

Grass and clover effects on milk fatty acids

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Nutritional targets

- Saturated fatty acids should be $< 10\%$ of energy intake
- Polyunsaturated: saturated fatty acid (P:S) ratio should be about 0.45
- $n-6:n-3$ fatty acid ratio should be less than 4 (need to increase $n-3$)

UK Department of Health, 1994

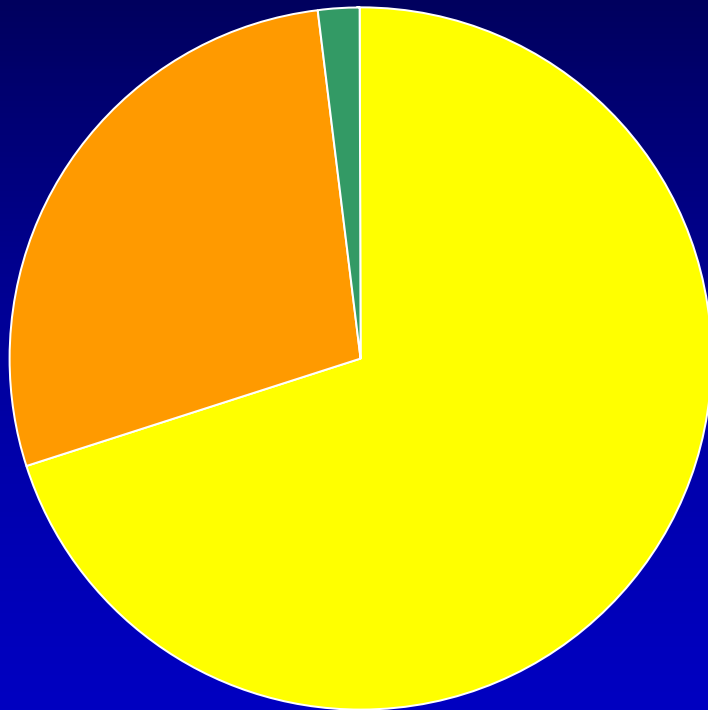
UK consumption of milk and cream

- Declined from 3.0 L/week 1950-1975 to 2.0 L/week 2002-2003
- 2.1 L/week decline in whole milk consumption only partially offset by increased consumption of skimmed milk

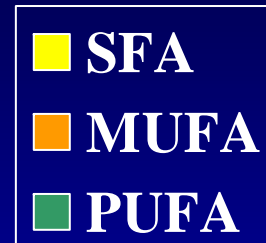
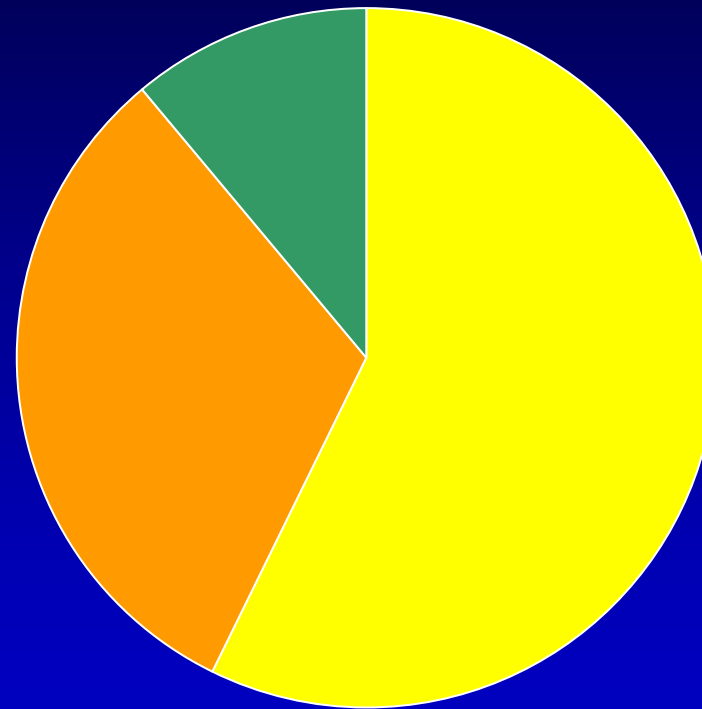
UK DEFRA, 2004

