THE ESSENTIAL FATTY ACIDS

Is There Evidence of Essential Fatty Acid Deficiency/Benefit in Dairy Animals?

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IFAS Extension

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SMART SOLUTIONS FOR INNOVATIVE DAIRIES

Essential Fatty Acids – Deficiencies?

- Gross deficiencies – symptoms?
- Marginal deficiencies – symptoms?

THE ESSENTIAL FATTY ACIDS
Gross Deficiencies of Feeding Fat-Free Diets to Nonruminants

- Rats were fed a fat-free diet…
  - Reduced growth (but diets were not isocaloric)
  - Skin lesions, hair loss, and inflamed tail and feet at 70 to 90 days of life
  - Death at ~150 days of life, likely due to kidney failure
  - Irregular ovulation intervals
  - Anovulatory rats resumed ovulation within 5 days of fat intake
  - Feeding fat at 1% of diet alleviated symptoms

Burr & Burr, 1929; 1930

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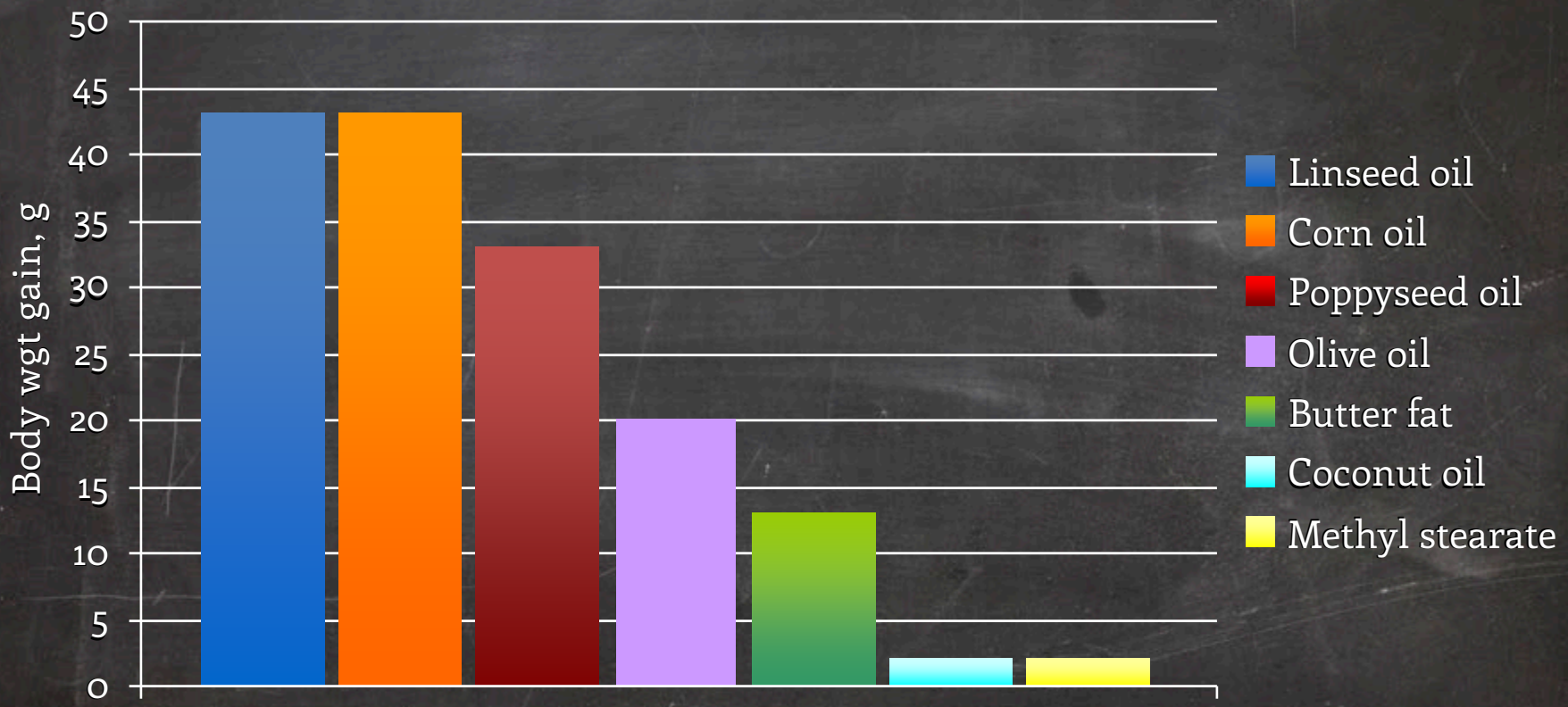
40 Day Gain of Rats Fed Fat-free Diets Resupplemented With Fat



Burr & Burr, 1929; 1930

Linoleic and Linolenic Acids Act Synergistically

Female rats were fed a fat-free diet for 10 weeks; then fed increasing amounts of essential fatty acids during pregnancy and lactation.

