Amino Acid Nutrition and Transition Cows

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Commonly accepted benefits to balancing for Lys and Met in MP

- Increased milk yield
- Increased milk component percentages
- Increased milk component yields
- Increased conversion of feed N to milk protein
- Reduced need for supplemental RUP
- Increased herd profitability

Four commonly asked questions

- Should we start AA balancing before calving?
- Is balancing for Lys and Met more important in post-fresh cows than 3-4 wk after calving?
- Does AA balancing of early fresh cows really have an affect on health and breeding?
- Should our target levels for Lys and Met in MP be the same as for the rest of the cows?

Protein requirements of transition cows: pre-fresh cows (NRC, 2001)

	Days before calving			
	21	14	7	1
Heifers				
w/o mammary	10.0, 2.9	10.0, 4.1	10.0, 4.4	10.1, 4.5
w/ mammary[1]	10.0, 4.0	10.0, 5.4	10.0, 5.7	10.1, 6.1
Cows				
w/o mammary	10.0, 1.3	10.0, 1.5	10.0, 2.0	10.2, 3.2
w/ mammary[1]	10.0, 2.2	10.0, 2.5	10.0, 3.0	10.2, 4.4

Diet (% of DM): 35 normal corn silage, 34 mid maturity grass silage, 10 ground high moisture corn, 8 solvent SBM, and 13 beet pulp

[1] VandeHaar and Donkin (1999)

RDP and RUP balances of the pre-fresh heifers and cows (NRC, 2001)

	Days before calving			
	21	14	7	1
Heifers				
w/o mammary	-153, +281	-122, +97	-118, +59	-91, +29
w/ mammary[1]	-153, +151	-122, -34	-118, -71	-91,-101
Cows				
w/o mammary	-173, +552	-168, +506	-152, +402	-115, +183
w/ mammary[1]	-173, +422	-168, +376	-152, +272	-115, +53

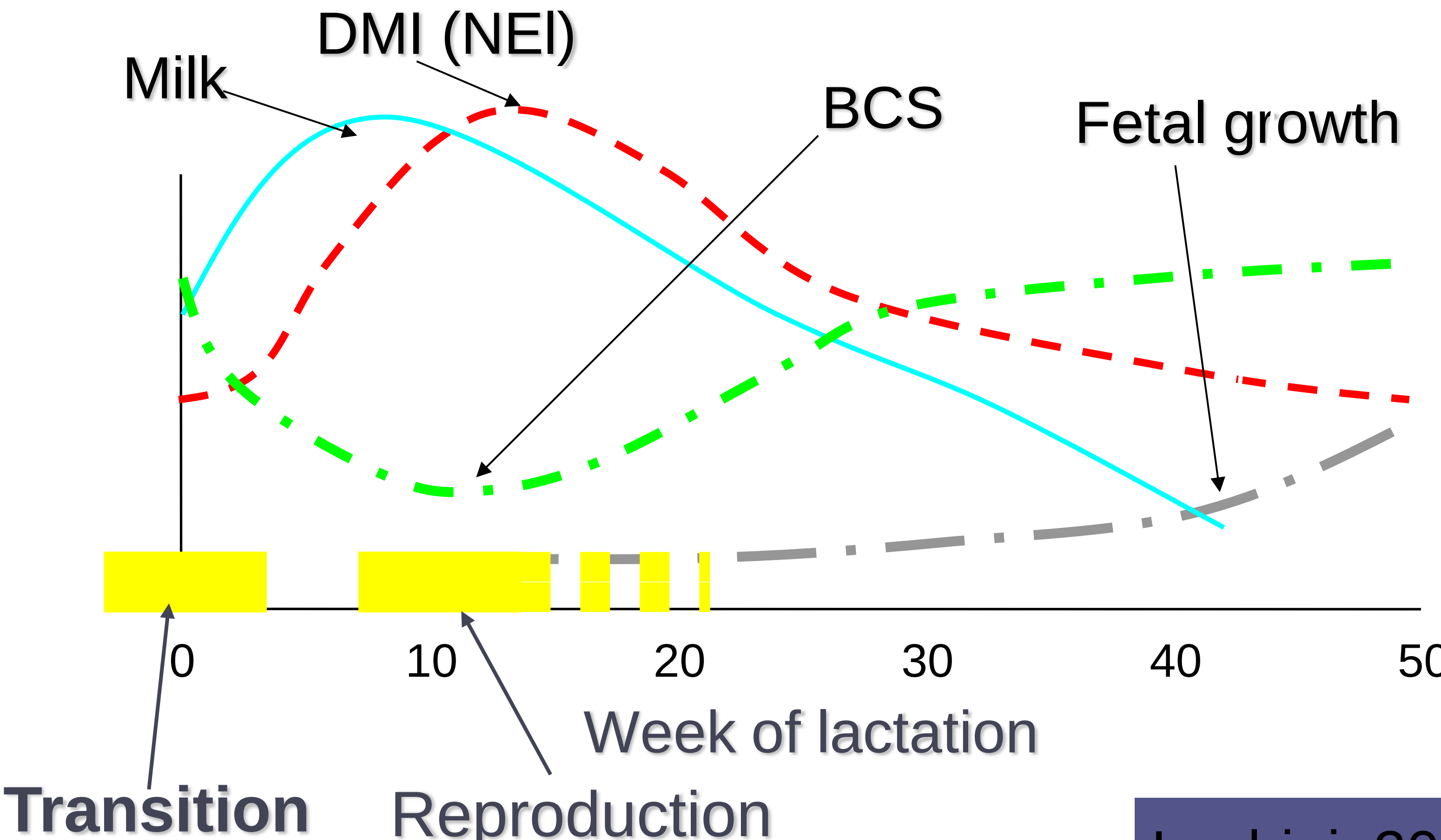
Diet (% of DM): 35 normal corn silage, 34 mid maturity grass silage, 10 ground high moisture corn, 8 solvent SBM, and 13 beet pulp

[1] VandeHaar and Donkin (1999)

