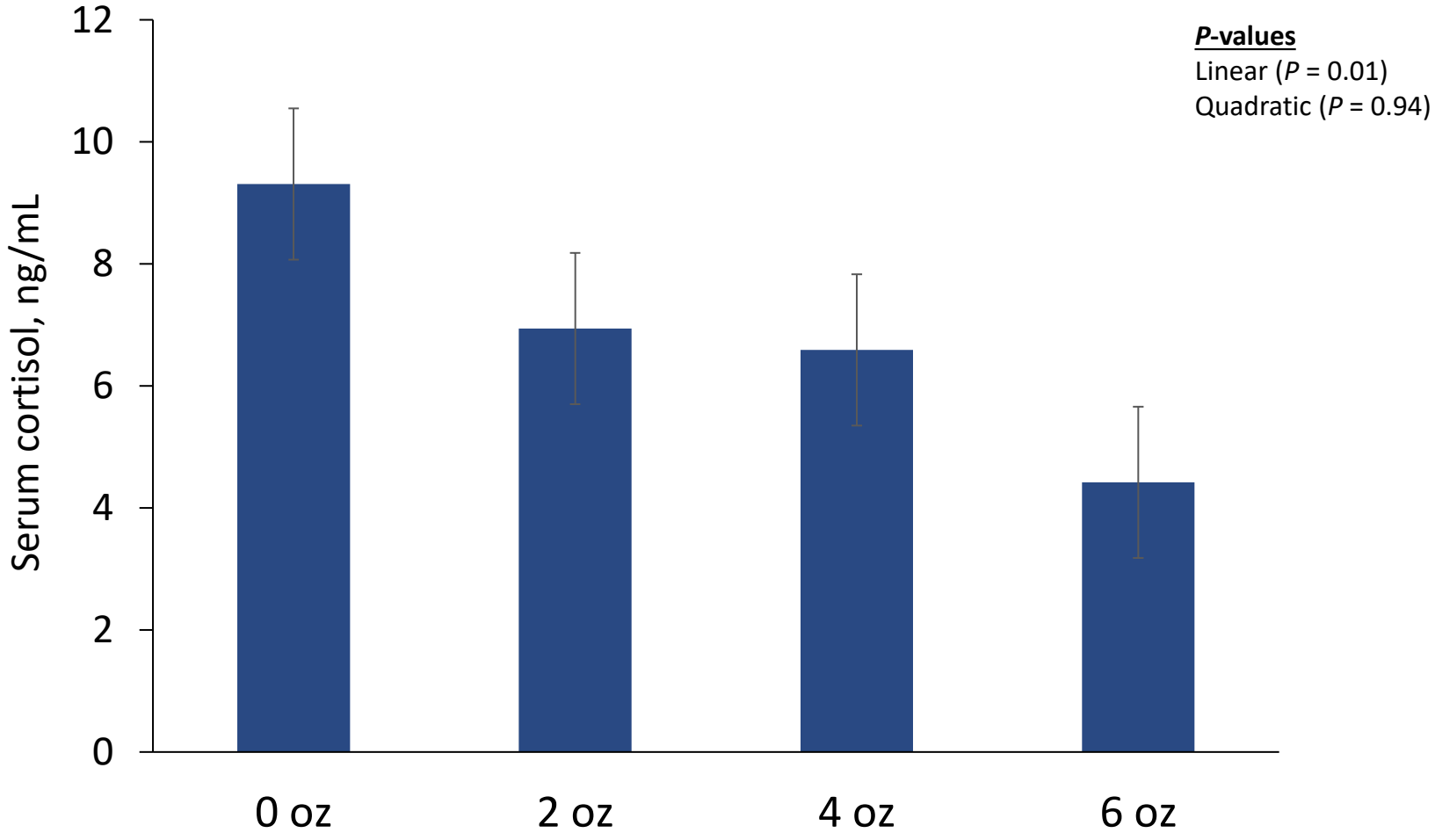
Source: Brito et al. (unpublished)

Serum cortisol in dairy cows fed kelp meal during the winter



Source: Antaya et al (2015)

Serum cortisol in confined dairy cows fed kelp meal during the summer



Source: Brito et al. (unpublished)

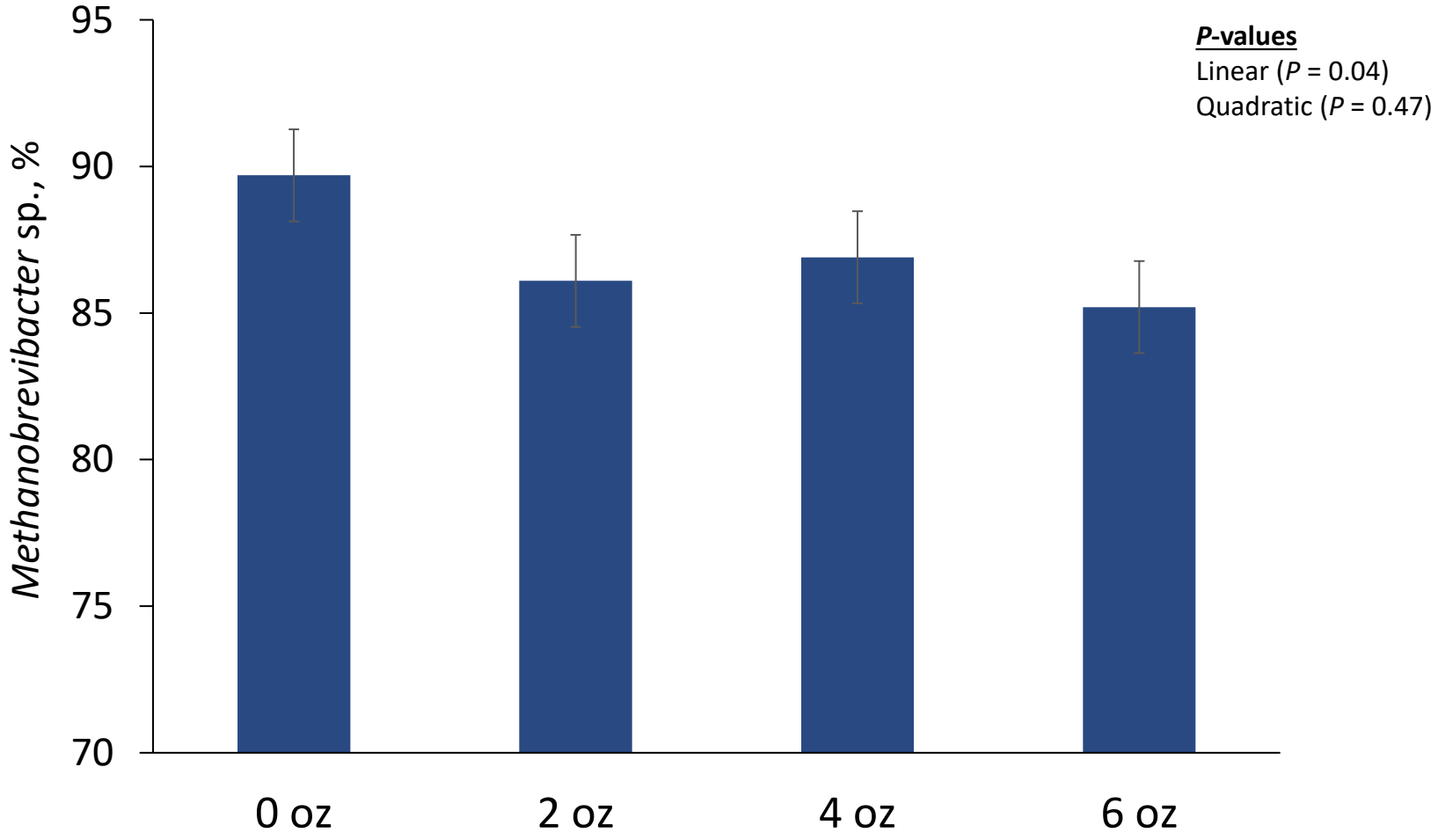
The portable GreenFeed gas emission monitoring system