	C18:2	C18:3	C18:2+C18:3	C18:2	C18:3
Intake of fatty acids, g/d	20	20	20 + 20	40	40
Number of pups born per litter	9.7	9.3	10.1	8.7	9.5
Pup mortality at 3 days of life, %	41	88	5	20	35

Journal of Nutrition. 57:297

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Gross Deficiencies of Feeding Fat-Free Diets to Unweaned Ruminants

	Lambert et al., J. Nutr. 52:259		Cunningham & Loosli, JAS 13:265	
	Preweaned dairy heifers		Preweaned lambs	
	Fat-free synthetic milk replacer	Synthetic milk replacer + 1.8% hydrogenated soybean oil & lecithin	Fat-free synthetic milk replacer	Synthetic milk replacer + 2% lard
Body wt. gain	88 g / day	246 g / day	33 g / day	123 g / day
Symptoms	Scaly dandruff, dry hair, loss of hair	Healthy	Died in 3 to 7 weeks	Healthy

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Response of Unweaned Holstein Calves to Supplemental EFA in Milk Replacer During the First 30 Days of Life

Reference	Changing intake of C18:2 (g/day)	Changing intake of C18:3 (g/day)	Response to increased intake of EFA
Garcia et al., JDS 97:5045	2.4 to 8.0	0 to 0.7	Increased ADG
Garcia et al., JDS 98 (in print)	1.9 to 9.3	0.1 to 1.2	Increased ADG

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Supplementation of Essential Fatty Acids Has Improved Reproductive Performance of Adult Cows

- Increased size of dominant ovarian follicle and corpus luteum
  (Staples et al., JDS 81:856)
- Improved conception rate
  (Cerri et al., JDS 92:1520) 92:1520–1531
- Reduced loss of embryos
  (Ambrose et al., JDS 89:3066; Silvestre et al., JDS 94:189)

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Performance of Dairy Cows Fed Changing Ratios of Essential Fatty Acids

	Dietary Ratio of Omega-6 to Omega-3 Fatty Acids		
	6:1	5:1	4:1
DM intake, kg/day	24.7[a]	24.6[a]	26.1[b]
Milk, kg/day	43.2[a]	44.8[a]	46.8[b]

Diet of 3.7% fatty acids

Greco et al., J. Dairy Sci, in press

Feeding Low Linoleic Acid Diets to Lactating Cows

- Pre and postpartum diets were formulated to be as low as possible in linoleic acid while containing reasonable ingredients.
- Ingredients used were barley grain, peanut meal, citrus pulp, bermuda grass silage, and alfalfa hay (very little corn silage).
- Diets fed 4 weeks prior to calving and 13 weeks postpartum.
- Measured EFA in diets and milk fat.

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Dietary Concentrations of EFA

	Florida Study	Typical TMR[1]
Linoleic acid, % of diet DM	0.60	1.14
Linolenic acid, % of diet DM	0.29	0.26

[1]Average of 6 studies from 2012 J. Dairy Sci.

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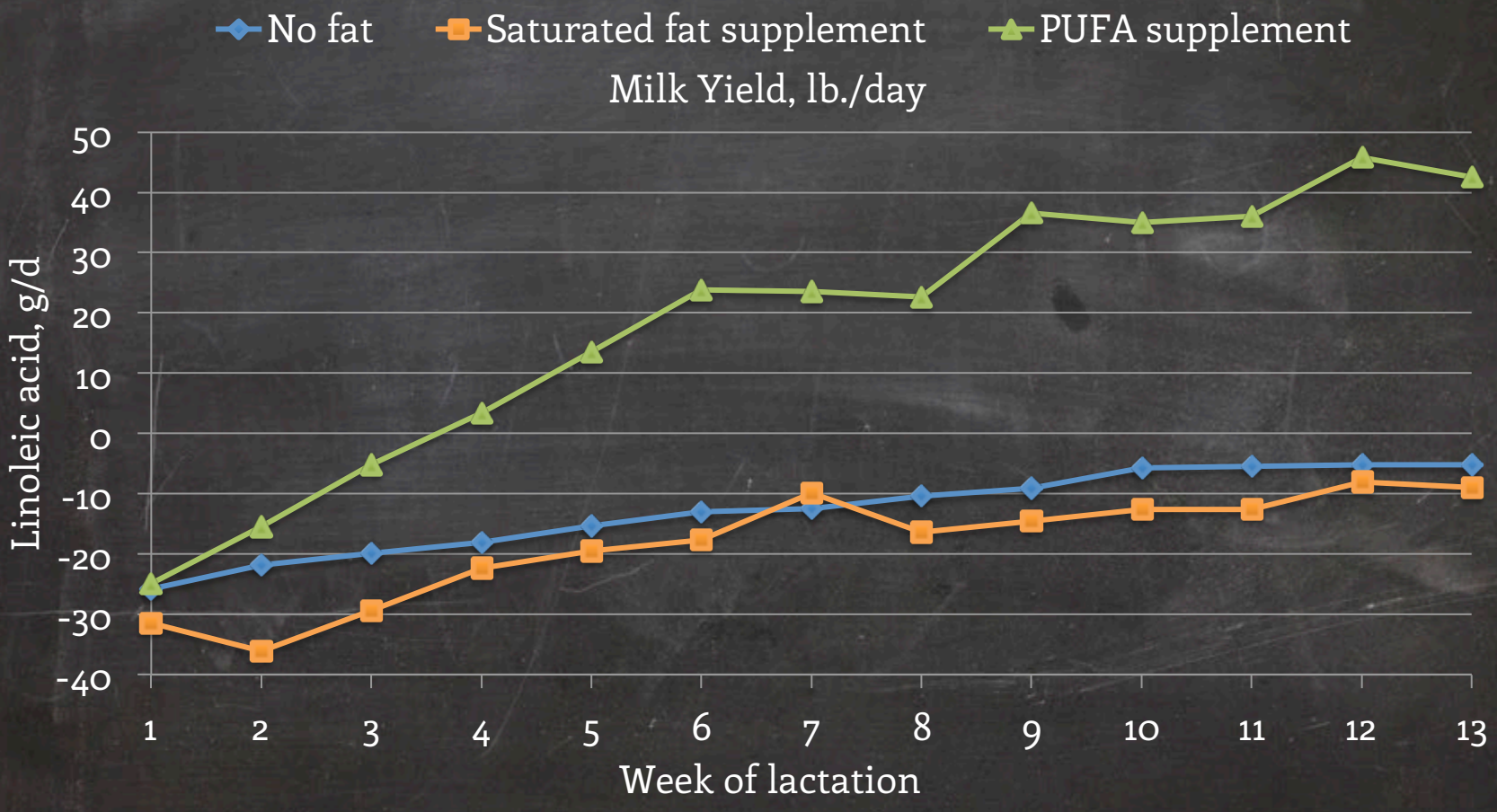
Linoleic Acid (C18:2) "Balance" of Multiparous Cows Fed Low C18:2 Diets With and Without Supplemental Fat



