RESEARCH UPDATE: ENERGY STRATEGIES FOR DRY COWS

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INTRODUCTION

A successful transition of dairy cows from the dry period into lactation is reflected by preventing disease and ensuring the profitability of dairy cows (Drackley, 1999). Research efforts have concentrated on both pre- and postpartum management strategies to identify nutritional, housing and preventive procedures that can be employed to accomplish this goal.

Nutritional strategies for the dry cow have varied during the last decades with several different ones being used on dairy farms today. Because dry matter intakes (DMI) invariably drop before calving, some authors have proposed to increase the energy content of the prepartum ration in order to improve production and health in early lactation (Grummer, 1995; McNamara et al., 2003) and it was shown that DMI is increased in the prepartum period when higher energy diets are fed. On the other hand, research and experience in the field have shown beneficial effects to feeding cows a controlled energy diet prepartum (Drehmann, 2000; Douglas et al., 2006; Janovick et al., 2011; Vickers et al., 2013). A difference was shown for the effect of diets differing in energy being fed either during the far-off or close-up period and the authors concluded that overfeeding in the far-off period had more severe negative consequences than overfeeding in the close-up period (Dann et al., 2006).

According to Drackley and Janovick Guretzky (2007) it is advisable to adopt a high-straw, low-energy TMR concept for the whole dry period and research carried out by the same group showed that this can be done successfully (Janovick et al., 2011) and avoids social stress from regrouping. Because a two-group dry cow feeding system is common on dairy farms, our research aimed at comparing three dietary dry cow strategies, including a step-up approach. The objective was to evaluate the effect of each dry cow ration on postpartum negative energy balance, ketone body production and productivity.

EXPERIMENTAL APPROACH

In this randomized block design, 84 Holstein cows from the Cornell Teaching and Research Center Dairy herd were blocked by expected calving date at enrollment (57 days before expected parturition) and assigned to one of three dry cow dietary energy levels.

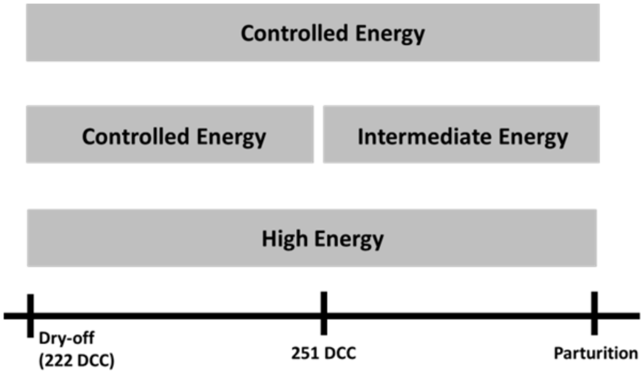

Figure 1. Experimental design treatment schematic.

The treatments consisted of a controlled energy diet **(C)**, formulated to meet energy requirements during the dry period, a high energy diet **(H)**, formulated to supply 150% of requirements, and an intermediate **(I)** energy diet, representing a step-up dietary strategy.

Cows in group I received the controlled energy diet for the first four weeks after dry off and approximately 28 days before expected calving were switched to a diet formulated to supply 125% of requirements until the day of calving. All treatments were formulated to contain 300 mg/day of monensin. After calving, all cows were fed the same fresh cow diet **(F)** until the end of the study at 42 DIM. The ingredient composition of the dry and fresh cow diets is described in Table 1. All diets were fed ad libitum and adjusted to allow for a minimum of 5% refusals.

Individual intakes were recorded daily and dry matter intake (DMI) determined from weekly dry matters of all TMRs. Weekly blood samples were taken from all cows before the morning feeding. Sampling frequency was increased to three times per week from three weeks before to three weeks after calving. Concentrations of ß-hydroxybutyrate (BHBA) in whole blood were measured cow-side using the Precision Xtra handheld device (Abbott Laboratories) and concentrations of NEFA in serum were measured using a commercial kit (WAKO Life Sciences). Milk yield was recorded for every milking; samples were collected weekly and submitted for analysis of components to Dairy One (Ithaca, NY). A composite sample of colostrum was obtained and submitted for determination of concentration of Immunoglobulin G (IgG) at the Animal Health Diagnostic Center (Cornell University). Samples of all TMRs were collected weekly and composited into monthly samples before submitting them to Dairy One for wet chemistry analysis. Energy corrected milk (ECM) for 3.5% fat and 3.0% protein was calculated according to the NRC (2001). The analyzed composition of the diets is described in Table 2.