Methane (CH_4) emissions in grazing dairy cows fed kelp meal

Item	Diets		SEM	*P*-values		
	Control	Kelp meal		Diet	Month	Interaction
CH_4 production, g/day	317	321	15.9	0.83	<0.001	0.94
CH_4 yield, g/kg DMI	18.1	17.2	0.64	0.31	<0.001	0.34
CH_4 intensity, g/kg ECM	21.4	21.0	1.62	0.86	0.11	0.45

DMI = dry matter intake
ECM = energy-corrected milk
Source: Brito et al. (unpublished)

Proportion of *Methanobrevibacter* sp. in rumen fluid of confined dairy cows fed kelp meal during the summer



Source: Brito et al. (unpublished)

Summary

- Kelp meal supplementation maintained or slightly improved production of milk and milk components during the grazing season

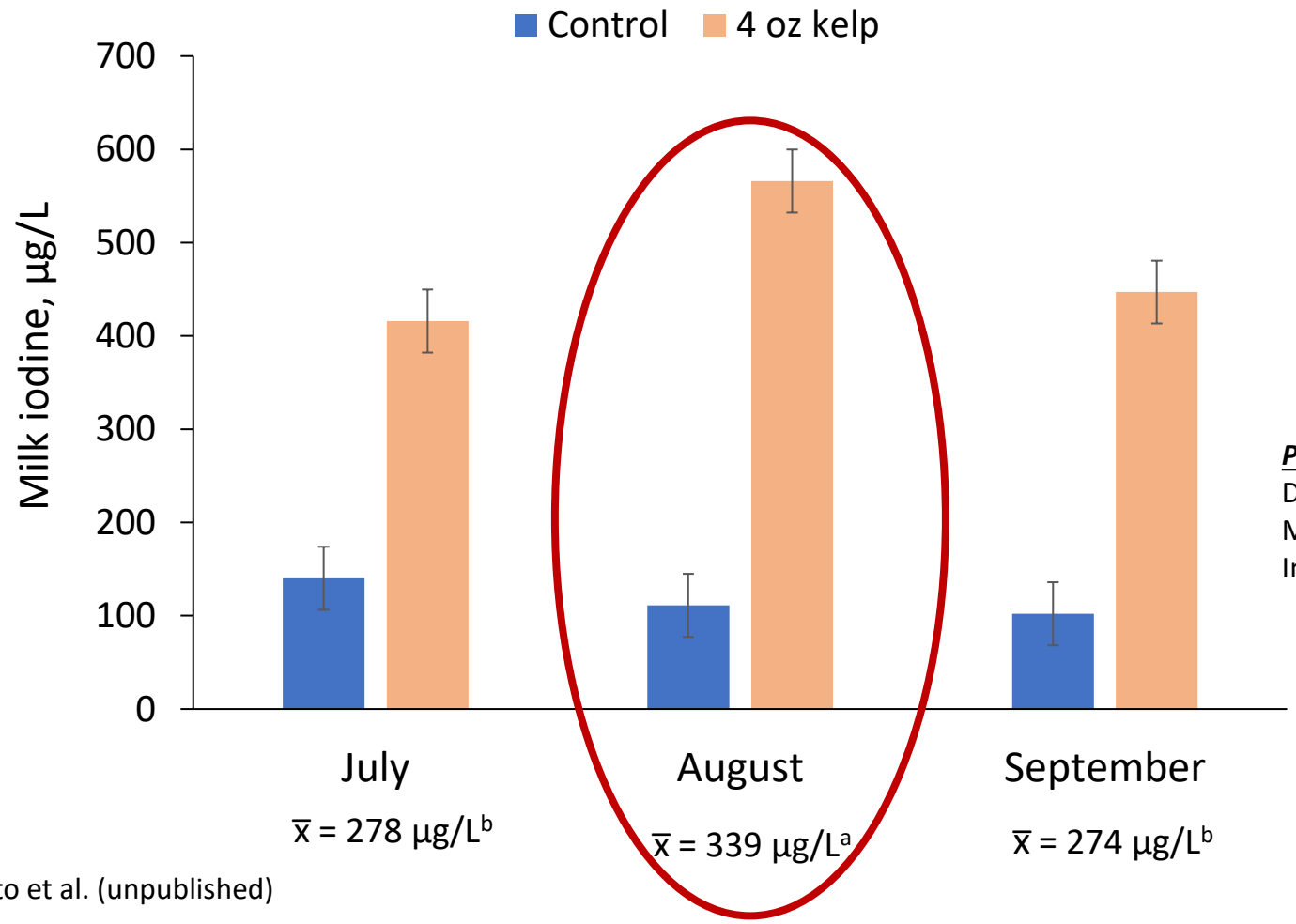
- Effects of kelp meal supplementation of blood cortisol, milk somatic cells count, and CH_4 emissions deserve further investigations

Kelp meal studies objectives at UNH

- Investigate the impact of kelp meal supplementation on milk production, nutrient digestibility, animal health, and methane (CH_4) emissions during the grazing and winter seasons

- Improving the understanding of iodine metabolism in dairy cows fed kelp meal year-round

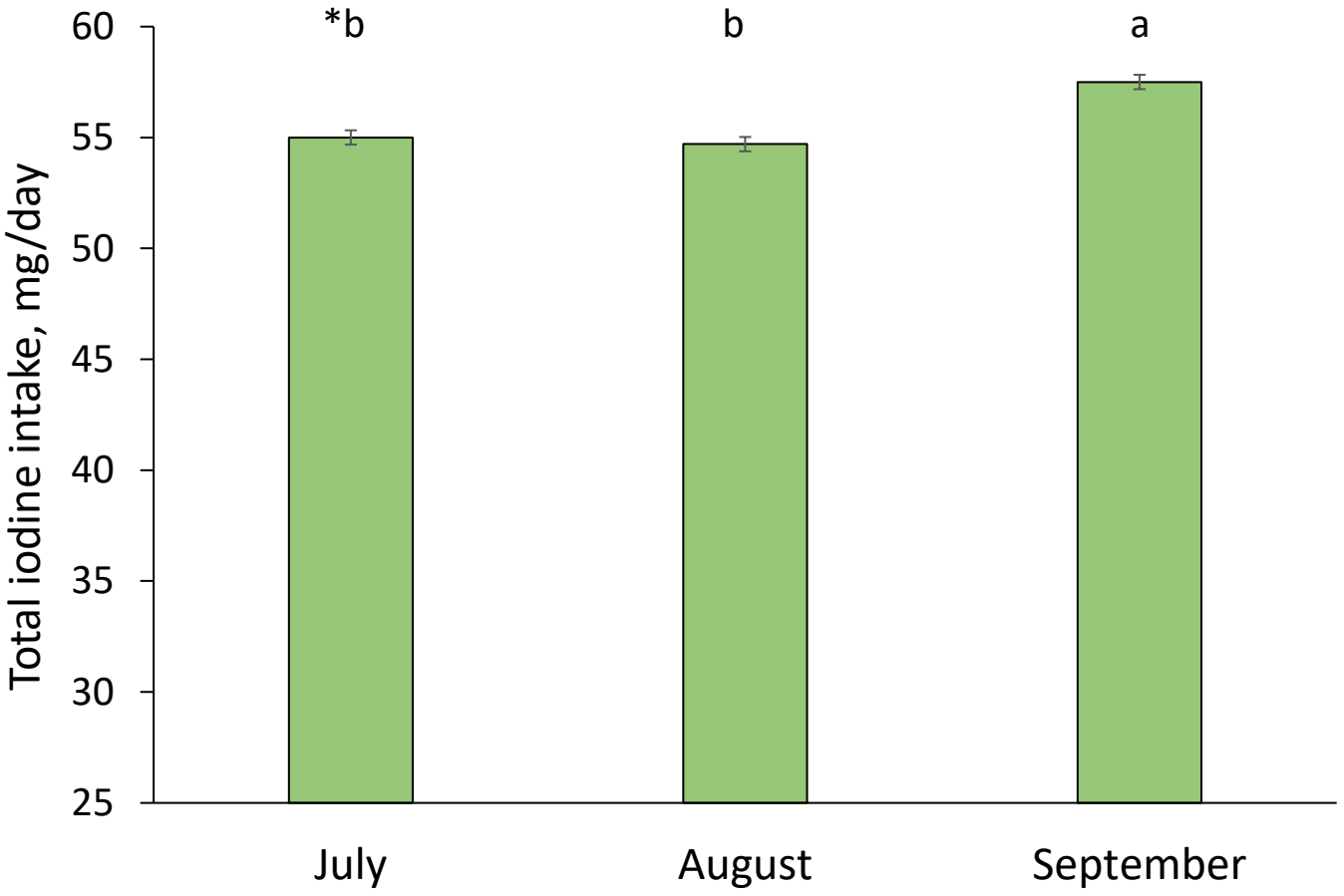
Milk iodine concentration in grazing cows fed kelp meal