C18:3 Balance calculated using CPM Fat Submodel values for Biohydrogenation and absorption of C18:3

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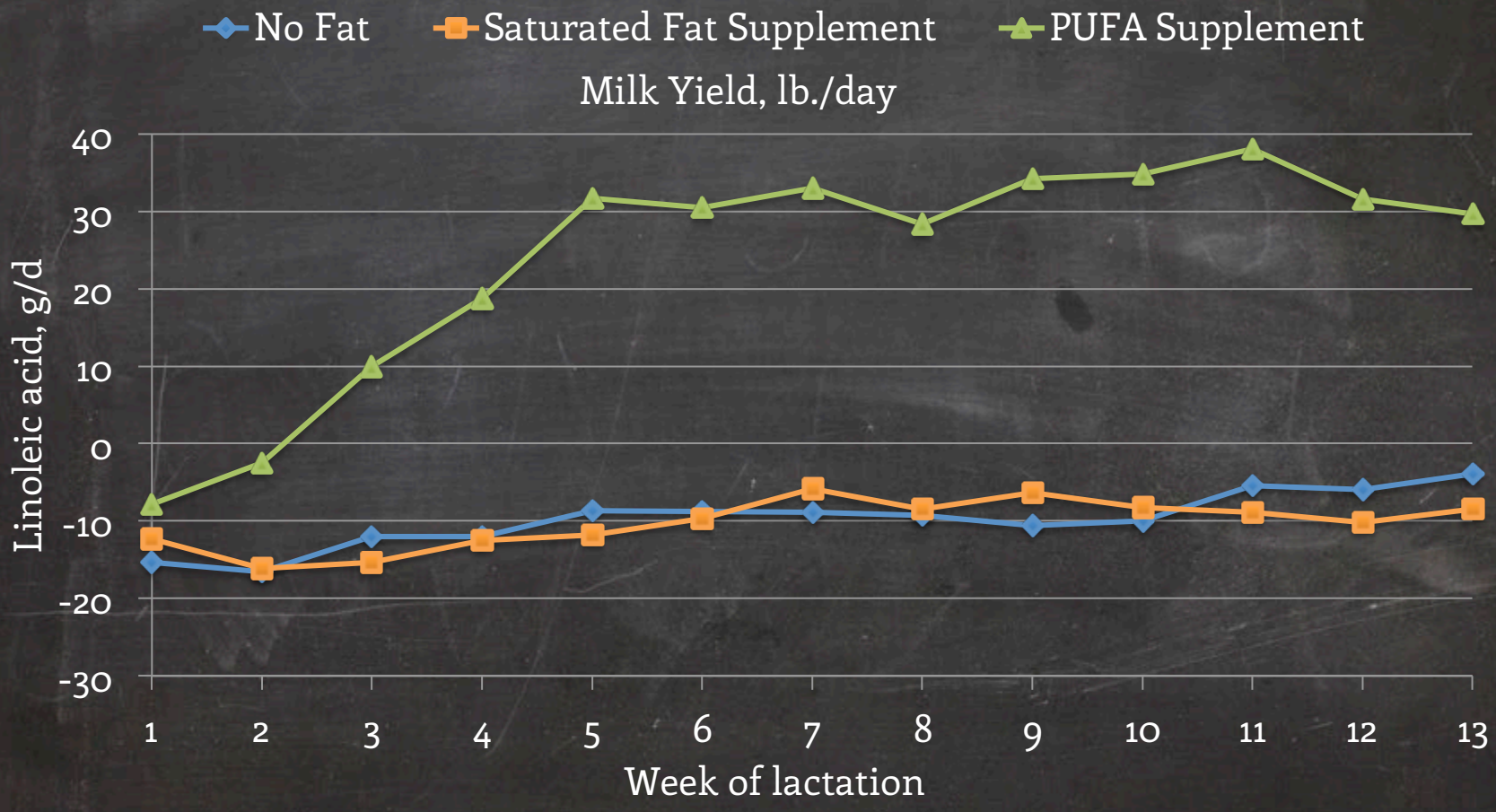
Linoleic Acid (C18:2) "Balance" of Primiparous Cows Fed Low C18:2 Diets With and Without Supplemental Fat