Effects on plasma LDL cholesterol

Normal milk

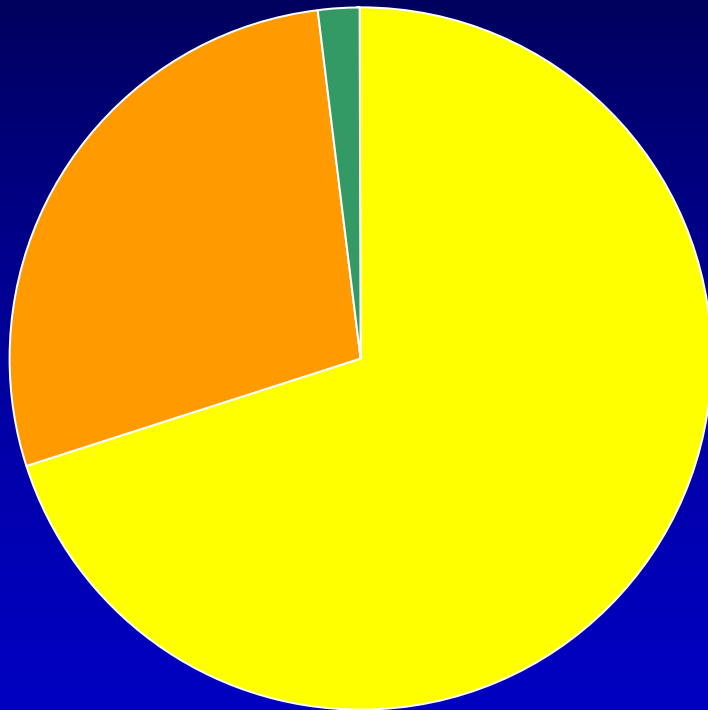


Modified milk



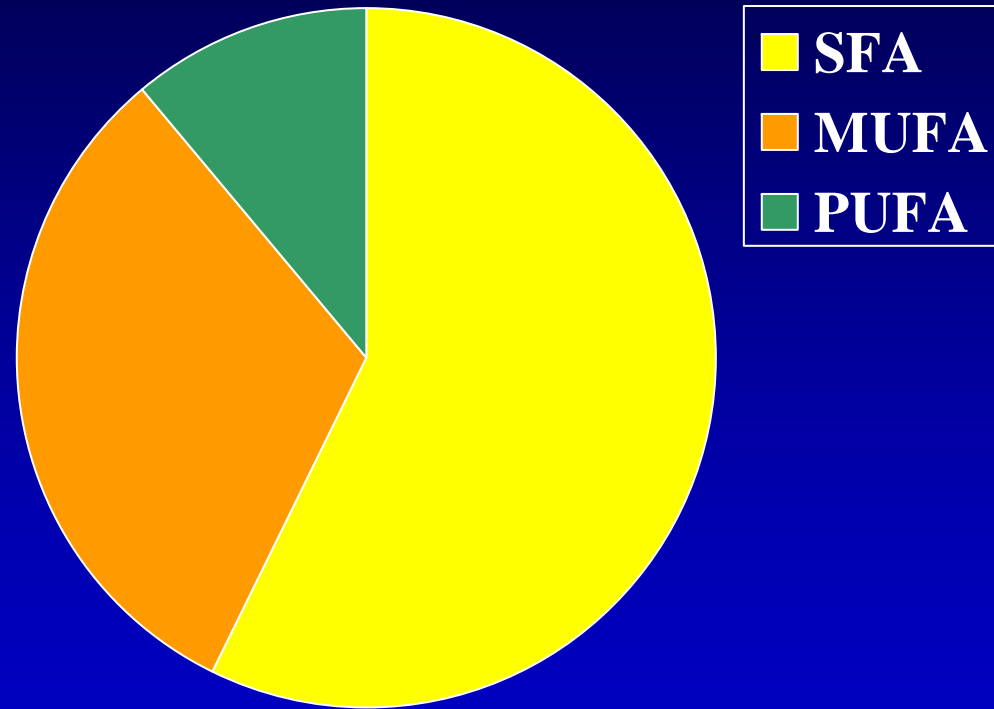
Effects on plasma LDL cholesterol

Normal milk



4.49 mmol/L

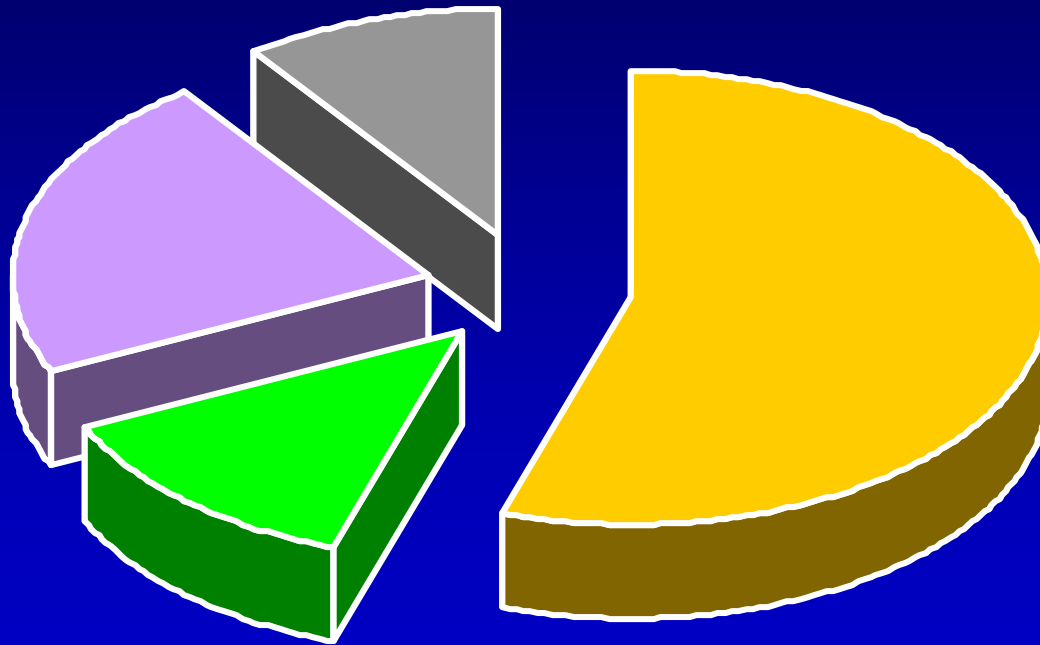
Modified milk



4.25 mmol/L

Noakes et al. 1996

Opportunity: herbage fatty acids



■ linolenic acid
(18:3n-3)

■ linoleic acid
(18:2n-6)

■ palmitic acid
(16:0)