Table 1. Ingredient composition of diets (% of total dry matter).

Ingredient	Prepartum			Postpartum
	Controlled	Intermediate	High	
Corn silage	28.5	42.2	55.9	44.2
Wheat Straw	35.6	24.0	12.4	-
Hay Crop Silage	-	-	-	10.7
Hay Switchgrass	-	-	-	2.7
Amino Plus®	10.54	6.03	1.52	4.50
Canola Meal	6.82	7.86	8.92	9.82
Chocolate Dairy Mix	-	-	-	1.07
Citrus Pulp	3.67	4.38	5.10	-
Corn Germ Meal	-	-	-	3.83
Corn ground	2.64	3.633	4.64	4.73
Distillers Grain	4.52	3.038	1.56	7.24
Soybean Hulls	2.42	3.678	4.95	5.97
Blood Meal	0.53	0.45	0.38	0.84
Fat- Energy booster®	-	-	-	0.78
Urea	-	-	-	0.058
Minerals and vitamins	3.1	3.4	3.7	1.7
Alimet®	0.07	0.07	0.06	0.037
Dextrose	-	-	-	0.73
Molasses	-	-	-	0.93
Rumensin 90®	0.01	0.01	0.01	0.01
Soy Chlor®	1.71	1.26	0.82	-

Table 2. Analyzed composition of diets, presented as average of eleven monthly composites ± SD.

Component	Prepartum			Postpartum
	Controlled	Intermediate	High	
Dry matter (DM) %	56.4 ± 3.8	49.8 ± 3.1	44.7 ± 3.9	46.8 ± 3.1
CP % of DM	14.2 ± 1.6	13.9 ± 0.7	12.5 ± 0.9	17.8 ± 0.9
NDF % of DM	48.4 ± 5.0	42.2 ± 4.5	41.0 ± 4.2	35.4 ± 2.3
ADF % of DM	30.1 ± 4.2	28.5 ± 3.2	26.6 ± 3.3	21.3 ± 4.4
Starch % of DM	15.0 ± 2.5	20.1 ± 3.6	23.7 ± 2.6	21.2 ± 2.3
Fat % of DM	2.7 ± 0.2	2.9 ± 0.2	3.1 ± 0.1	4.1 ± 0.3
Ca % of DM	0.90 ± 0.08	0.96 ± 0.11	0.91 ± 0.14	0.83 ± 0.07
P % of DM	0.36 ± 0.03	0.39 ± 0.03	0.37 ± 0.04	0.45 ± 0.02
Mg % of DM	0.34 ± 0.02	0.38 ± 0.02	0.37 ±0.04	0.34 ± 0.03
K% of DM	1.07 ± 0.10	1.06 ± 0.08	0.99 ± 0.11	1.29 ± 0.14
S % of DM	0.38 ± 0.03	0.39 ± 0.02	0.37 ± 0.02	-
Cl % of DM	0.44 ± 0.03	0.43 ± 0.06	0.38 ±0.04	-
DCAD meq/100g	-0.76 ± 1.65	-0.39 ± 3.32	-0.53 ± 2.24	-

Energy balance was estimated in CNCPS (v. 6.1) for each week and individual by entering the weekly average of the animal's body weight and dry matter intake and either days carried calf for dry period estimates or milk yield as well as percent milk fat, protein and lactose for the postpartum period. Energy balance was expressed as percentage of requirements. On days 28 and 10 before expected calving as well as on days 4 and 21 after calving, baseline concentrations of insulin and glucagon were determined via radioimmunoassay (Millipore) four hours after removal of orts.