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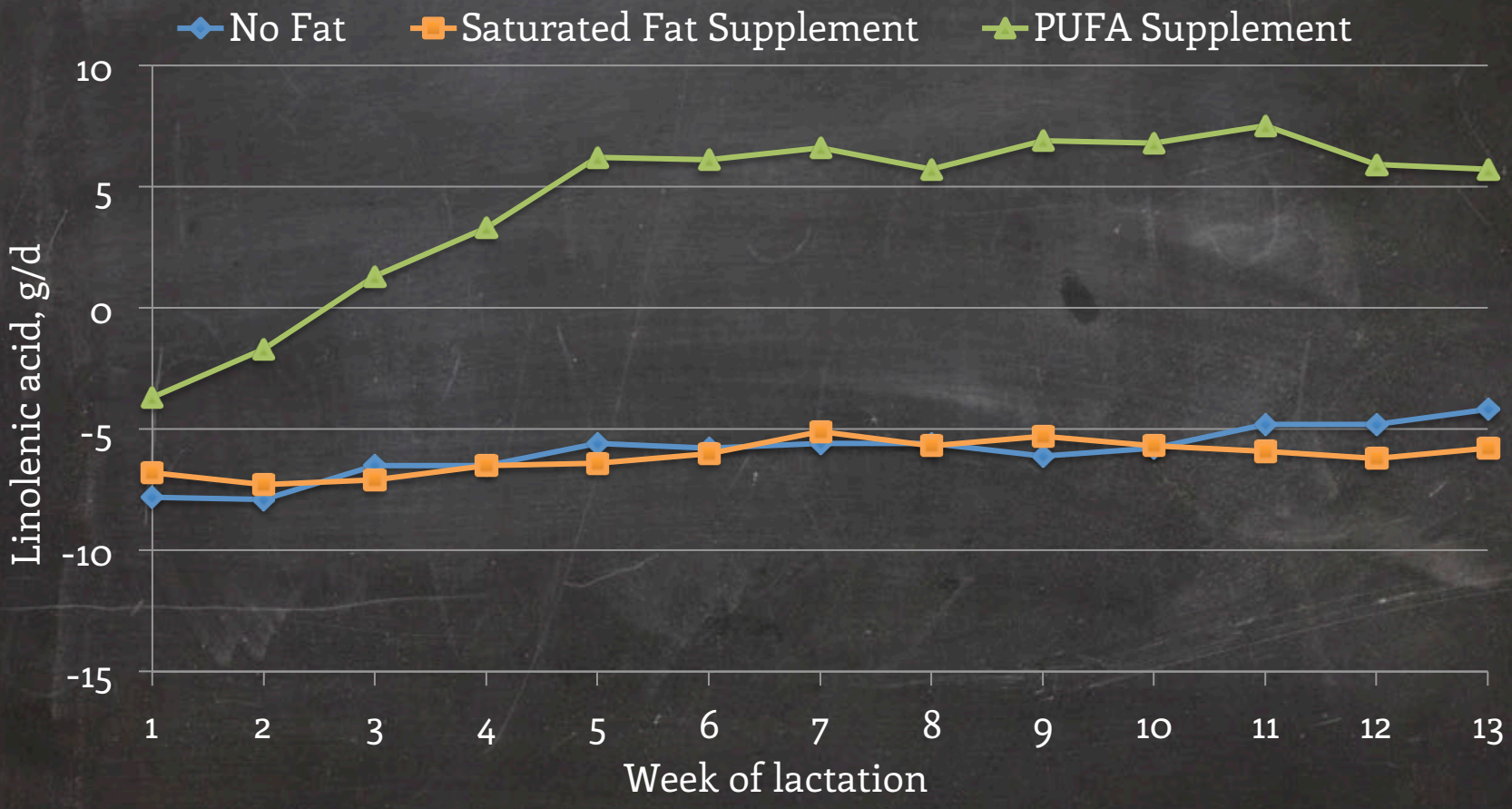
Linolenic Acid (C18:3) "Balance" of Multiparous Cows Fed Diets With and Without Supplemental Fat