■ other

Maximising delivery of PUFA from sward to milk

Sward



Breeding and management

Conservation



Wilting

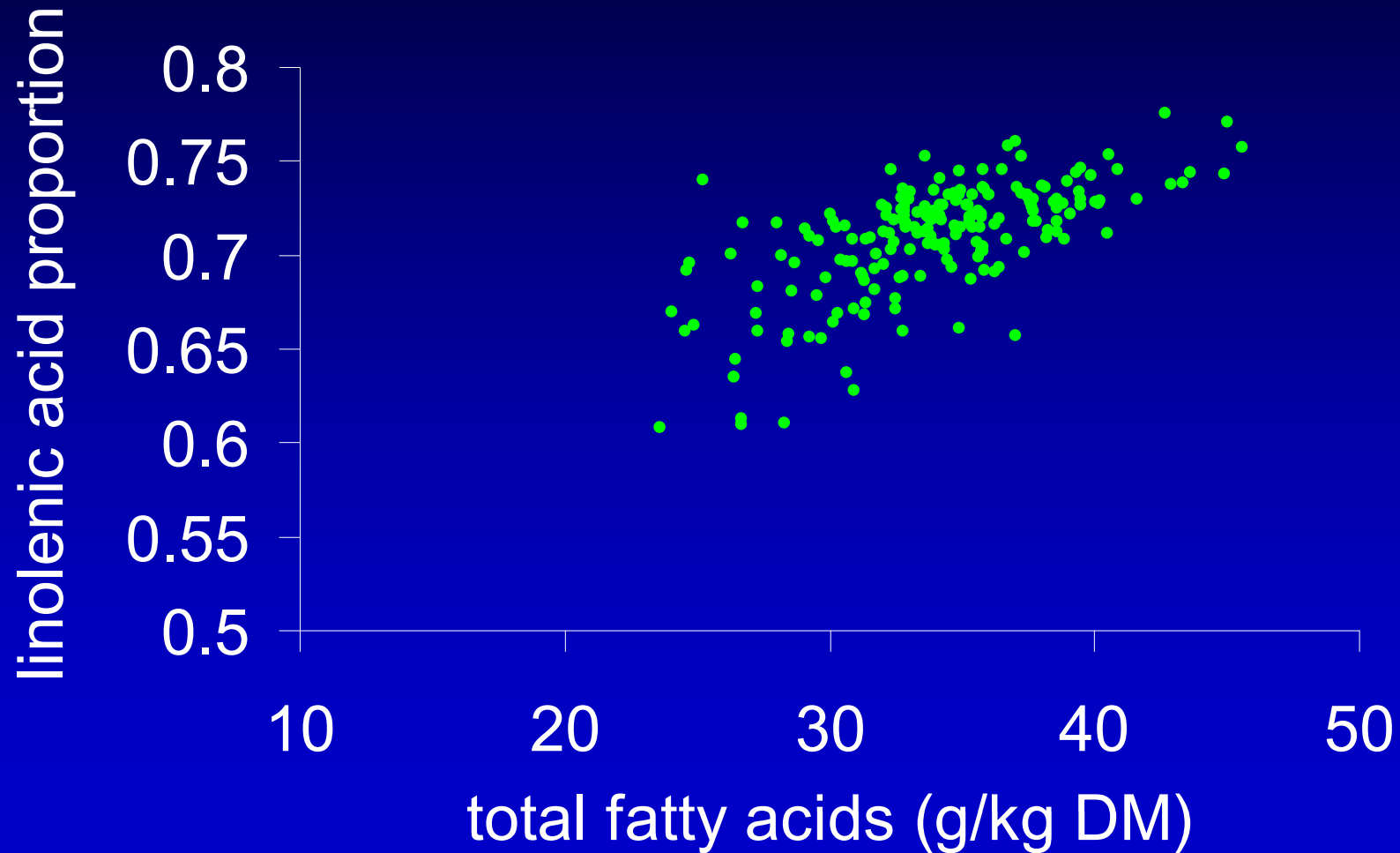
Rumen