Chi-square tests were generated with PROC FREQ of SAS (SAS 9.3, SAS Institute Inc., Cary, NC) for differences in episodes of BHBA ≥1.2 mmol/L as well as treatment episodes for clinical ketosis. Repeated measures ANOVA was performed for the outcomes DMI, energy balance, BHBA and NEFA concentrations, milk and ECM yield using PROC MIXED in SAS. Five covariance structures were tested for each variable analyzed (simple, compound symmetry, autoregressive order 1, Toeplitz and unstructured). The covariance structure with the smallest Aikaike information criterion was chosen. Fixed effects were treatment group and parity with the REPEATED statement for the time variable. Data were analyzed separately for pre- and postpartum. When results of the ANOVA analysis yielded a p-value of ≤ 0.05, Tukey´s posthoc test was used for comparison of means across all groups to control experimentwise error rate.

EFFECT OF DRY PERIOD ENERGY LEVEL ON ENERGY METABOLITES; DRY MATTER INTAKE AND MILK YIELD

Results from repeated measures ANOVA are presented in Table 3. Concentrations of BHBA pre- as well as postpartum were highest in group H. Four cows in group I and five cows in group H were treated for clinical ketosis, while none of the cows in group C required treatment (p=0.07). Of all possible tests in the first 21 DIM, when blood was tested three times per week for each cow, there were 13,32 and 31 positive episodes in group C, I and H, respectively (p=0.007). Concentrations of NEFA were highest in group C prepartum and highest in group H postpartum. Dry matter intake prepartum was different among the groups with the highest intakes in group H and the lowest intakes in group C. No differences in DMI or milk yield were measured postpartum. Numerical differences were found for % of milk fat and ECM yield with highest fat % and ECM in group H and lowest in group C. Energy balance estimations are presented in Figure 2.

EFFECT OF DRY PERIOD ENERGY LEVEL ON COLOSTRAL IMMUNOGLOBULIN

Immunoglobulin G concentration was different for cows in the three treatment groups (Table 4). Concentrations were highest in group C and lowest in group H. The overall average and each group's average exceeded the industry recommended minimal concentration of 50 g/L.

Table 3. Least squares means for energy metabolites, DMI and milk yield. T=treatment.

Parameter		T			Fixed effects	
		Controlled	Intermed.	High	T	T x Time
		LS means ±SE			*p*	
BHBA, mmol/dL	*prepartum*	0.29 ± 0.01^{a}	0.30 ± 0.01^{ab}	0.34 ± 0.01^{b}	0.04	0.03
	postpartum	0.63 ± 0.06^{a}	0.77 ± 0.06^{ab}	0.85 ± 0.06^{b}	0.05	0.19
NEFA, µEq/L	*prepartum*	237 ± 12.4^{a}	180 ± 12.7^{b}	175 ± 12.5^{b}	0.001	0.03
	postpartum	659 ± 36.4^{a}	665 ± 36.7^{a}	796 ± 39.5^{b}	0.02	0.37
DMI, kg/d	*prepartum*	14.2 ± 0.3^{a}	15.3 ± 0.3^{b}	16.4 ± 0.3^{c}	<0.0001	0.03
	postpartum	22.3 ± 0.6	22.4 ± 0.6	22.4 ± 0.6	0.99	0.75
Milk yield, kg/d		43.8 ± 1.2	43.6 ± 1.2	43.9 ± 1.2	0.98	0.31
ECM yield, kg/d		46.1 ± 1.2	47.0 ± 1.2	48.3 ± 1.3	0.48	0.94
Milk fat %		3.9 ± 0.1	4.1 ± 0.1	4.2± 0.1	0.10	0.97

^{a,b,c} Row means with different superscripts differ ($p \leq 0.05$).