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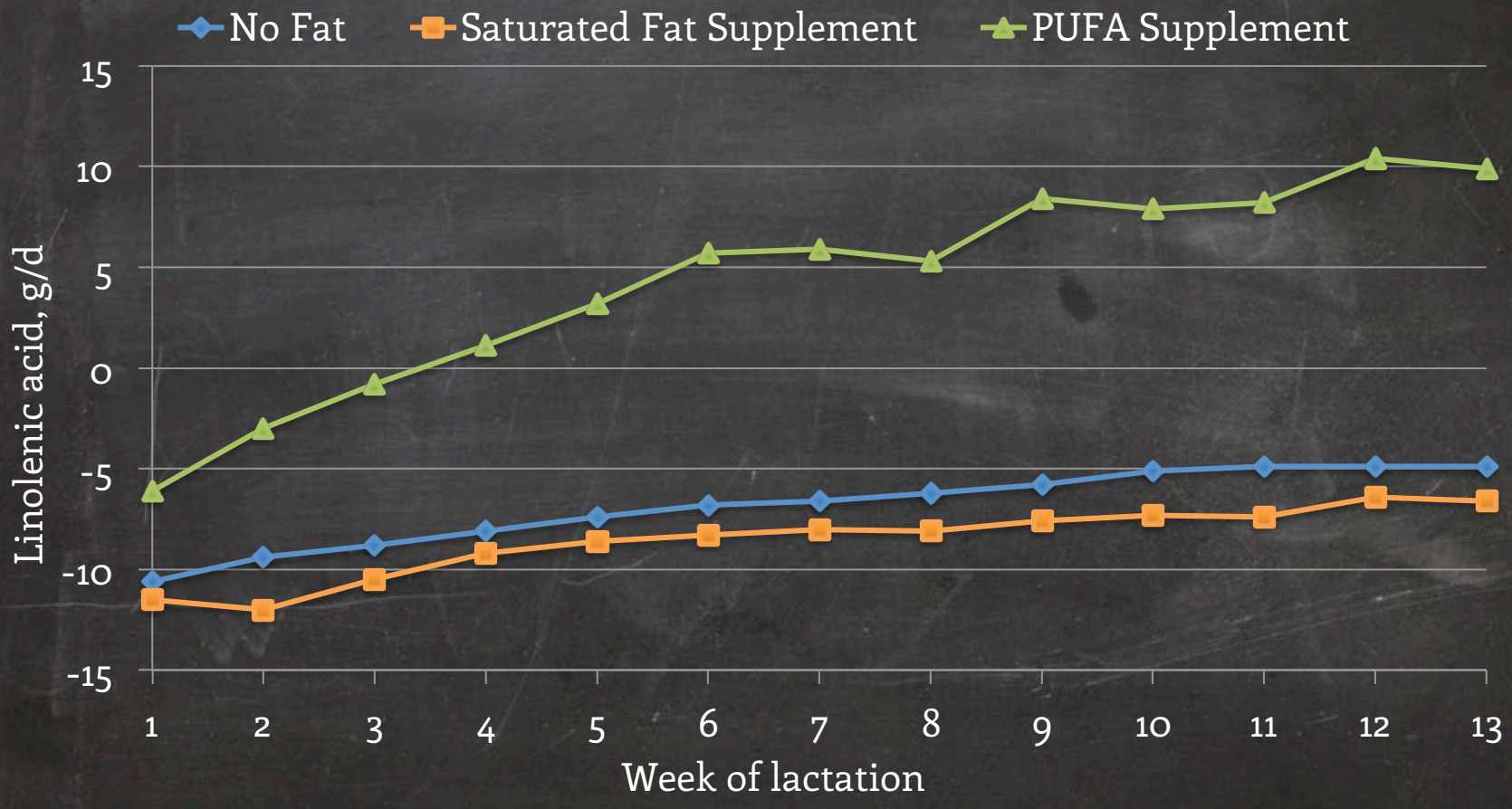

C18:3 Balance calculated using CPM Fat Submodel values for Biohydrogenation and absorption of C18:3

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Why Not Greater Evidence of EFA Deficiencies?

- Body reserves may supply C18:2 during times of C18:2 deficiencies.

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Tissue Storage of Essential Fatty Acids

	Total fat, %	C18:2 % of FA	C18:3, % of FA	C18:2, g	C18:3, g
Internal adipose	74	2	0.2	756	76
Subcutaneous fat	74	2	0.1	290	15
Muscle	7	11	0.4	518	19
Mammary	26	5	0.3	78	5
Liver	12	12	0.4	29	1
Endometrium	4	13	0.9	5	1
Total				1676	112

Adapted from JDS 2006. 89:3386 and Arch. Tierz., Dummerstorf 2007. 50:59-70.