Findings regarding energy and protein metabolism of transition cows

- Feed intake is not commensurate with nutritional needs

The critical times of the lactation cycle

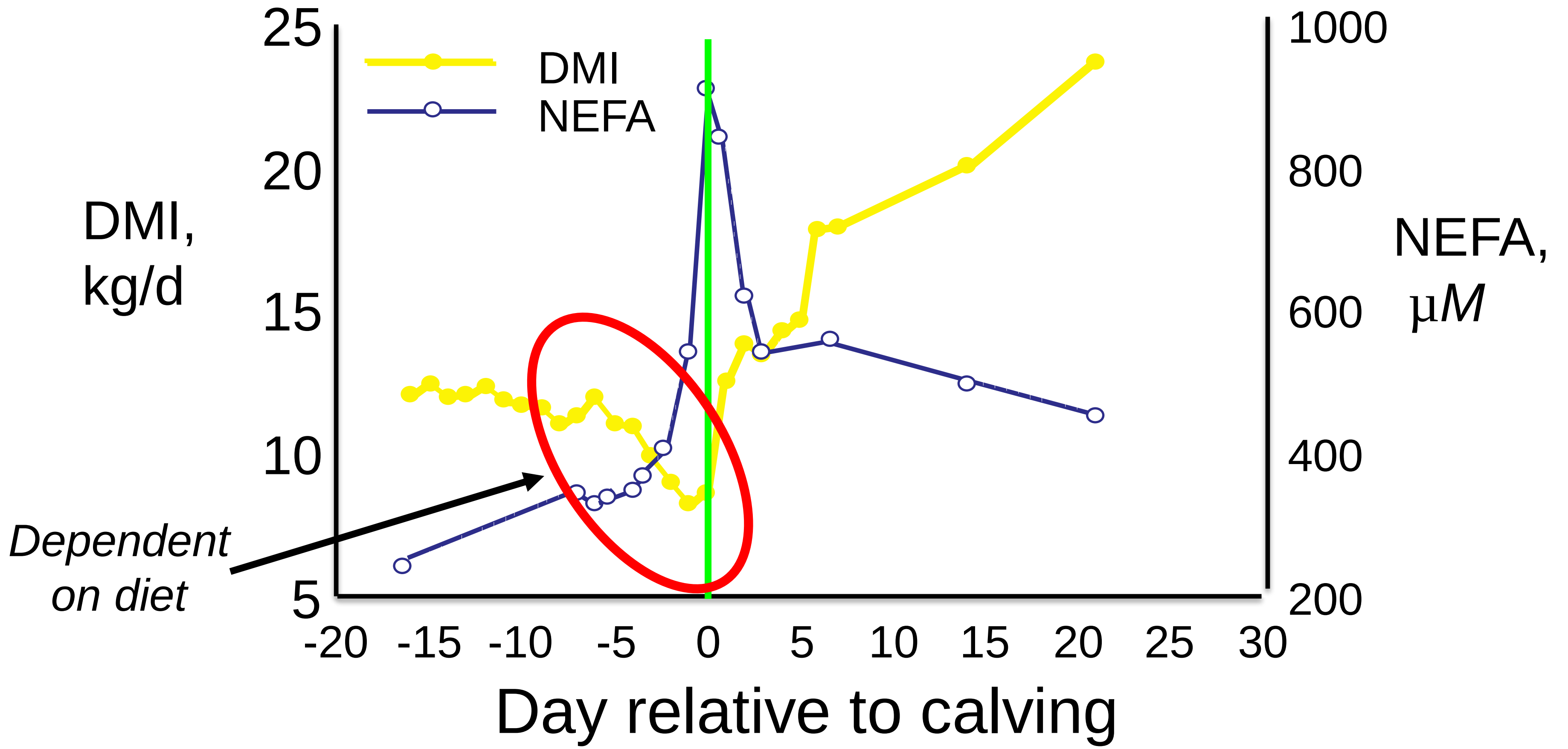


Luchini, 2012

Findings regarding energy and protein metabolism of transition cows

- Feed intake is not commensurate with nutritional needs
- Reduced feed intake and priority for milk production over most other physiological processes induces mobilization of fat, protein and other nutrients
- These shifts in metabolism lead to dramatic increases in plasma NEFA, resulting in increased uptake of fatty acids by the liver, often in amounts that exceed capacity for oxidation, resulting in both ketone production and storage of TG in the liver

Dry matter intake and plasma NEFA are inversely related



Grummer, 1993

Elevated NEFA in blood increases fat accumulation in liver, with peak content at about 10 days post-calving

Impacts of excessive liver fat accumulation:

- Increased ketosis
- Increased displaced abomasum
- Impaired reproduction
- Decreased milk production
- Increased culling
- Increased death loss

Findings regarding energy and protein metabolism of transition cows

- Protein metabolism of the transition cow has been rarely investigated
- Losses of body protein during early lactation are variable and can be significant

Authors	Week of lactation	Amount (lb)
Gibb et al. (1992)	1	12.3
Komaragiri and Erdman (1997)	2-5	46.2
Dalback et al. (2001)	1-4	10.3 (EAA)
Phillips et al. (2003)	2-8	17.6

Findings regarding energy and protein metabolism of transition cows

- Protein depletion-repletion studies indicated that skeletal muscles are by far the largest contributor to protein mobilization (Swick and Benevenga, 1977)
- Increasing abundance of mRNA coding for proteins in the ubiquitin-mediated proteolytic pathway in muscle biopsies from both postpartum transition cows and sows (Clowes et al., 2005; Chibisa et al., 2008) also indicate that milk protein secretion in the initial phase of the lactation is largely sustained by protein mobilization from skeletal muscle
- Evidence exists that postpartum uterine involution might be an important source of AA during the first days of lactation

Findings regarding energy and protein metabolism of transition cows

- AA released from mobilized protein appears to be important in supporting the AA requirements of the mammary gland at least in the earliest stages of lactation
- Mobilized AA are also used to fuel gluconeogenesis - whole-body glucose turnover is increased dramatically at initiation of lactation and propionate availability from rumen fermentation is not sufficient
- The ability of cows to up-regulate gluconeogenesis in early lactation is critical to avoiding metabolic problems (e.g., ketosis) and maximizing peak milk production

Findings regarding energy and protein metabolism of transition cows

- Fatty livers have decreased capacity for glucose synthesis (from propionate and glucogenic AA); i.e., activities of several rate-determining gluconeogenic enzymes are decreased
- Immune function appears to be decreased throughout the 6-wk transition period

Conclusions from aforementioned research…

- Substantial amounts of AA from body protein are mobilized, particularly during the post-fresh transition period, to help support several critical functions over and beyond the need for milk protein synthesis
- QUESTIONS:

  1) What rate of protein mobilization is needed, or how much protein needs to be mobilized, before it begins to contribute to metabolic stress (e.g., increased fatty liver, depressed glucose synthesis and decreased immunity) and adversely affect animal performance (e.g., milk and milk component production, health and reproduction?