***P*-values**
Diet ($P < 0.001$)
Month ($P < 0.01$)
Interaction ($P < 0.01$)

Source: Brito et al. (unpublished)

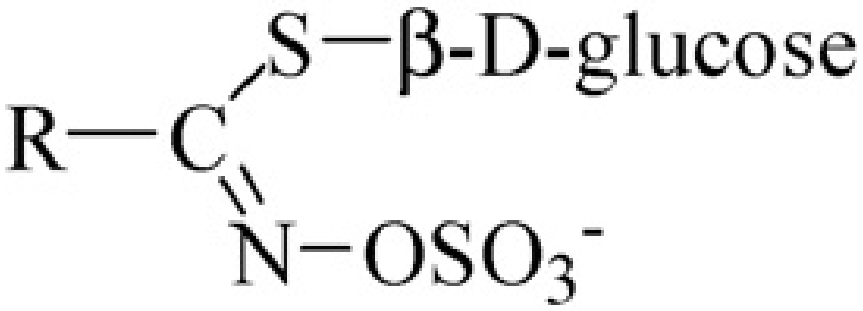
Total iodine intake during the grazing season



***P*-values**
Diet ($P < 0.001$)
*Month ($P < 0.001$)
Interaction ($P = 0.59$)

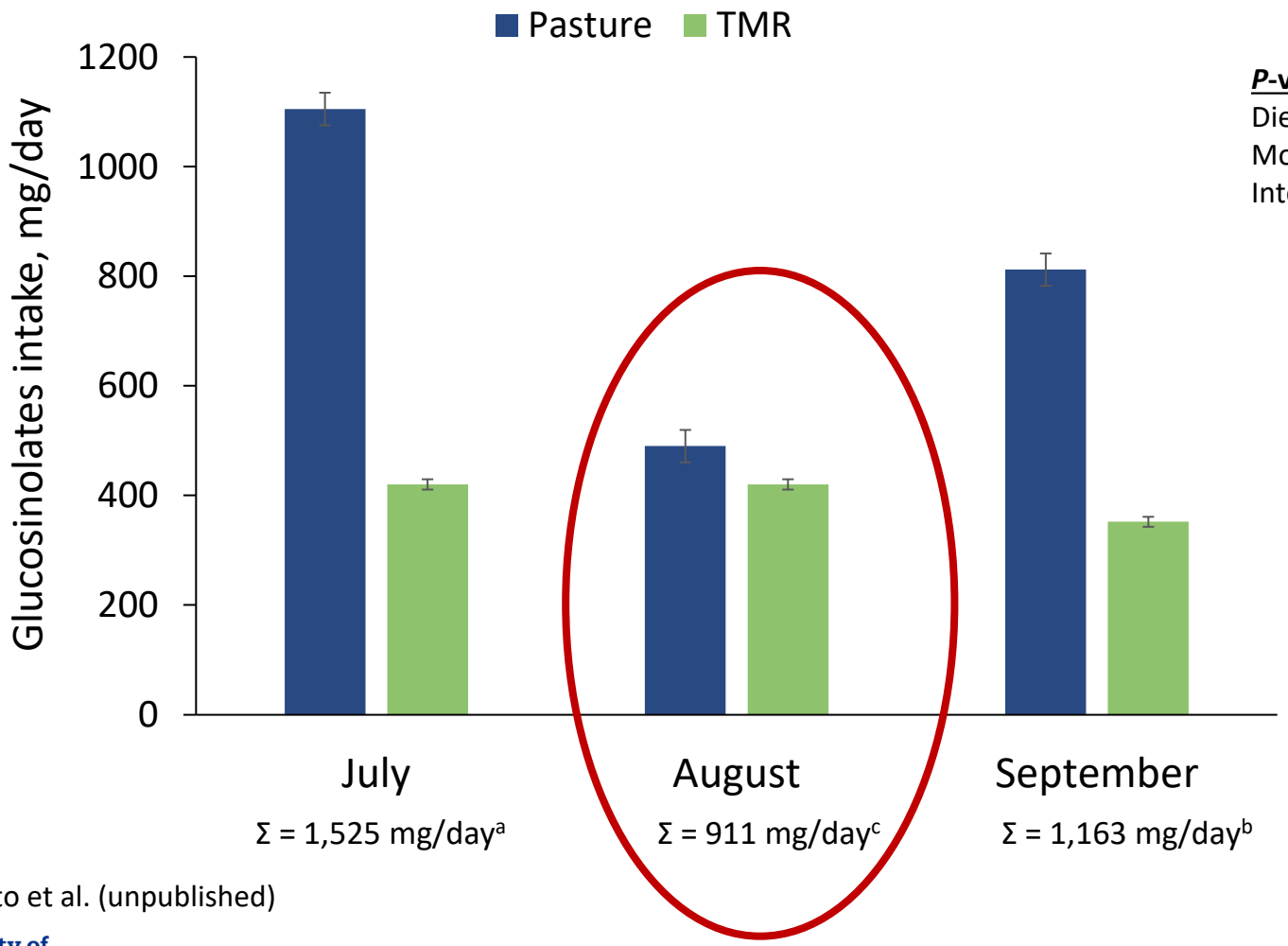
Source: Brito et al. (unpublished)

General structure of glucosinolate



Source: Tripathi and Mishra (2007)