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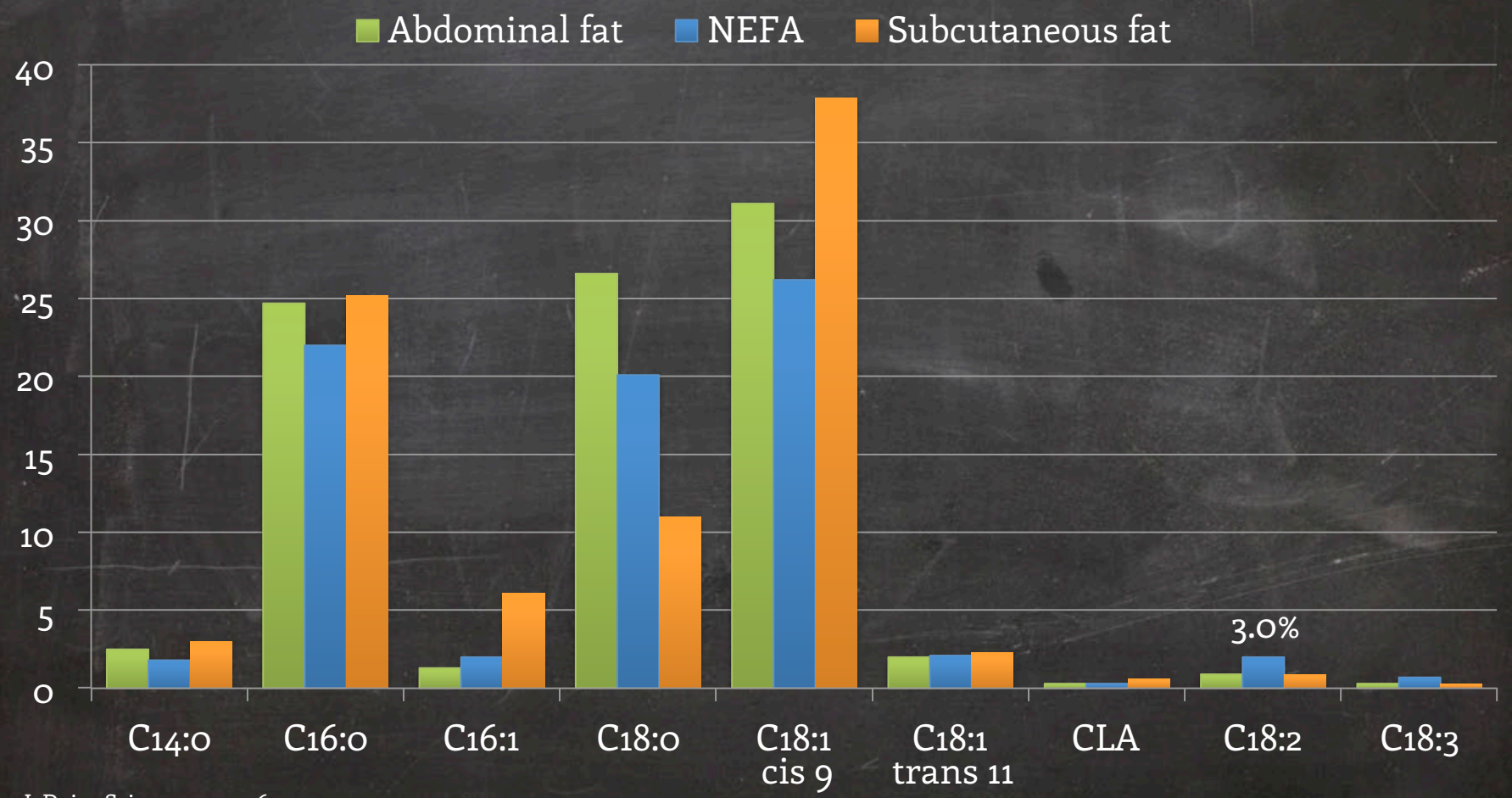
Fatty Acid Profile of Body Fat Stores



J. Dairy Sci. 2012. 95:3756

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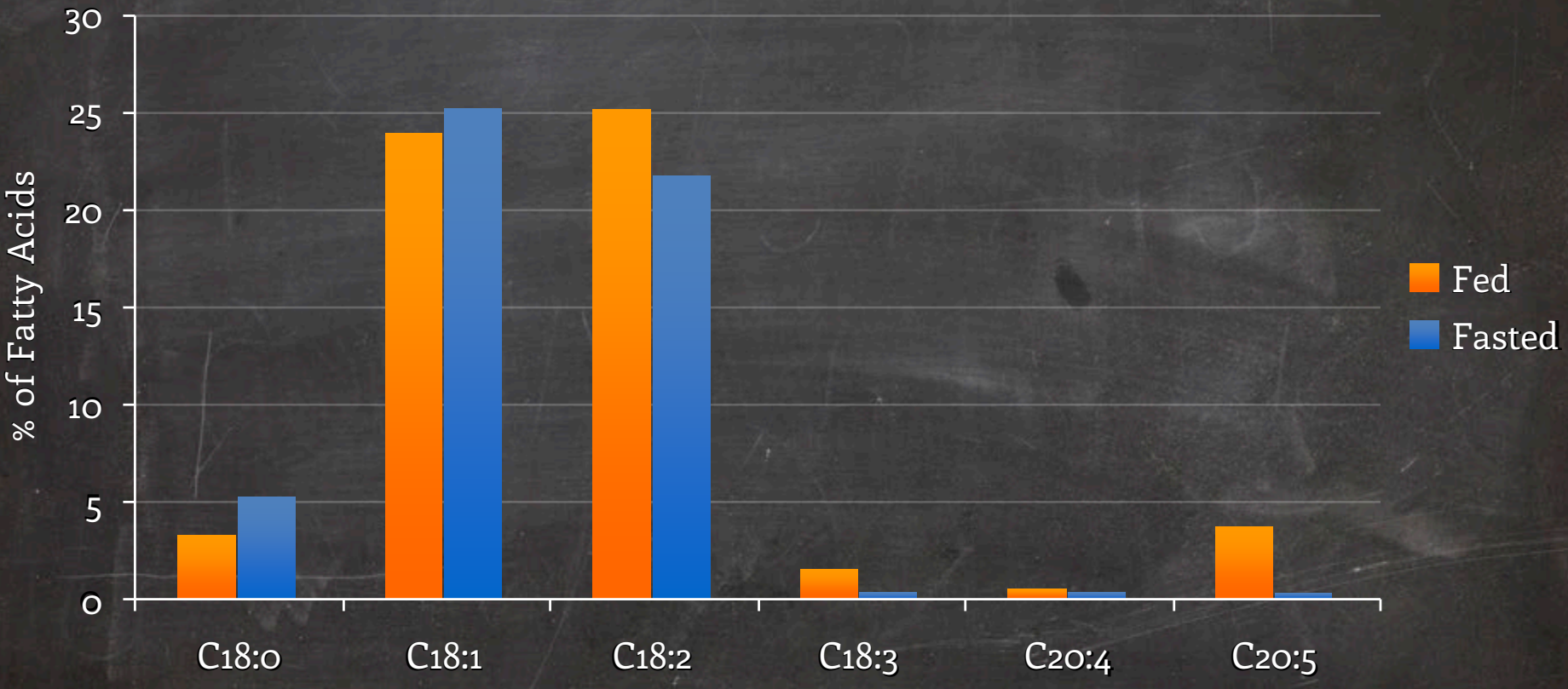
Concentration of Fatty Acids in Retroperitoneal Adipose Tissues in Fed and Fasted Rats