Biohydrogenation

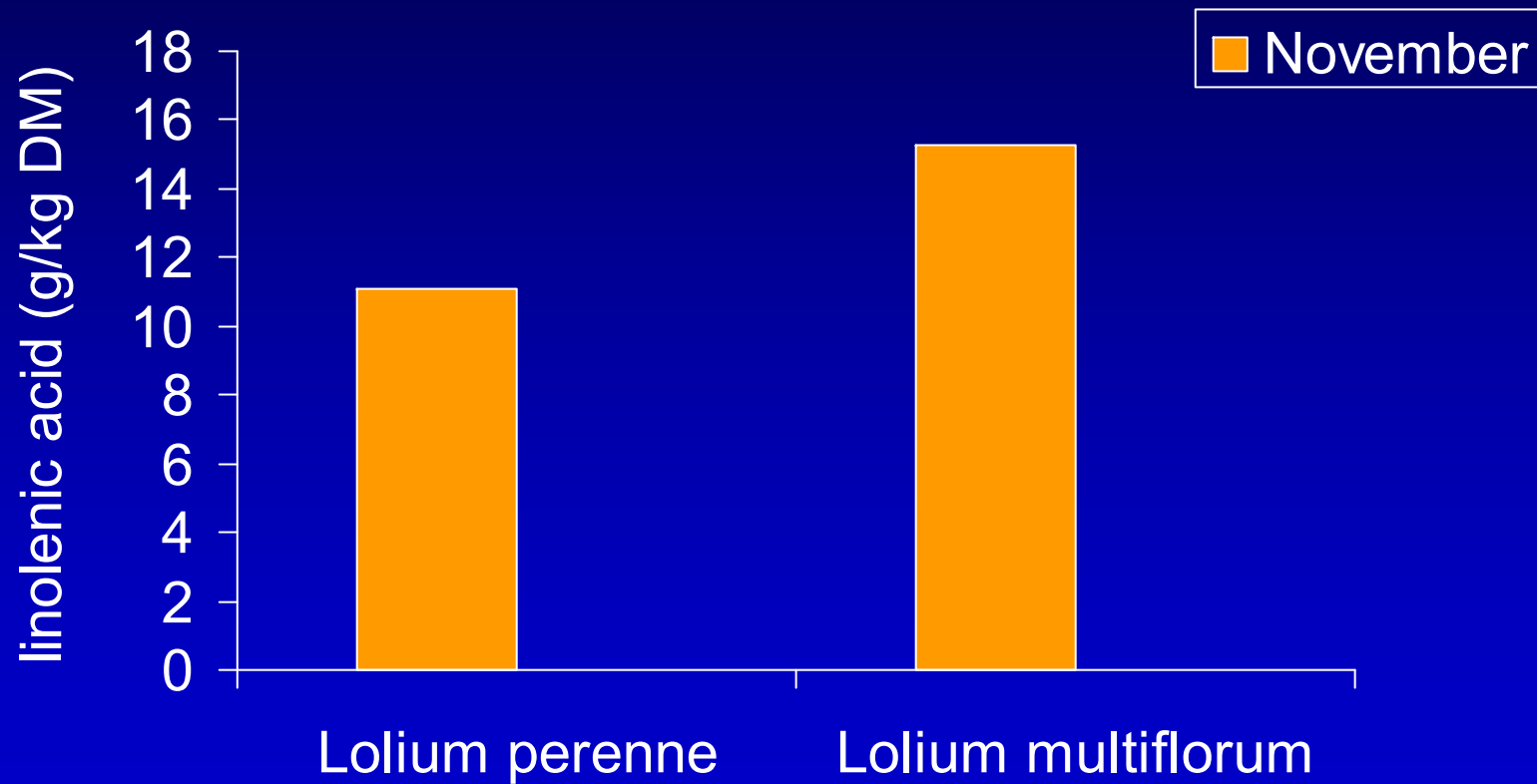
Milk

Breeders population of perennial ryegrass (same stage: vegetative)



Dewhurst *et al.*, unpubl.