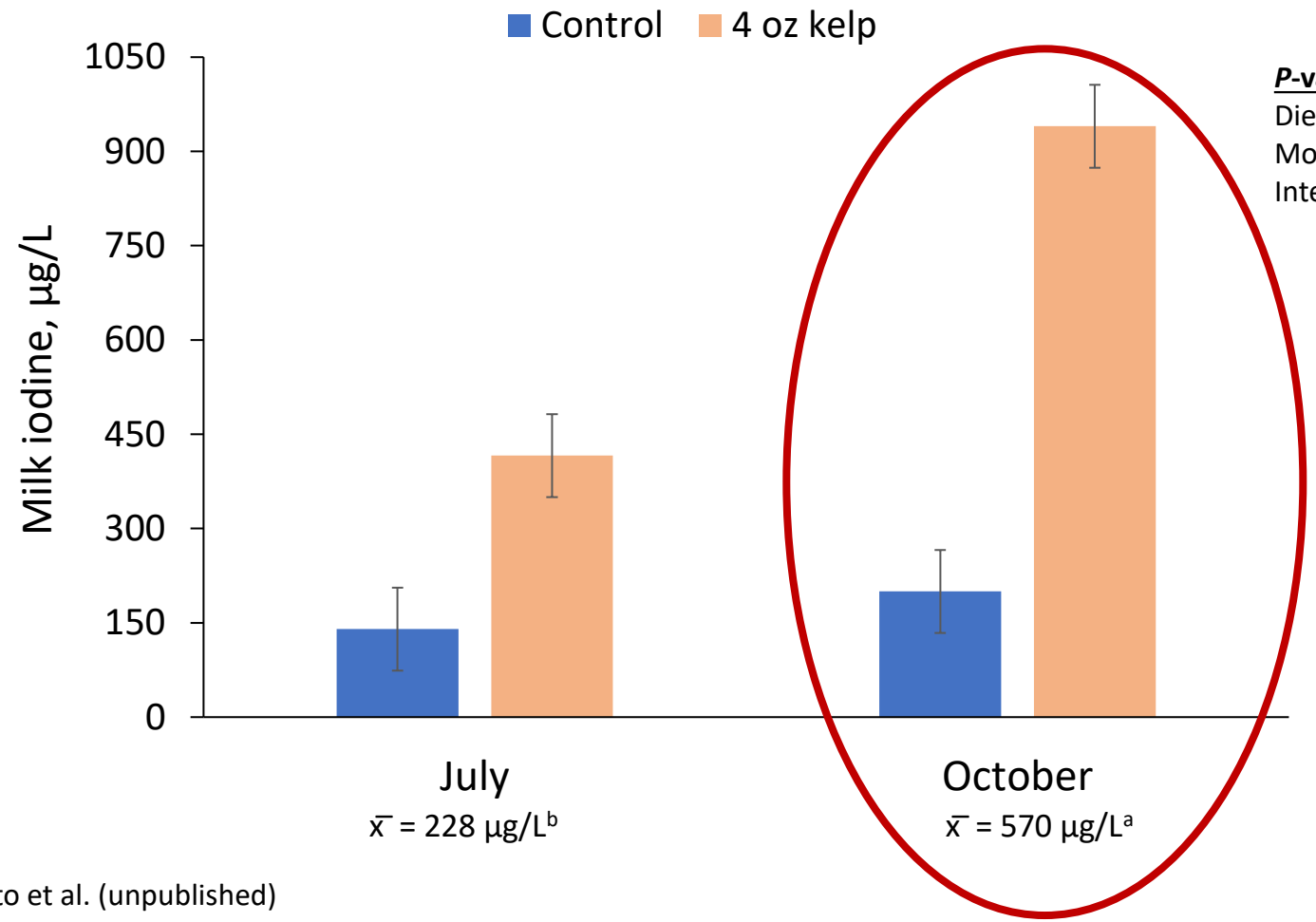
Glucosinolates intake during the grazing season



***P*-values**
Diet ($P = 0.09$)
Month ($P < 0.001$)
Interaction ($P = 0.40$)

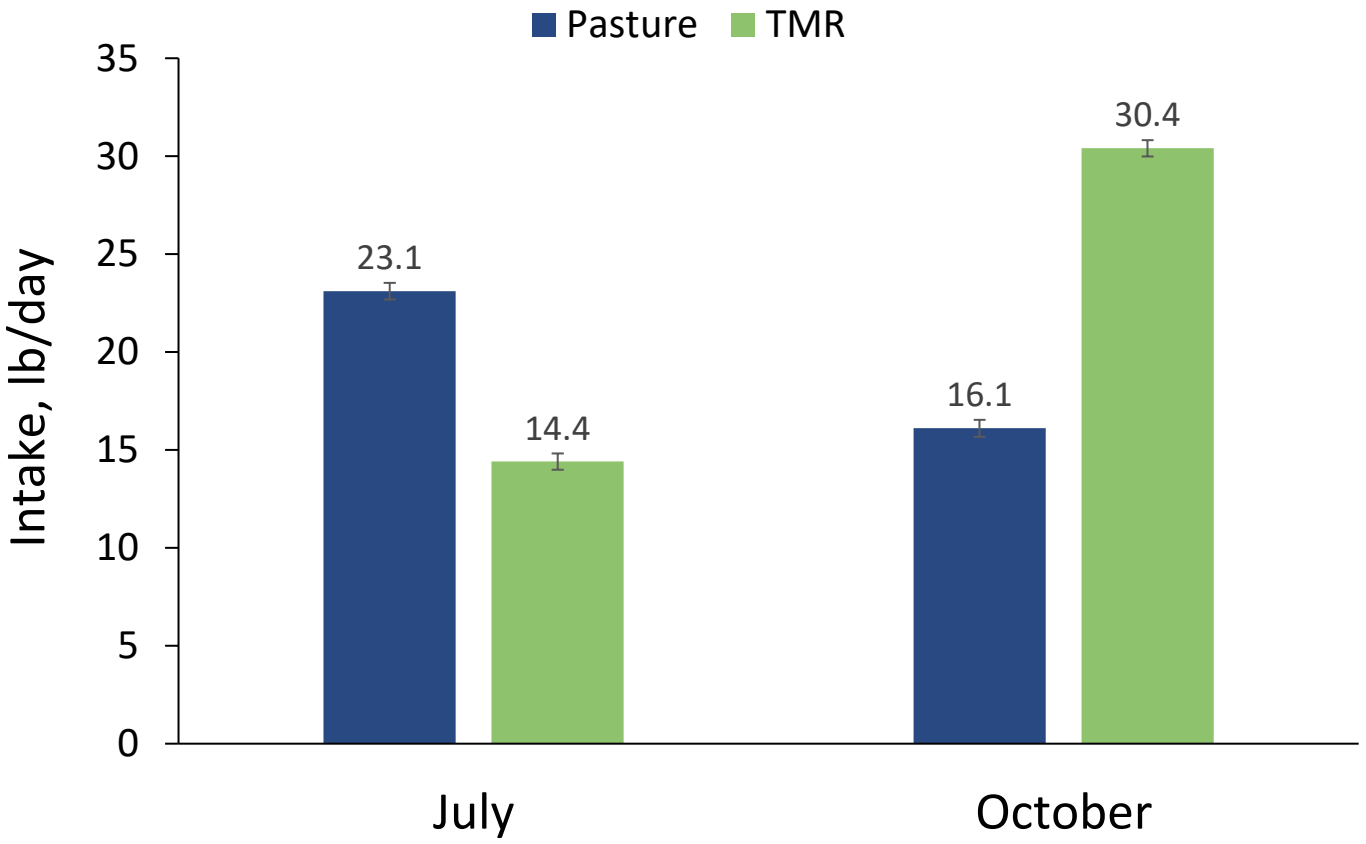
Source: Brito et al. (unpublished)

Milk iodine concentration in grazing cows fed kelp meal



Source: Brito et al. (unpublished)