J. Lipid Res 36:2164. 1995.

Why Not Greater Evidence of EFA Deficiencies?

- Tissues, including the mammary gland, may “adjust” uptake of C18:2 based upon C18:2 supply.
- Is there a “bottom line” or minimum intake of C18:2 that must be met to secure normal performance?

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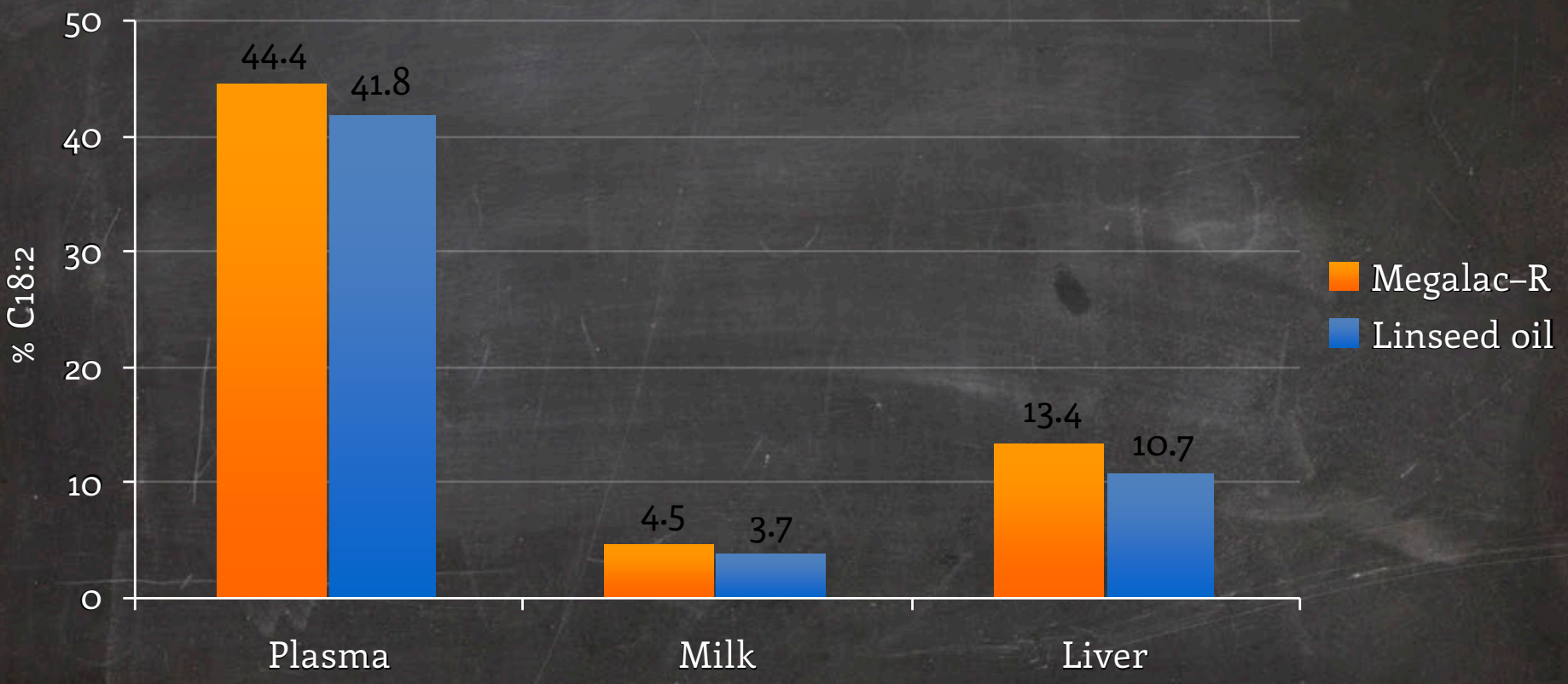
Linoleic Acid in Plasma, Milk, and Liver of Dairy Cows Fed Omega-6 or Omega-3 Fat Supplements