  2) Will balancing for AA help alleviate some of the “protein-related” challenges of the transition cow?

Challenges of meeting the MP requirements of post-fresh cows[1]

	17.0% CP	15.7% CP
	(% of DM)	
Corn silage	34	30
Legume silage	17	20
Ground dry cow	24.9	30
Corn DDGS	7	7.5
Cottonseed	5	5
Solvent SBM	4	5
Expeller SBM	4.5	--
Blood meal	0.85	0.20
Fat supplements	1.03	1.02
Minerals and vits	1.73	1.31

Grummer and Ordway (2011)

Impact of milk yield and DIM on predicted estimates of MP adequacy[1]

	60 lb milk			80 lb milk			100 lb milk		
DIM	7	14	21	7	14	21	7	14	21
Pred. DMI	29.5	33.0	35.9	33.8	37.9	41.2	38.1	42.7	46.5
	17.0% CP diet								
MP-milk	51	58	63	59	68	74	68	77	85
MP (+/-)	-187	-46	+69	-417	-252	-116	-645	-457	-302
	15.7% CP diet								
MP-milk	43	49	54	51	58	63	58	66	73
MP (+/-)	-343	-220	-117	-595	-453	-335	-847	-685	-553

Assuming the NRC (2001) predictions of DMI and MP balance are correct…

- Most post-fresh transition cows within a herd will experience shortages of MP
- Shortages of MP will be variable among cows based on level of milk production and DIM
- The RUP requirements of post-fresh transition cows are higher than at any other time within their lactation
- Conclusion: The transition from no milk protein production before calving to 2+ pounds per day within a few days after calving, when little change in DM intake is occurring, challenges the AA status of the cow

Should one start balancing for Lys and Met before calving, and if so why?

- Yes, if it's convenient to do so
- Reasons:
  1) Reduce the chances that they will become limiting, at least before the other AA, and contribute to the metabolic challenges or nutritional insults associated with depressed feed intake preceding and immediately following calving
  2) The time associated with this period is extremely short so why take the risk, particularly with pre-fresh transition heifers that have higher RUP requirements and are more likely to experience an AA deficiency?

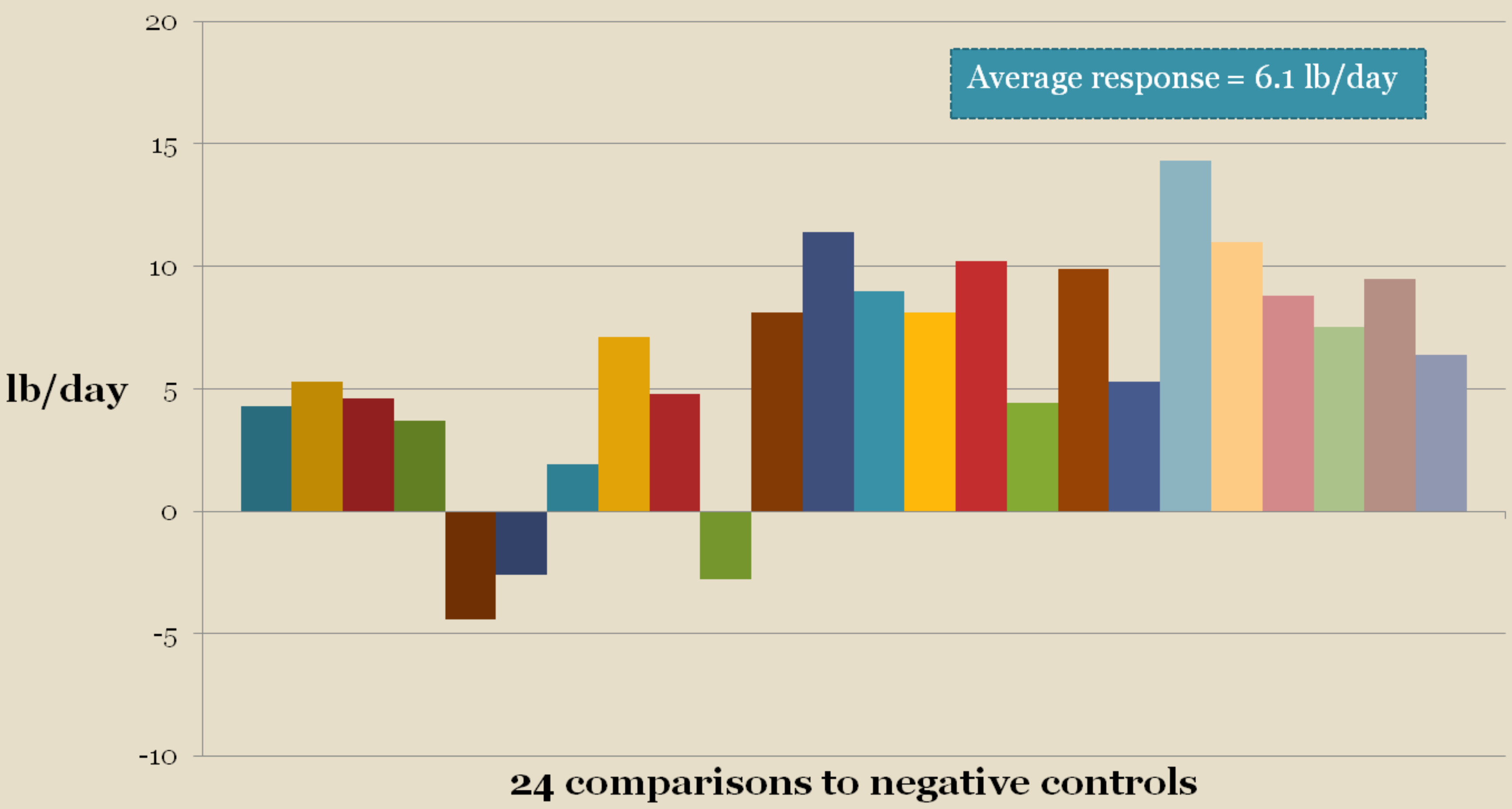
Average responses of early lactation cows to initiation of Met or Met/Lys supplementation before (6 expts) vs. after calving (7 expts)