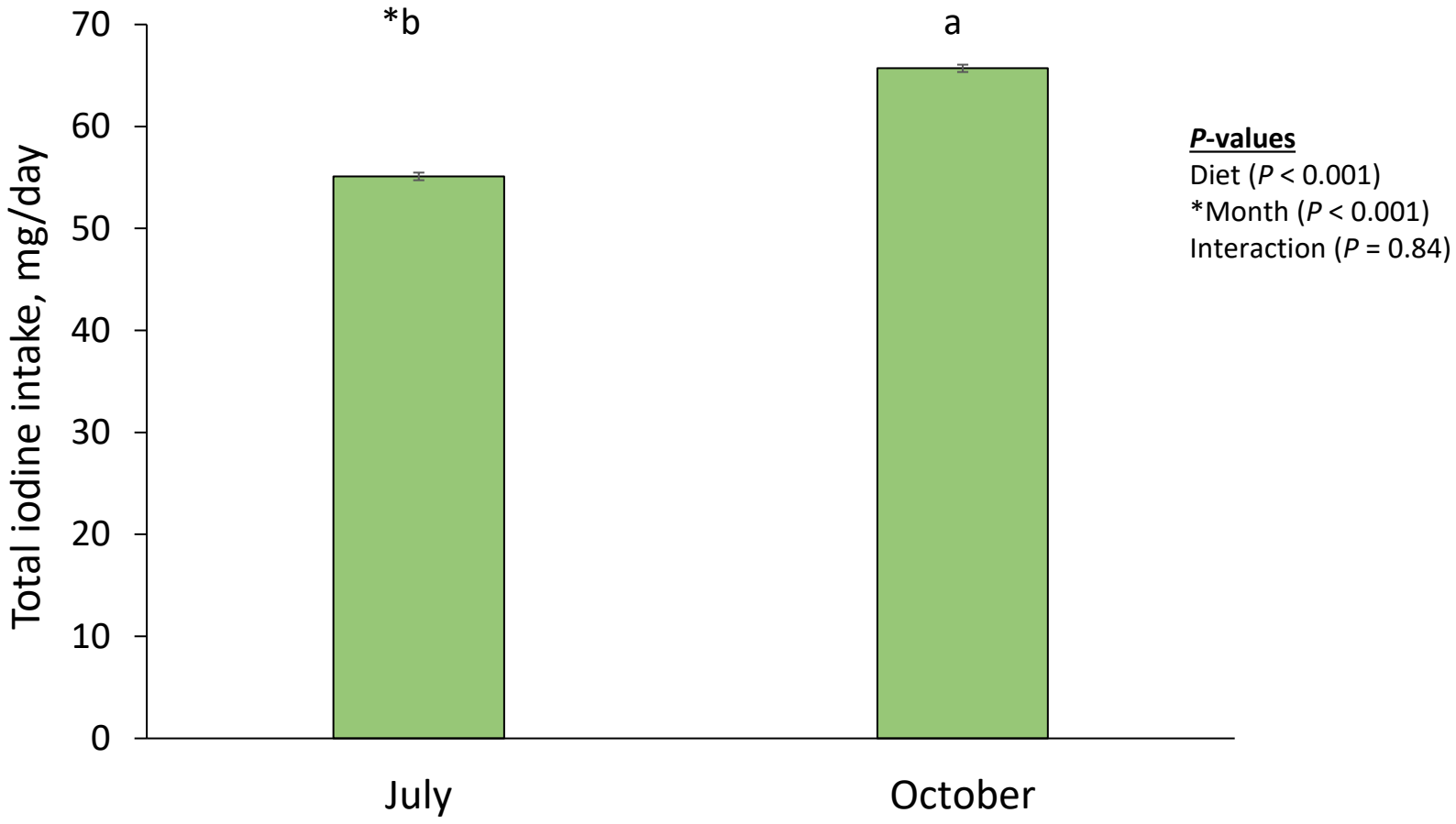
Pasture and TMR intake during the grazing season



***P*-values**
Diet ($P = 0.32$)
Month ($P < 0.001$)
Interaction ($P = 0.13$)

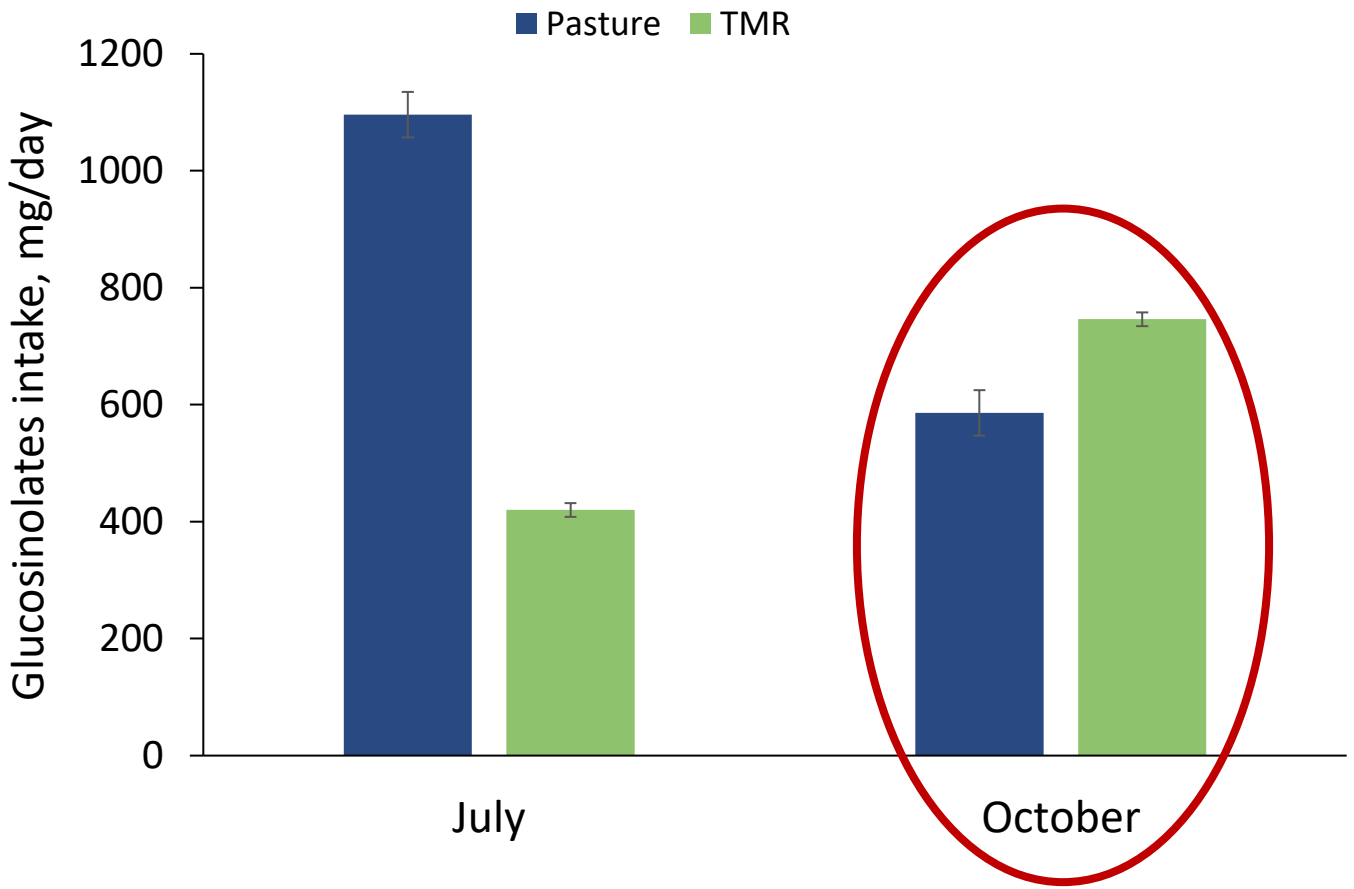
Source: Brito et al. (unpublished)

Total iodine intake during the grazing season



Source: Brito et al. (unpublished)