do Amaral, 2008; Florida

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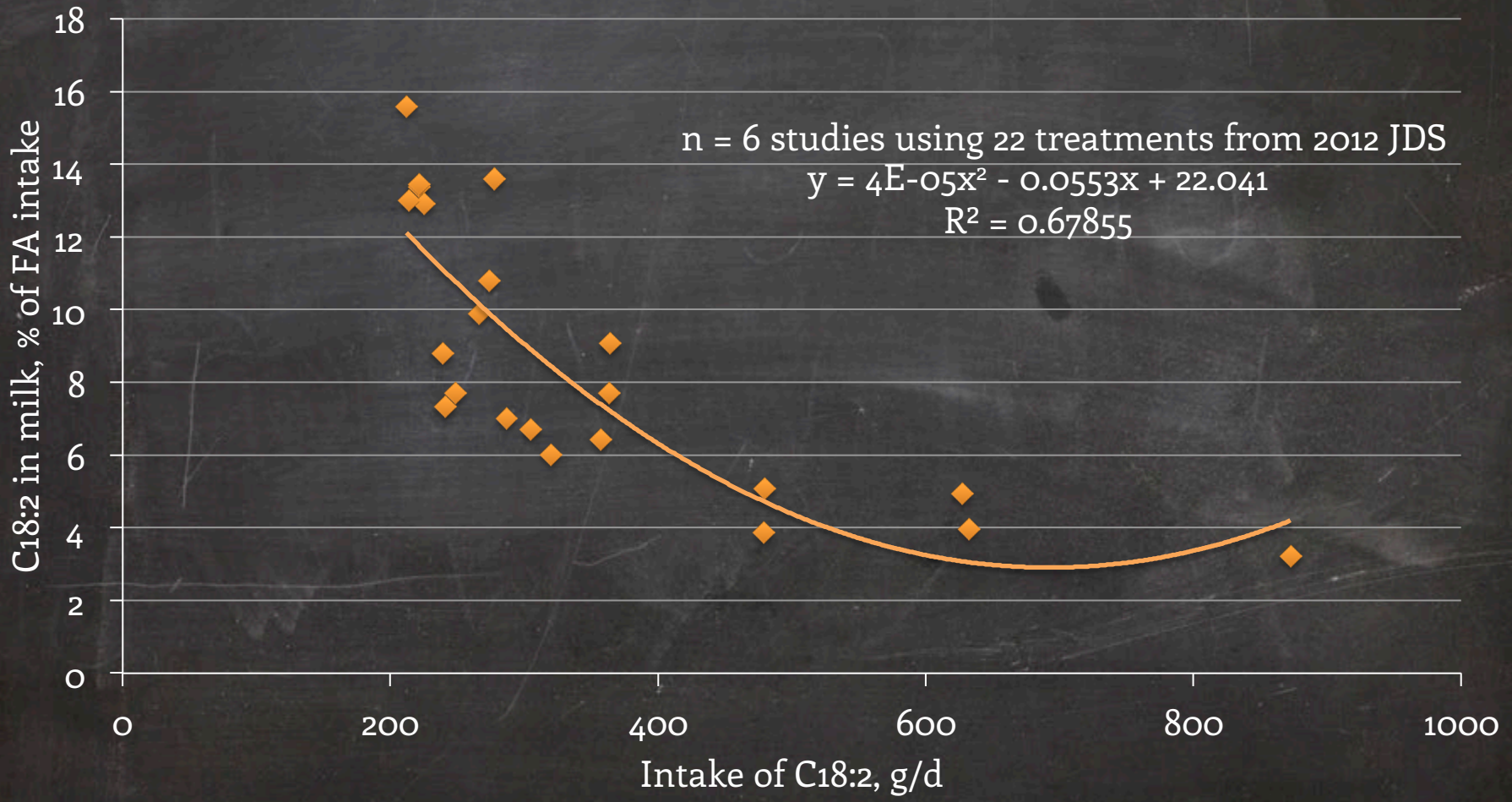
Transfer Efficiency of C18:2 from Diet to Milk



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Examples of Diets Supplying C18:2 at ~500 g/d

Ingredient	Example 1	Example 2	Example 3
Alfalfa hay/silage	16	35	32
Corn silage	33	18	10
Corn ground	25	11	20
Soybean meal etc.	13	8	7
Soyhulls/byproducts	5	23	12
Animal-Vegetable blend	5	…	…
High linoleic sunflower oil	…	1.9	…
Whole cottonseed	…	…	15
Mineral/Vitamin mix	3	2	4

DMI of 23 kg/day × 2.2% C18:2 (DM basis) = 500 g/day intake of C18:2

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C18:2 Recommendation for Lactating Cows?

- A 1450 lb dairy cow producing 90 lb of milk requires ~11 g/day of C18:2 for maintenance (based upon rodent research)
- This 11 g/day required for maintenance plus 30 g/day required in milk fat = 41 g of C18:2 per day required for absorption
- Transfer efficiency from gut to milk is ~70%, thus requiring the delivery of 59 g/day of C18:2 to the lower gut (41 g ÷ 0.7 = 59 g)
- If ruminal biohydrogenation is 85%, then required intake is 390 g/day (59 g ÷ 0.15 = 390 g)
- Average intake of C18:2 is ~250 g/day for a lactating cow without fat supplements

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