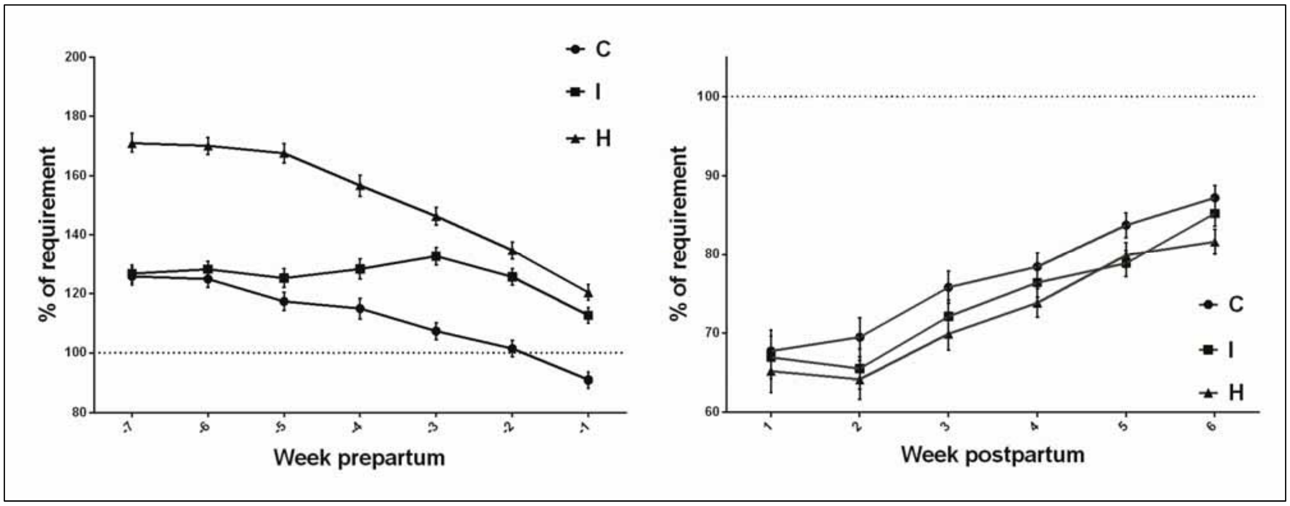

Figure 2. Energy balance estimation expressed as % of requirement using CNCPS v. 6.1 (C=controlled energy diet, I= intermediate energy diet, H= high energy diet).

Table 4. Immunoglobulin G (IgG) concentration as well as first colostrum weight for the three different treatment groups.

	Controlled	Intermediate	High	Overall	p-value
IgG (g/L) (95% CI)	96.2^{a} (83.5-109)	88^{ab} (75.8-100.0)	72.24^{b} (60.4-84.4)	85.1 (77.7-92.4)	0.03
Colostrum weight (lbs)	13.1 (9.8-16.4)	15.5 (12.4-18.6)	16.0 (13.0-19.2)	14.8 (13.2-16.7)	0.40

^{a,b} Row means with different superscripts differ ($p \leq 0.05$).

EFFECT OF DRY PERIOD ENERGY LEVEL ON INSULIN AND GLUCAGON

When insulin is lacking (fasted state) or a state of insulin resistance develops, lipolysis leads to a rise in NEFA concentration. NEFA can be used as an energy source and used for milk fat synthesis by the mammary gland. When taken up by the liver, NEFA can get repackaged as triglycerides and exported as very low density lipoproteins (VLDL) or get completely oxidized in the Krebs cycle to produce energy for gluconeogenesis. If hepatic NEFA in the form of acetyl-CoA overwhelms the Krebs cycle, ketogenesis is initiated. Glucagon increases the rate of gluconeogenesis and low insulin: glucagon ratios further triggers NEFA release.

Results of the insulin and glucagon concentrations in plasma at four timepoints throughout the study are presented in Figure 3. Insulin concentration was lowest in group H at day 4 postpartum while the glucagon concentration was highest in this group at the same timepoint.