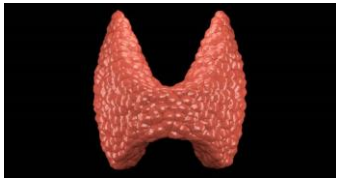
Glucosinolates intake during the grazing season



***P*-values**
Diet (*P* = 0.32)
*Month (*P* < 0.001)
Interaction (*P* = 0.13)

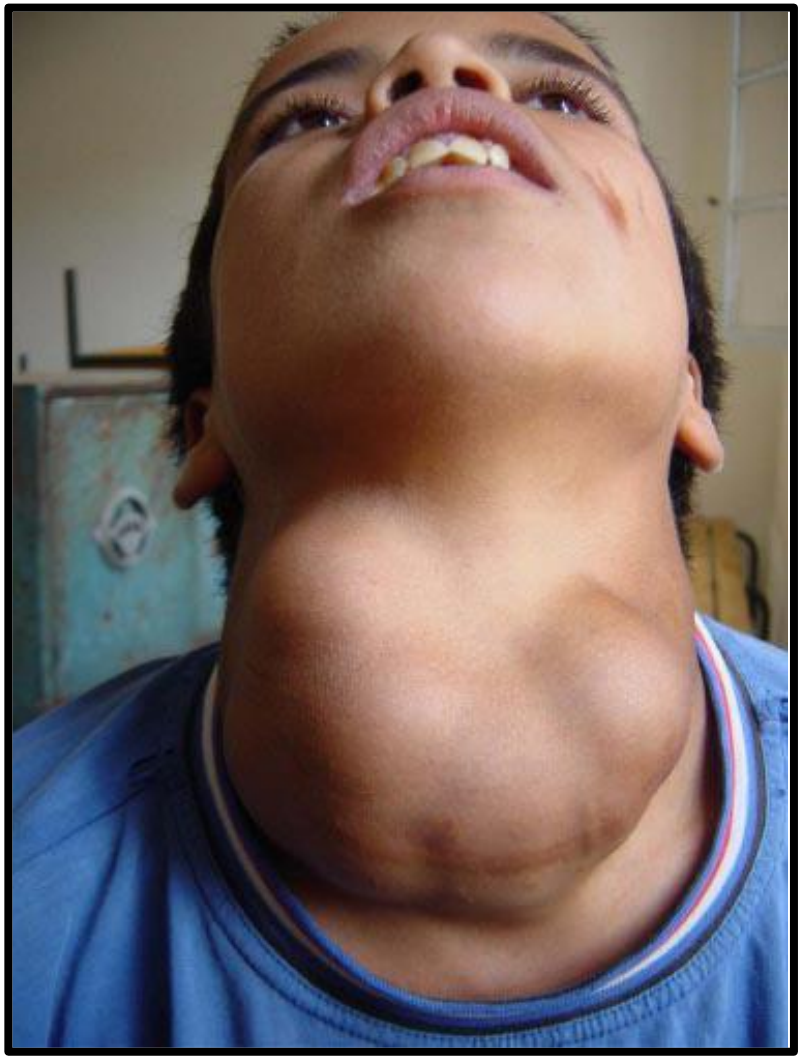
Source: Brito et al. (unpublished)

Tyroide hormone functions



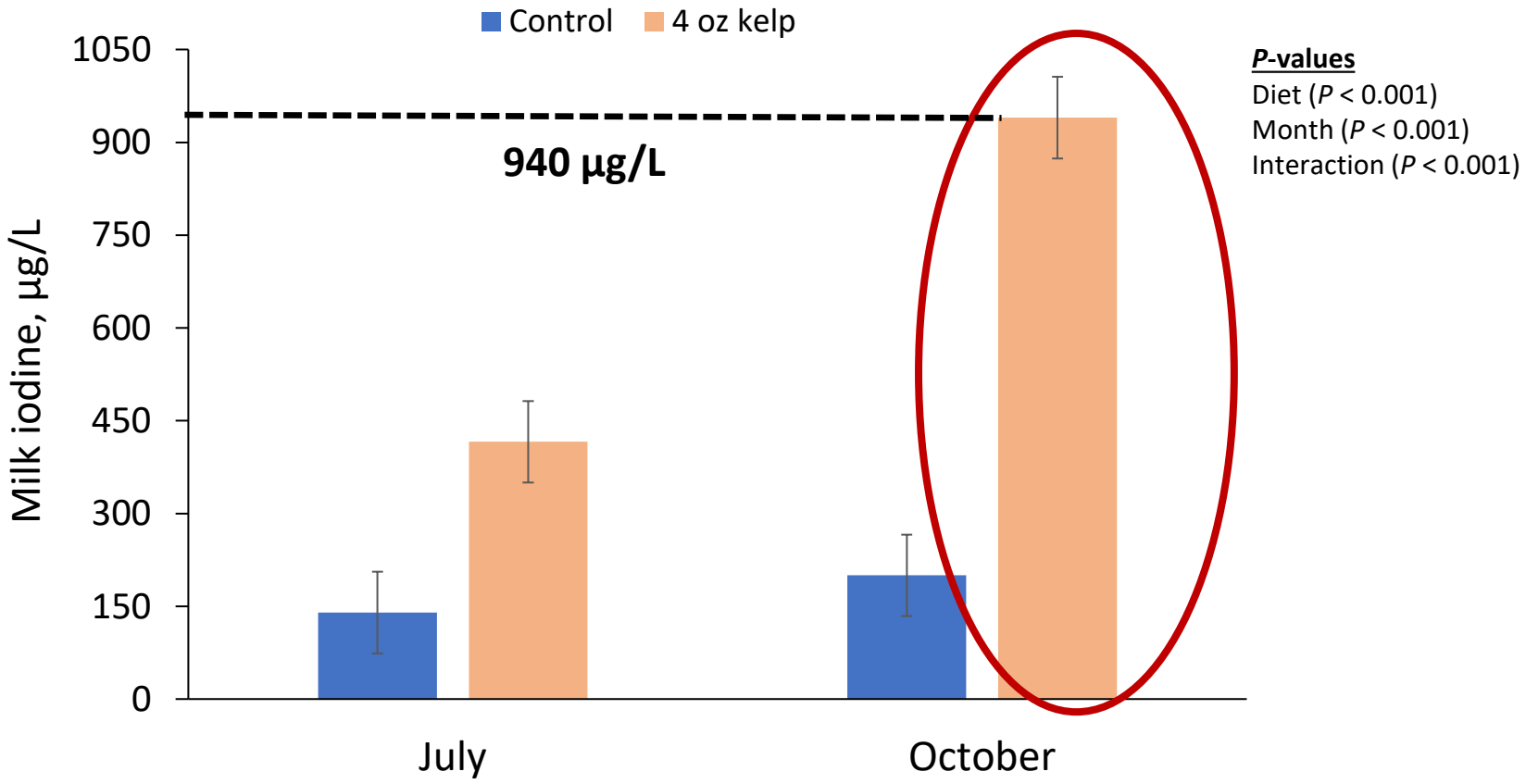
- Regulation of metabolic processes essential for normal growth and development (Oetting and Yen, 2007; Cheng et al., 2010; Brent, 2012)
- Regulation of metabolism in adults (Oetting and Yen, 2007; Cheng et al., 2010; Brent, 2012)
- Stimulation of lipogenesis and lipolysis (Oppenheimer et al., 1991)
- Influence key metabolic pathways that control energy balance by regulating energy storage and expenditure (Oetting and Yen, 2007; Liu and Brent, 2010; Iwen et al., 2013)

