FREE-CHOICE ACCESS TO A MODERATE-ENERGY DIET INCREASES INTERNAL BODY FAT IN DRY COWS

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TAKE HOME MESSAGES

- Feeding moderate energy diets to dry cows leads to large increases in internal (visceral) fat accumulation but no detectable difference in body condition score.
- Body condition score (BCS) as a visual measure of energy reserves in dry cows may provide little information on how energy nutrition affects internal fat stores and liver function.
- Controlling energy intake during the dry period will minimize internal fat deposition.

INTRODUCTION

Abdominal fat accumulation in humans has been related to an increased risk of type 2 diabetes and associated health problems. Non-obese people with normal body mass index could still be at risk of metabolic malfunctions if they have measurable fat stores around visceral organs. In dairy cows, overfeeding energy during the dry period by liberal access to moderate or high energy diets leads to fat accumulation in the liver. Fatty liver may interfere with glucose synthesis and detoxification of ammonia. The blood supply from visceral fat tissues leads directly to the liver, which underlines the potential of internal fat to affect liver function. However, the extent of visceral fat buildup in response to excess energy intake in dry cows is unknown. Our hypothesis was that overfeeding during the dry period would lead to increased visceral fat deposition even in the absence of overconditioning. The objective of our experiment was to determine dietary energy effects on energy intake, visceral fat mass, visceral organs mass, metabolites in blood, and body condition score (BCS) in nonlactating cows.

MATERIALS AND METHODS

Eighteen nonpregnant, nonlactating Holstein cows (BW = 1,443 ± 64 lb; BCS = 3.04 ± 0.25) were used in a completely randomized block design study with BCS as block. Cows received either a moderate energy (**M**; NE_L = 0.7 Mcal/lb) or a low energy (**L**; NE_L = 0.6 Mcal/lb) TMR for ad libitum intake. The M diet had 74.5% forage with no straw and 50.3% corn silage, whereas the L diet had 84.6% forage including 41.9% wheat straw and 29.3% corn silage (DM basis). The diets were mixed with a Keenan Klassik 140 mixer wagon equipped with knives; the straw was chopped during TMR preparation without pre-processing.

Cows were housed in a free-stall barn equipped with individual electronic transmission gates and transponders (Calan feed system) for access to feed. Blood was sampled from a tail vein at weeks 2, 4, and 7. Body condition was scored at weeks 1, 4, and 7. Following the 8-week feeding period, cows were euthanized and visceral tissues including heart, liver, total digestive tract, and kidneys as well as mammary gland were separated and weighed. The adipose tissue masses in omental, mesenteric, and perirenal areas were dissected and weighed. Data were analyzed using the Mixed Models Procedure of SAS with fixed effects of diet, block (BCS), and their interaction plus the random effect of cow within diet by block. The repeated blood variables, DMI, and BCS were analyzed as a randomized complete block design with fixed effects of diet, block, week, and two- and three-way interactions.

RESULTS AND DISCUSSION

Cows fed the M diet consumed about 44% more DM and 69% more NE_L than did cows on the L diet (Table 1, $P < 0.01$), showing that free-choice access to moderate energy diets leads to substantially over-feeding energy. The nonsignificant interaction of block and diet indicates that the effects of diet on energy intake were consistent across different BCS groups. The much greater energy intake in M than in L cows indicates that decreasing dietary energy density by including chopped straw in the ration can effectively limit energy intake in dry cows.

Average and pre-harvest body weight and BCS were similar between treatments (Table 1). The M group had larger omental ($P < 0.01$), mesenteric ($P = 0.01$), and perirenal ($P < 0.05$) adipose masses than the L group. Mesenteric and omental adipose sites drain directly to the liver and so can increase delivery of NEFA and various signaling molecules to the liver. Consequently, the liver may receive large amounts of NEFA from visceral adipose tissues regardless of the apparent mass of external adipose tissue. As a result, risks for fatty liver and associated metabolic disorders may increase. The increase in omental fat depots in cows fed the M diet was 35.9 lb for cows with BCS < 3, 31.2 lb for cows with BCS of 3-3.75, and 2.9 lb for cows with BCS of ≥ 4 (Figure 1), suggesting that dry cows with lower BCS are more susceptible to the effects of overfeeding energy on visceral fat accumulation. Our results demonstrate that feeding high bulk, low energy diets to dry cows effectively limits internal fat accumulation and thus may decrease the degree of fatty liver.

Cows fed M had greater concentrations of BHBA in blood than did cows fed L (Table 2, $P < 0.05$). Since the cows were dry and nonpregnant, and therefore were in positive energy balance, the greater blood BHBA in the M cows was likely due to greater DMI and more extensive rumen fermentation compared to the L group. Serum NEFA were greater at week 4 (0.14 vs. 0.08 mmol/L, $P = 0.04$) and tended to be greater at week 7 (0.10 vs. 0.08 mmol/L, $P = 0.06$) in the M group compared to the L group. The greater NEFA could indicate greater fatty acid flow from the larger mass of visceral adipose tissues. The numerically greater serum insulin in M cows might suggest altered insulin response.