	Before	After
Milk yield, lb/day	+ 5.1 lb	+ 1.5 lb
Protein content	+ 0.09% units	+ 0.16% units
Protein yield	+112 g (+ 7.1%)	+ 79 g (+ 3.1%)
Fat content	+0.10% units	+ 0.02% units
Fat yield	+ 116	+ 48 g
DM intake	2.9 lb	1.3 lb

Is balancing for Lys and Met more important in post-fresh cows than 4-5 weeks after they calve?

- Virtually all available data would indicate that the answer is yes
- That would be expected, because it is during the earliest stages of lactation that the need for absorbed AA, relative to available supply, is the highest
- Research and field experience indicates these cows are the most responsive, particularly in terms of milk yield

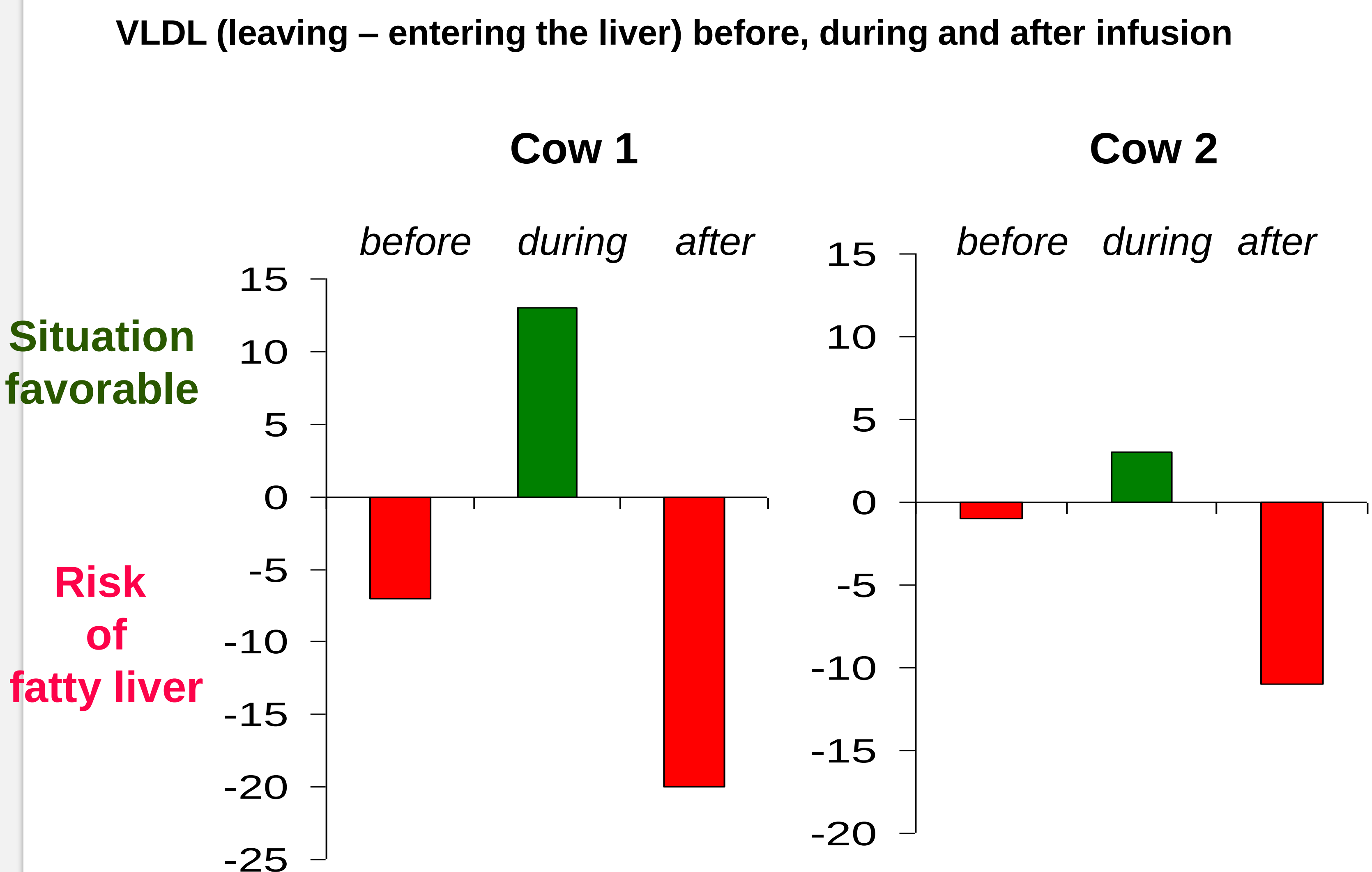
Milk yield responses to feeding RP-Lys or RP-Lys + Met to early lactation cows in 15 experiments



Does AA balancing of early fresh cows reduce post-calving metabolic disorders and improve breeding?

- Research is slowly accumulating to confirm these observations
- Apparent benefit of improved Lys and Met nutrition of early fresh cows on liver function
- Met has long been advocated as having a favorable role on hepatic metabolism through its capacity as a methyl donor. A series of trials (Bauchart et al., 1998) illustrate the roles that Met plays in hepatic metabolism. Met plays a key role in assuring the synthesis of apoprotein B, an essential component in the formation of the very low density lipoprotein (VLDL) complex which is responsible for evacuating triglycerides from the liver to peripheral tissues.

Effect of portal infusion of Lys and Met on net appearance or disappearance of VLDL from the liver of lactating dairy cows



Durand et al., 1992 - JDS 75(Suppl. 1) 279

Luchini, 2012

Does AA balancing of early fresh cows reduce post-calving metabolic disorders and improve breeding?