Large nodular goiter in a 14-year old boy



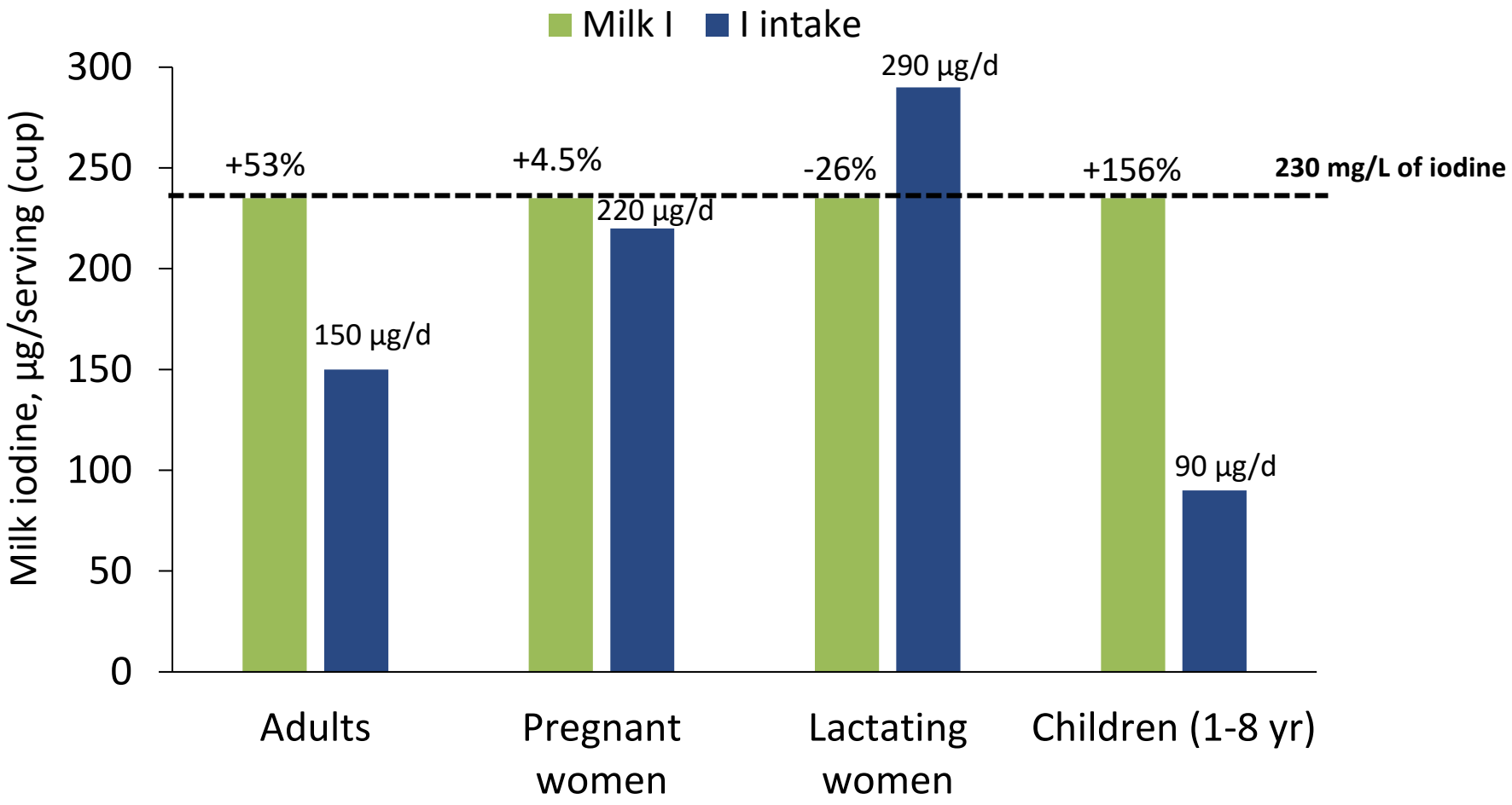
Source: Zimmermann 2009 (Endoc. Rev. 30:376–408)

Milk iodine concentration in grazing cows fed kelp meal



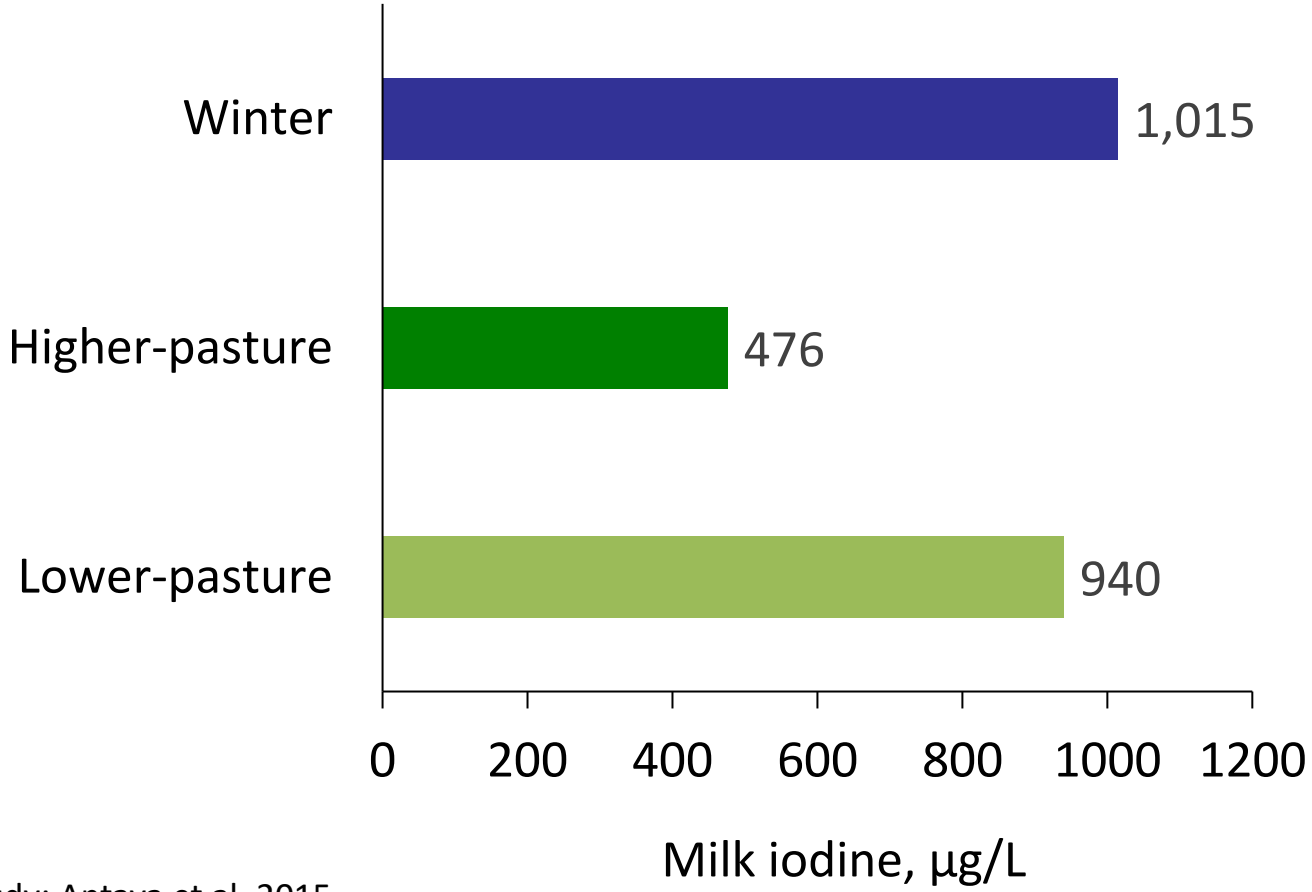
Source: Brito et al. (unpublished)