Dietary energy intake did not affect weights of liver, heart, kidneys, mammary gland, or total gastrointestinal tract (Table 1). The BCS was strongly correlated ($r > 0.75$) with the internal adipose mass for both treatments. However, because treatment differences in body weight and BCS were minor, monitoring BCS and body weight changes in dry cows lacks sensitivity to detect dietary energy effects on visceral adipose tissue accumulation.

CONCLUSIONS

Ad libitum access of dry cows to a moderate energy diet compared to a low-energy, high-straw diet for 8 weeks increased omental, mesenteric, and perirenal fat stores without affecting visceral organs mass. Common management tools such as BCS provide little information on the extent of internal fat accumulation, which may be of critical importance to development of fatty liver and related metabolic disorders. Feeding bulky low-energy diets to meet but not greatly exceed energy requirements may minimize such risks.

Table 1. Intake, body weight (BW), body condition score (BCS), visceral organs mass, mammary gland mass, and internal adipose tissue mass in nonlactating cows fed moderate-energy (M) or low-energy (L) diets

	Diets			*P*-value		
Item	M	L	SEM	Diet	Block	Diet × Block
DMI, lb/d	34.5	24.0	1.3	<0.0001	0.05	0.54
NE_L intake, Mcal/d	25.3	14.9	0.93	<0.0001	0.07	0.69
BW, lb	1617	1619	53	0.98	0.005	0.26
BCS	3.62	3.55	0.11	0.68	0.001	0.55
Omental fat, lb	61.8	38.5	2.9	<0.0001	<0.0001	0.02
Mesenteric fat, lb	48.4	26.6	5.2	0.01	0.05	0.44
Perirenal fat, lb	21.7	13.1	2.6	0.04	0.01	0.99
Digestive tract, lb	102.4	99.2	6.5	0.73	0.40	0.83

Table 2. Plasma metabolites and serum insulin in nonlactating cows fed moderate-energy (M) or low-energy (L) diets

	Diet			*P*-value[1]					
Analyte	M	L	SEM	D	B	T	D×T	D×B	D×T×B
Glucose, mg/dl	66.7	66.1	2.2	0.85	0.48	0.39	0.66	0.62	0.90
Urea N, mg/dl	13.2	12.5	0.51	0.37	0.12	0.02	0.92	0.77	0.48
Total proteins, g/dl	7.77	7.50	0.33	0.57	0.53	0.38	0.86	0.85	0.74
Albumin, g/dl	3.56	3.42	0.08	0.26	0.002	<.0001	0.43	0.65	0.19
BHBA, mmol/L	0.46	0.35	0.03	0.01	0.55	0.42	0.82	0.87	0.88
Cholesterol, mmol/L	120.2	99.8	4.5	0.005	0.05	0.02	0.0004	0.008	0.03
NEFA, mmol/L	0.11	0.11	0.01	0.96	0.30	0.08	0.02	0.88	0.47
Insulin µIU/ml	29.6	23.5	3.2	0.20	0.16	0.73	0.42	0.85	0.52

[1]D = diet, B = block (i.e., BCS), T = time or measurement week.

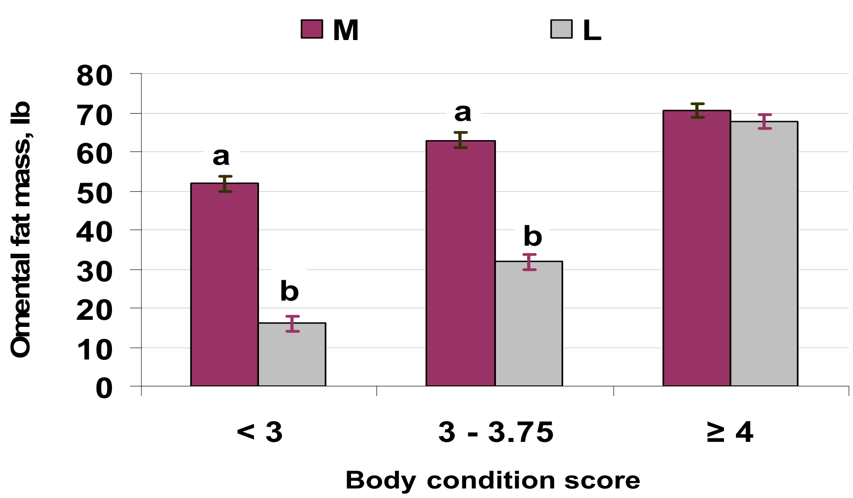

Figure 1. Omental adipose tissue mass in cows with different body condition scores. M = moderate energy diet, L = low energy diet.