- Hypothesized that this effect was due to Met acting at one or more of three levels of metabolism.

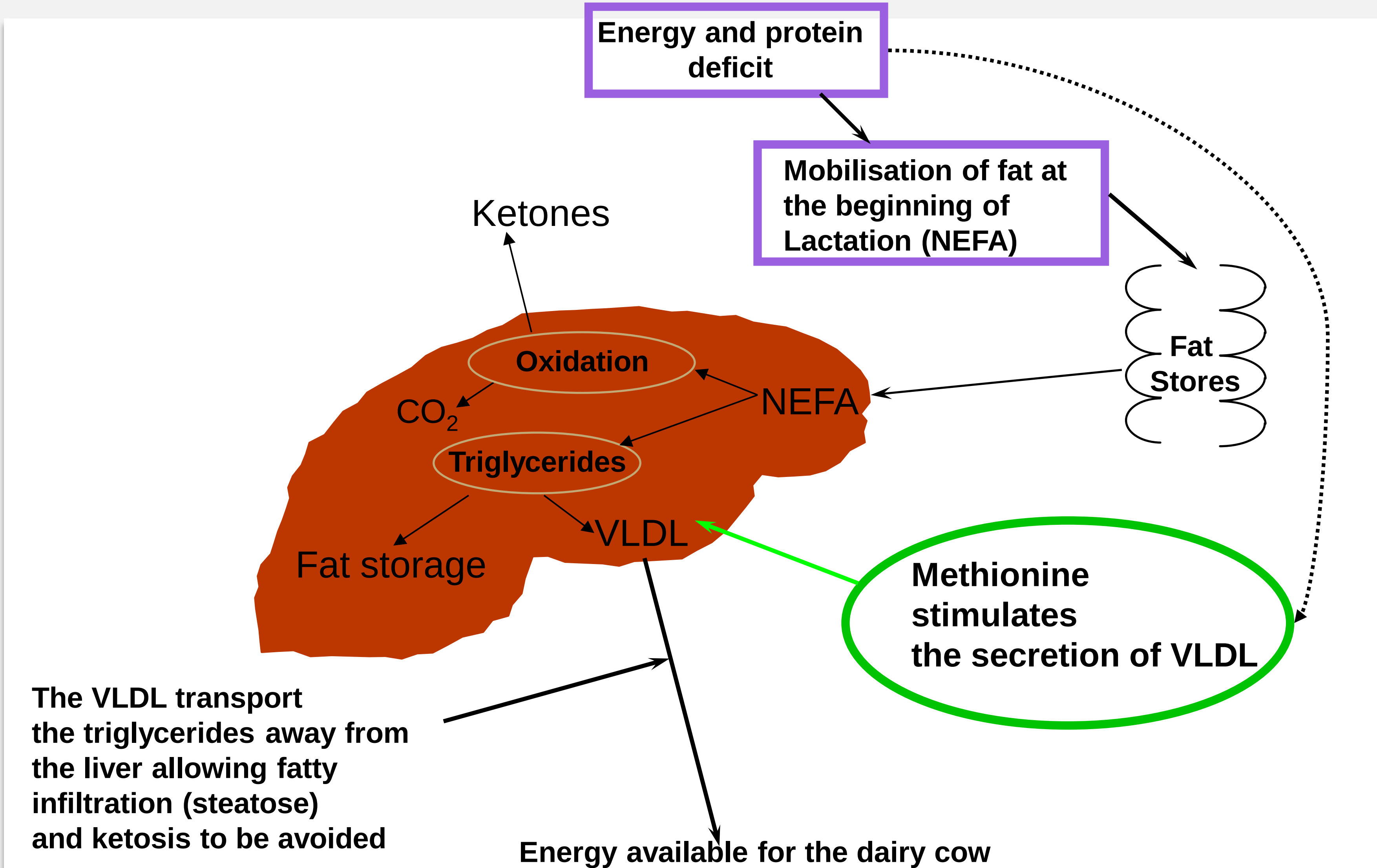
  1) Met is an essential building block for the formation of apoprotein B

  2) Met appears to be involved in the gene transcription and or translation of mRNA for apoprotein B synthesis

  3) Met may also act as a methyl donor to favor lecithin synthesis which is essential for the elaboration of the hydrophilic envelope of hepatic VLDL

  <u>Net effect</u>: a reduced risk of fat infiltration of the liver which causes problems such as fatty liver and ketosis

Can methionine alleviate the stress during transition?