Iodine intake per serving of milk from cows fed 4 oz of kelp relative to recommended iodine intake for humans[1]



[1]U.S. Institute of Medicine (2001) recommendations

Milk iodine concentration in dairy cows fed 4 oz of kelp meal during the winter[1] and summer seasons[2]



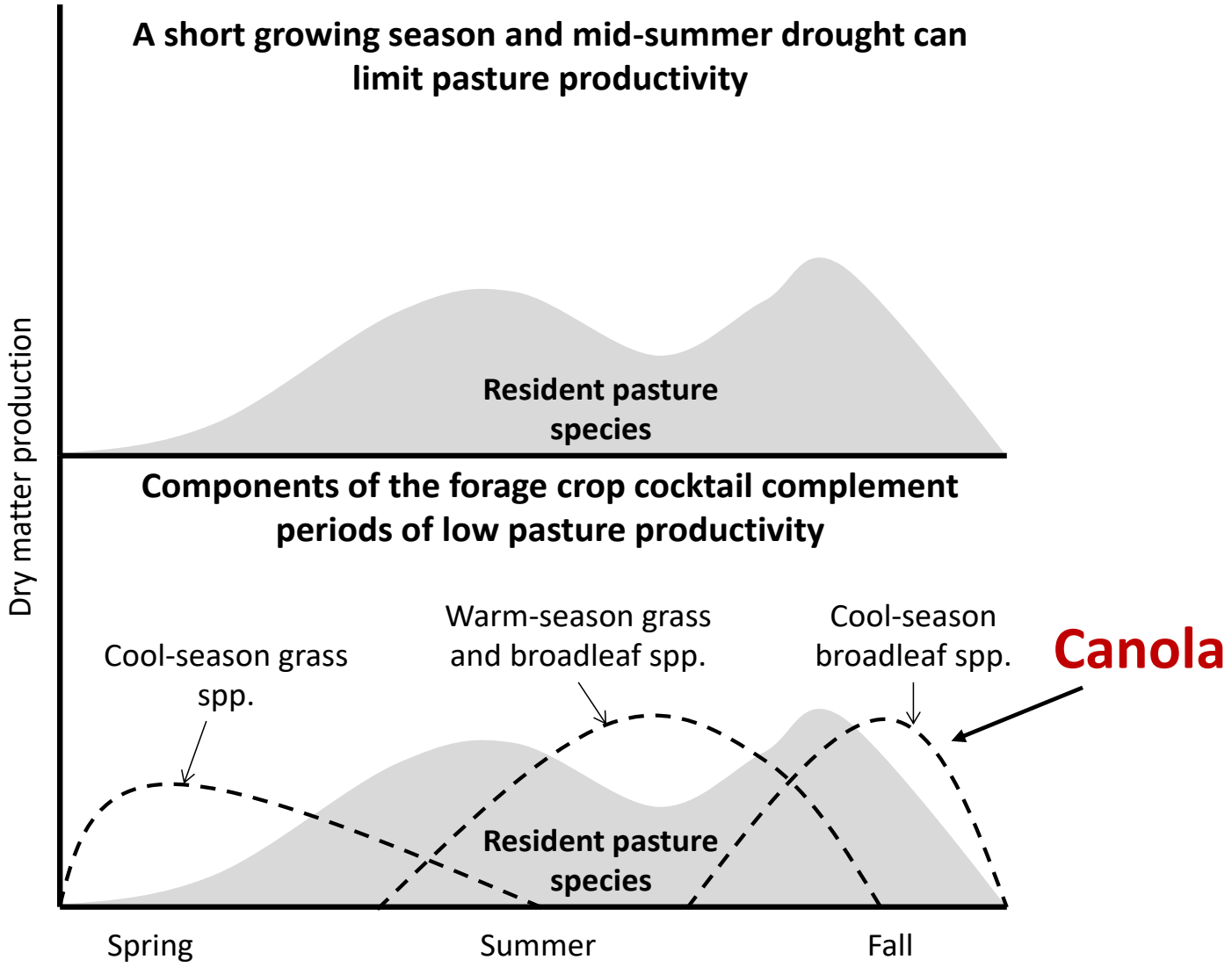
[1]Winter study: Antaya et al. 2015

[2]Summer study: Brito et al. (unpublished)

Summary

- Kelp meal supplementation effectively increases the concentration of iodine in milk
- Therefore, there are concerns and opportunities regarding the impact of iodine in human health

Use of alternative forage sources for grazing



General study procedures

- Eighteen mid-lactation Jersey cows
- Cows were randomly assigned to 1 of 2 diets: **TMR or TMR plus grazed canola**
- Diet was formulated to include 35% (dry matter basis) of canola as grazed forage offered after the afternoon milking
- Cows were milked and fed twice daily
- Feeds, milk, blood, feces, urine, and rumen fluid samples were collected throughout the 6-week study
- Methane was measured using the GreenFeed system

Cows grazing canola

Pre-grazing and post-grazed canola field

Pre-grazing and post-grazed canola field

Pre-grazing canola field after first frost

Annual ryegrass vs. Canola

Item	Feeds	
	Annual ryegrass	Canola
	-----% of dry matter (unless otherwise noted)-----	
Crude protein	30.2	28.2
Neutral detergent fiber	29.7	16.1
Acid detergent fiber	21.2	10.8
Lignin	5.3	0.8
Sugars	21.6	31.4
Glucosinolates	0.0	11.7
NEl, g/kg	1.68	1.98
Ca	0.64	1.78
P	0.28	0.40

Source: Dillard et al. (2018)

Milk production and composition in dairy cows fed TMR or TMR plus grazed canola (CAN)

Item	Diets		SEM	*P*-values		
	TMR	TMR+CAN		Diet	Week	Interaction
Milk, lb/day	49.1	45.9	0.84	<0.01	0.24	0.66
4% FCM, lb/day	58.9	56.5	1.54	0.23	0.57	0.50
ECM, lb/day	65.8	62.8	1.56	0.15	0.69	0.51
Milk fat, %	5.28	5.35	0.11	0.65	0.03	0.58
Milk fat, lb/day	3.06	2.98	0.36	0.48	0.30	0.50
Milk protein, %	3.70	3.91	0.04	<0.01	<0.01	0.95
Milk protein, lb/day	1.81	1.78	0.04	0.45	0.44	0.74
MUN, mg/dL	11.1	13.5	0.36	<0.01	<0.01	0.16

FCM = fat-corrected milk
ECM = energy-corrected milk
Source: Brito et al. (unpublished)

Methane emissions quantification using the GreenFeed system

Methane (CH_4) emissions in dairy cows fed TMR or TMR plus canola (CAN)

	Diets			*P*-values		
Item	**TMR**	**TMR+CAN**	**SEM**	**Diet**	**Week**	**Interaction**
CH_4 production, g/day	473	418	10.4	<0.01	0.93	0.49
CH_4 yield, g/kg DMI	18.4	16.9	0.48	0.03	0.67	0.29
CH_4 intensity, g/kg ECM	16.4	15.0	0.41	0.02	0.73	0.30

DMI = dry matter intake
ECM = energy-corrected milk
Source: Brito et al. (unpublished)

Final considerations

- Kelp meal supplementation may provide farmers with opportunities to improve animal health, but further research is needed
- Kelp meal is a high cost supplement ($50-60/50-lb bag)
- There is a critical need for develoing a comprehensive evaluation of iodine concentration in retail organic milk
- Canola seems to be an attractive option for filling gaps in forage production during the fall season

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Questions?


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