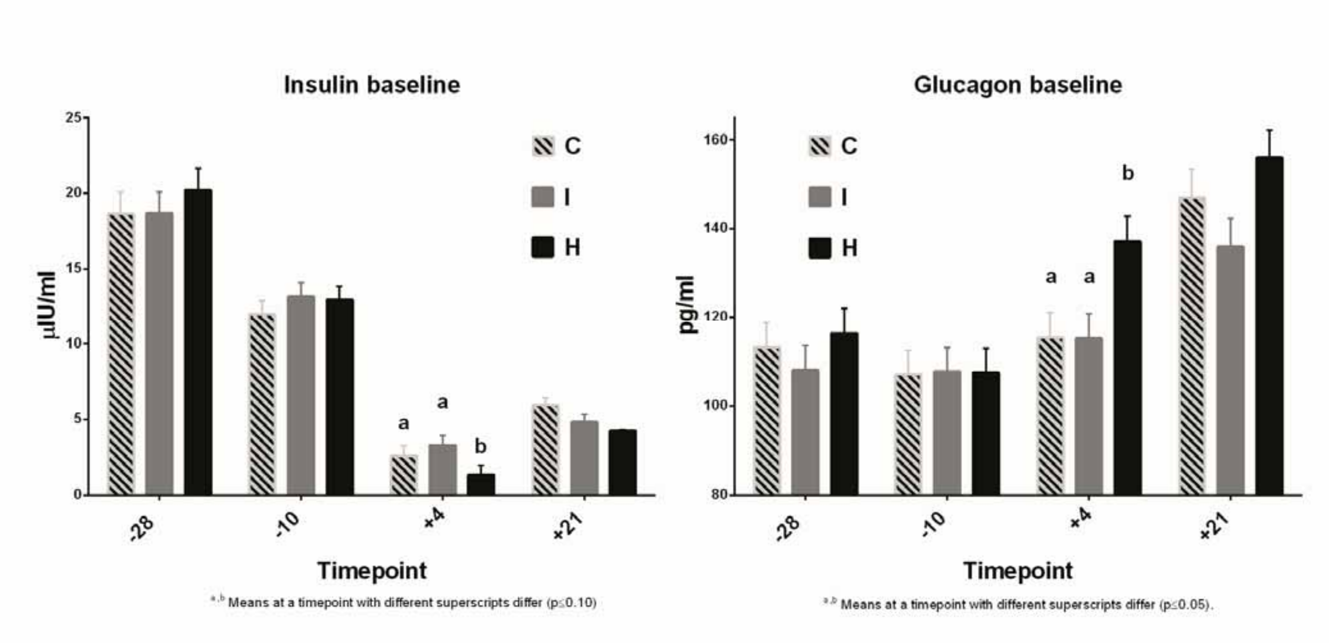

Figure 3. Insulin and glucagon baseline concentrations at four timepoints throughout the study (-28, -10= 28 and 10 days before expected parturition, respectively, +4, +21= 4 and 21 days after parturition, respectively.

IMPLICATIONS AND CONCLUSIONS

Data from this study show that cows fed a controlled energy diet throughout the whole dry period mobilized less adipose tissue as reflected by lower concentrations of NEFA and also had lower concentration of BHBA postpartum while milk production and postpartum DMI intake were not affected. Higher milk fat % in the group fed a high energy diet prepartum is likely due to a greater amount of NEFA being used for milk fat synthesis. Colostrum quality expressed as IgG concentration was improved in cows fed the controlled energy diet. Lower concentrations of insulin and higher concentrations of glucagon at 4 DIM reflects the greater degree of negative energy balance and decreased inhibition of insulin on lipolysis explains the higher concentration of NEFA in cows being fed a higher energy diet prepartum.

Cows fed an intermediate energy level in a step-up system had the same milk yield and postpartum DMI as cows in the other two groups. When taking into account concentrations of NEFA and BHBA postpartum, as well as treatment for clinical ketosis and episodes of subclinical ketosis, cows fed an intermediate energy level in a step-up system prepartum showed some of the same effects of more pronounced negative energy balance as cows being fed a high energy diet for the whole duration of the dry period, despite the fact that had received the same controlled energy diet during the far-off period.

Although sample size in this study was not adequate to compare health events, epidemiological data linking high BHBA and NEFA concentrations to an increased risk for several periparturient disorders, including displacement of the abomasum, metritis, reduced reproductive success as well as decreased milk production and removal from the herd (Ospina et al., 2010b, a; Chapinal et al., 2011; Chapinal et al., 2012; McArt et al., 2012; McArt et al., 2013; Suthar et al., 2013) is available. The conclusion of the authors is therefore that a controlled energy diet fed throughout the whole dry period showed clear advantages in preventing excessive negative energy balance that could lead to downstream disease and improved colostrum quality without affecting milk yield.

ACKNOWLEDGEMENTS

This project is supported by the Agriculture and Food Research Initiative competitive grant no. 2012-67015-30230 from the USDA National Institute of Food and Agriculture. The authors wish to acknowledge Gladys Birdsall and the staff at the Cornell University Teaching and Research Dairy for their assistance with carrying out the study. We thank Mélissa Dupléssis, Bryant Stuttle, Allison Lawton and Lauren Stanko Bristol as well as undergraduate research assistants Rheanna Foley and Elizabeth Martens for their invaluable help with sampling collection. We also thank the Place and Cummings labs for help with sample analyses.

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