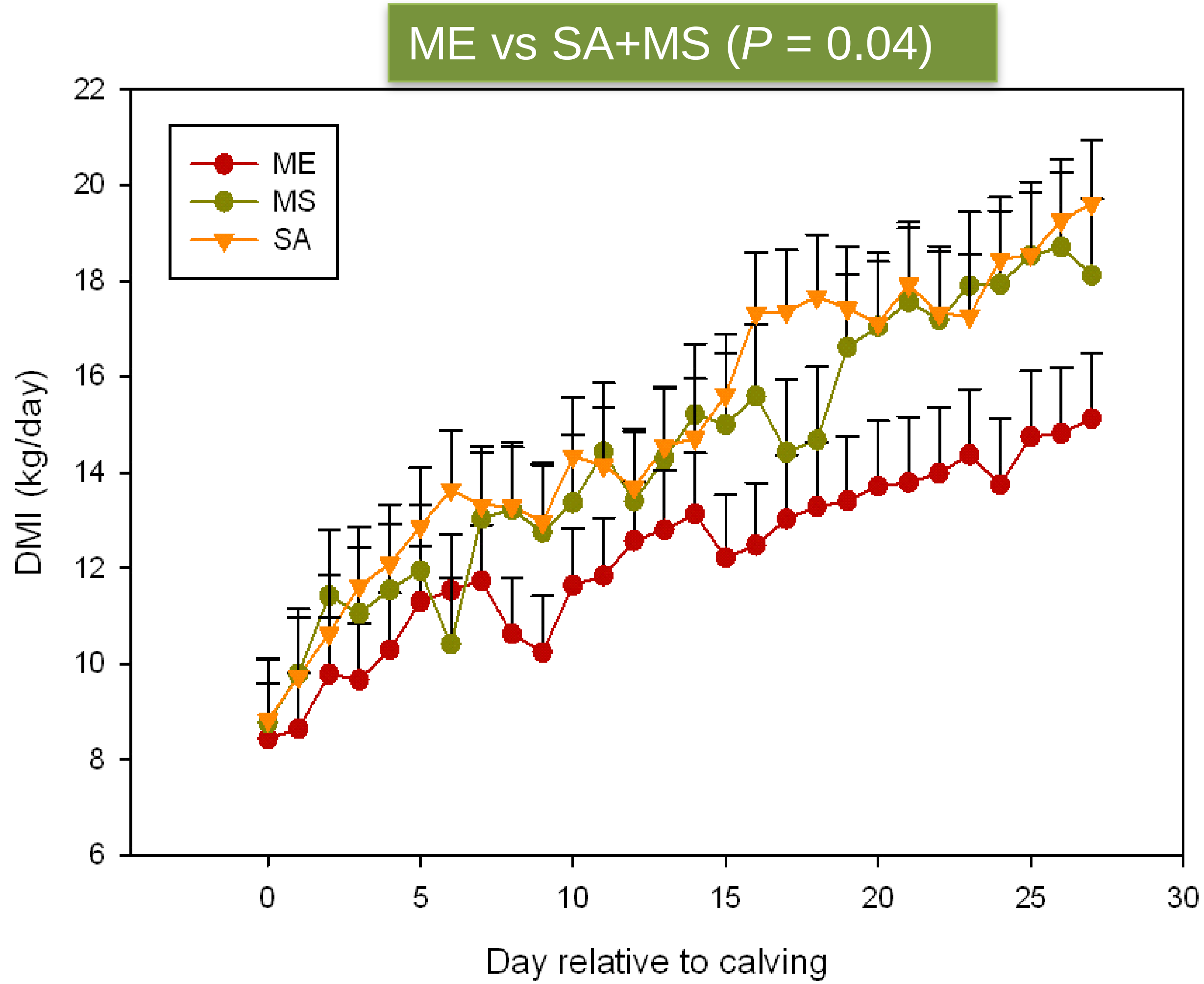
Effect of supplementing transition cow diets with RP-Met supplements on blood metabolites and liver function

	Prepartum (-21 to 0 DIM)			Lactation (1 to 30 DIM)		
		Control +			Control +	
	Control	**Smartamine**	**Metasmart**	**Control**	**Smartamine**	**Metasmart**
Ingredient, % of DM						
Corn silage	**35.9**	**35.9**	**35.9**	**33**	**33**	**33**
Alfalfa haylage	**8.2**	**8.2**	**8.2**	**5**	**5**	**5**
Alfalfa hay	**3.5**	**3.5**	**3.5**	**4**	**4**	**4**
Wheat straw	**15.4**	**15.4**	**15.4**	**4**	**4**	**4**
Whole cottonseeds	**---**	**---**	**---**	**3.5**	**3.5**	**3.5**
Wet brewers grains	**6**	**6**	**6**	**10**	**10**	**10**
Concentrate mix.	**31.0**	**31.0**	**31.0**	**40.5**	**40.5**	**40.5**
Metasmart	---	---	0.19	---	---	0.19
Smartamine	---	0.07	---	---	0.07	---
Chemical composition						
NEL, Mcal/kg	**1.54**	**1.54**	**1.54**	**1.67**	**1.67**	**1.67**
CP, % DM	**15.2**	**15.2**	**15.2**	**17.4**	**17.4**	**17.5**
ADF, % DM	**28.3**	**28.3**	**28.3**	**22.6**	**22.6**	**22.5**
NDF, % DM	**42.3**	**42.2**	**42.2**	**35.2**	**35.2**	**35.2**
Lysine, g MP/d	**69.8**	**69.8**	**69.8**	**147.8**	**148.1**	**148.2**
Methionine, g MP/d	**19.3**	**24.7**	**24.6**	**43.8**	**52.5**	**52.5**
Lys:Met % of MP	3.61	2.83	2.84	3.37	2.82	2.82

23 lbs DMI prepartum and 50 lbs DMI post partum

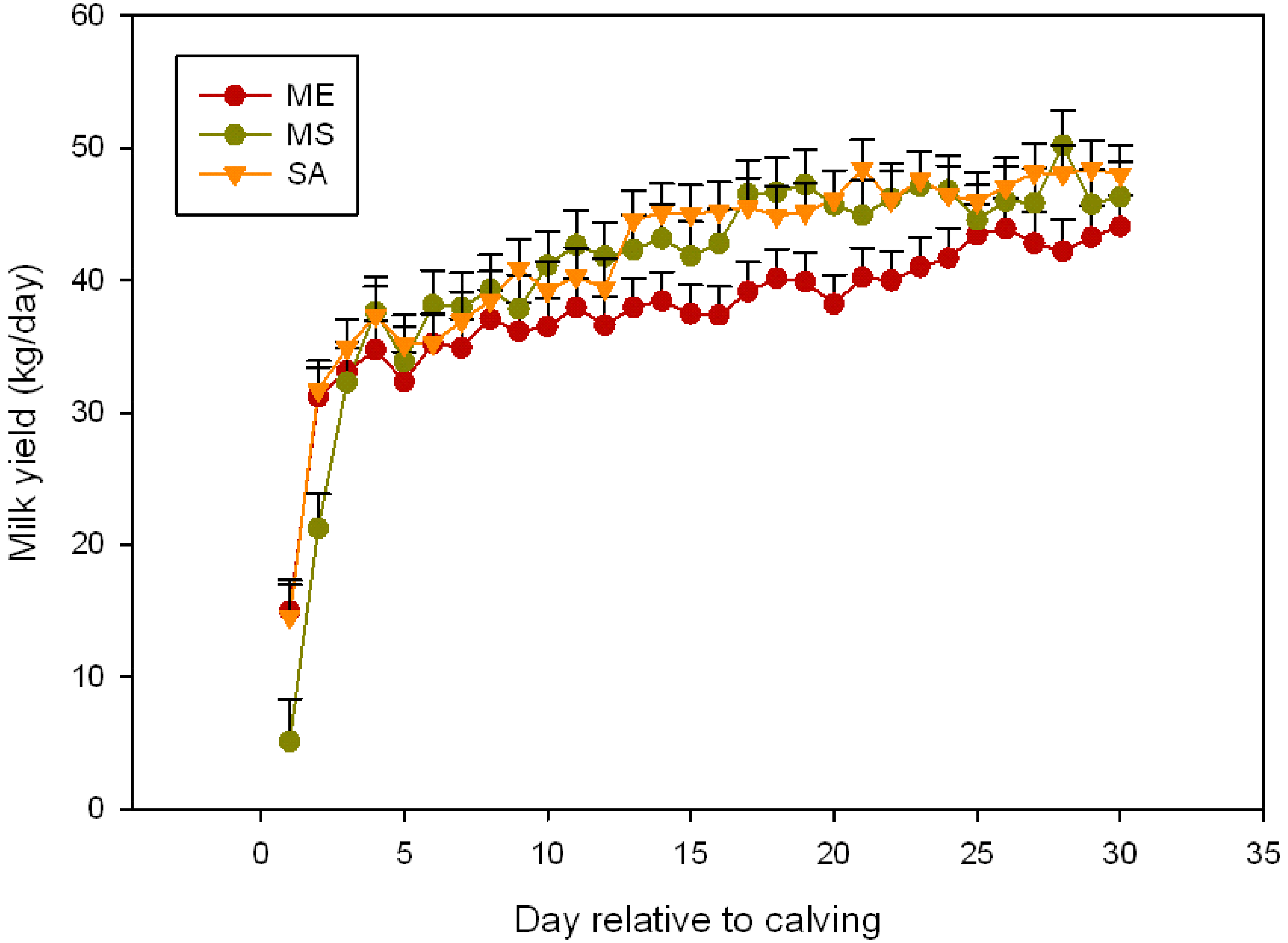
Osorio et al. ADSA 2011, Abs. 871, 872

DMI was significantly greater for Met supplemented cows (14.7 kg/d vs. 12.2 kg/d)



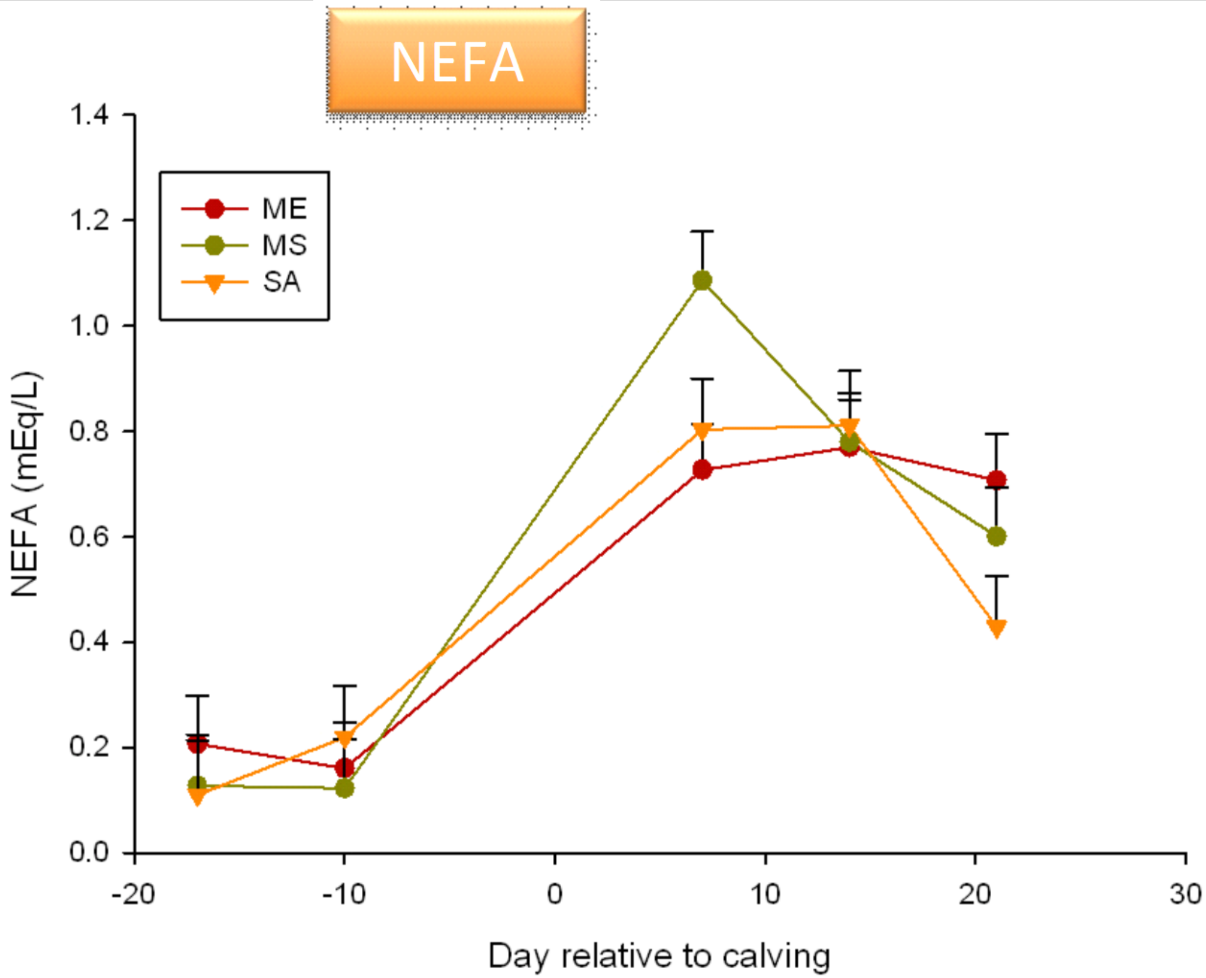
ME = Control (n = 14); MS = MetaSmart (0.19% of DM, n = 11); SA = Smartamine (0.07% of DM, n = 15)

Milk yield was greater with Met (41.5 kg/d) than control (ME 37.7 kg/d) *(P = 0.06)*



ME = Control (n = 14); MS = MetaSmart (0.19% of DM, n = 11); SA = Smartamine (0.07% of DM, n = 15)

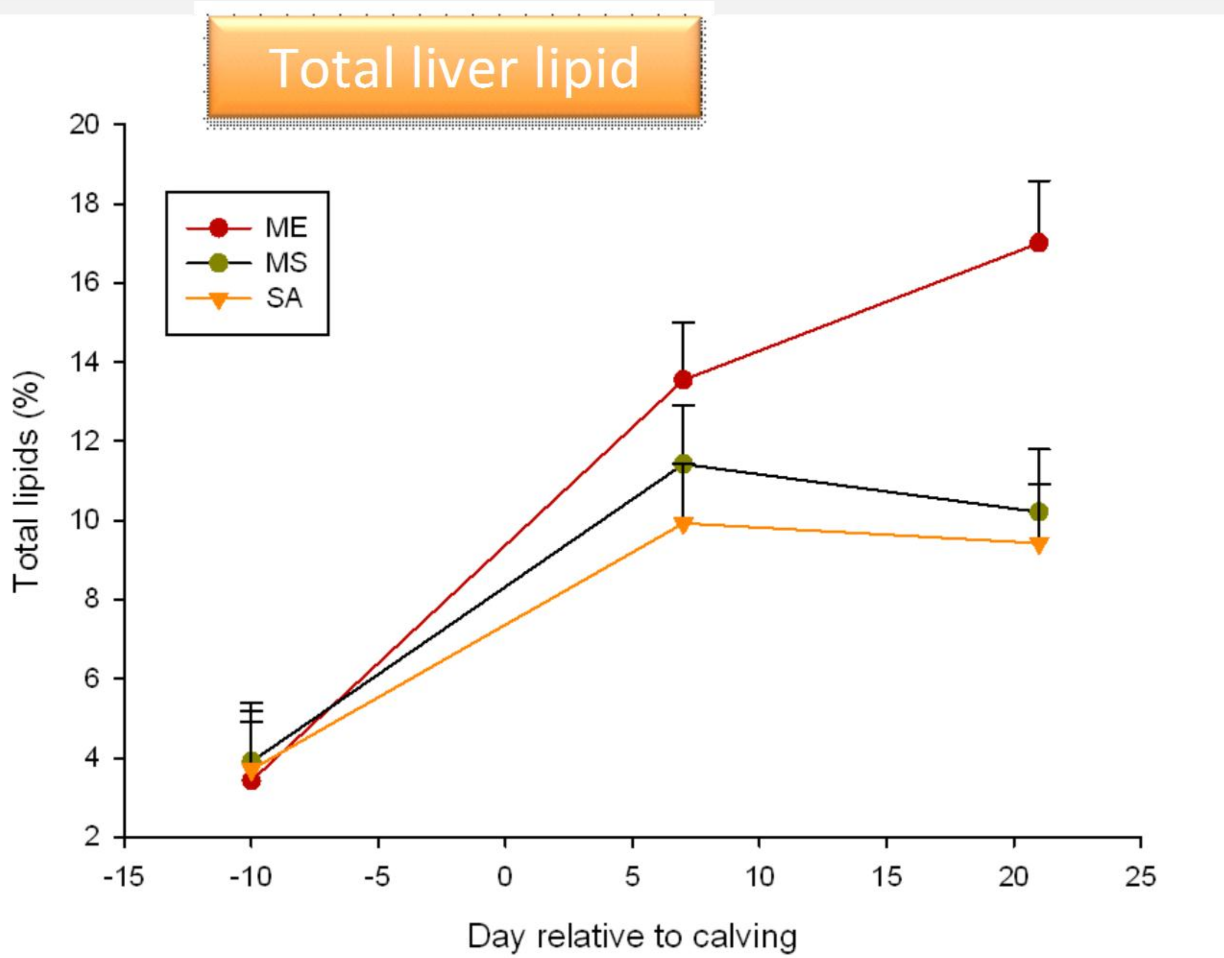
NEFA decreased more rapidly with Met supplementation



Only the slopes of NEFA concentrations of Met-supplemented cows were significant (P=0.02 between 7-21 DIM)

ME = Control (n = 8); MS = MetaSmart (0.19% of DM, n = 8); SA = Smartamine (0.07% of DM, n = 8)

Supplemental Met prevented increased lipid accumulation



The slope of total lipid % between d 7 and 21 for ME was significant (P=0.04), suggesting that supplemental Met prevented increased lipid accumulation.

ME = Control (n = 8); MS = MetaSmart (0.19% of DM, n = 8); SA = Smartamine (0.07% of DM, n = 8)

Osorio et al. ADSA 2011, Abs. 871, 872

Does AA balancing of early fresh cows reduce post-calving metabolic disorders and improve breeding?

- The authors noted that the “enhanced ECM” due to Met supplementation “was associated with a faster decline in serum NEFA and lack of additional lipid accumulation between 7 and 21 DIM”
- Using a newly-developed bioinformatics tool to visualize the dynamic adaptations of biological pathways and impact on liver transcriptome of feeding the two sources of supplemental Met, they observed that the two sources of supplemental Met elicited different effects and that carbohydrate metabolism was among the top-impacted pathways, particularly during the early postpartum period when gluconeogenesis and the TCA cycle are the most activated

Effect of methionine supplementation during postpartum period in dairy cows on embryo quality

	MET	CON	*P*-value
n	35	37	
CL number	17.0	17.7	0.90
Total ova/embryos recovered	9.1	6.8	0.18
% Ova/embryos recovered per CL	**49.5**	**35.8**	**0.05**
Number of fertilized ova	6.5	5.5	0.56
% Fertilized ova	74.7	82.2	0.27
Number of transferable embryos	5.0	4.3	0.57
% Transferable embryos of fertilized	59.7	62.4	0.55

- No differences between in CL number, fertilization, or embryo quality, but <u>% of structures recovered/CL was greater for MET than CON</u>
- <u>Potential effects of MET on embryo development after the first week of pregnancy need to be investigated</u>.

Souza et al., 2012

Summary

- Most early lactation cows experience negative protein balance
- Indications are strong that attempts to balance for more adequate concentrations of Lys and Met in MP in the transition cow are critical to achieving more optimal production, health and reproduction