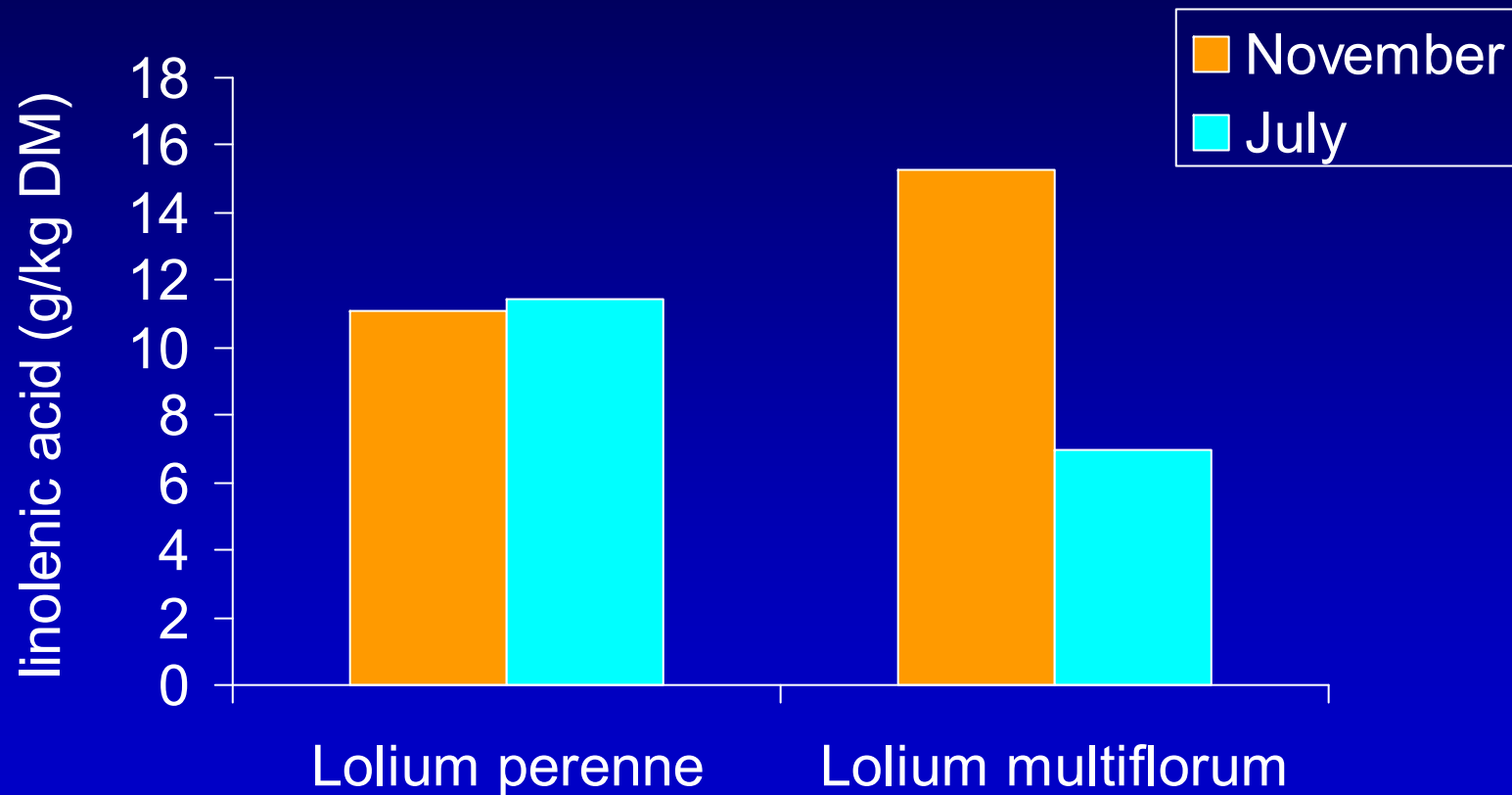
Grass species effect



Dewhurst et al. 2001

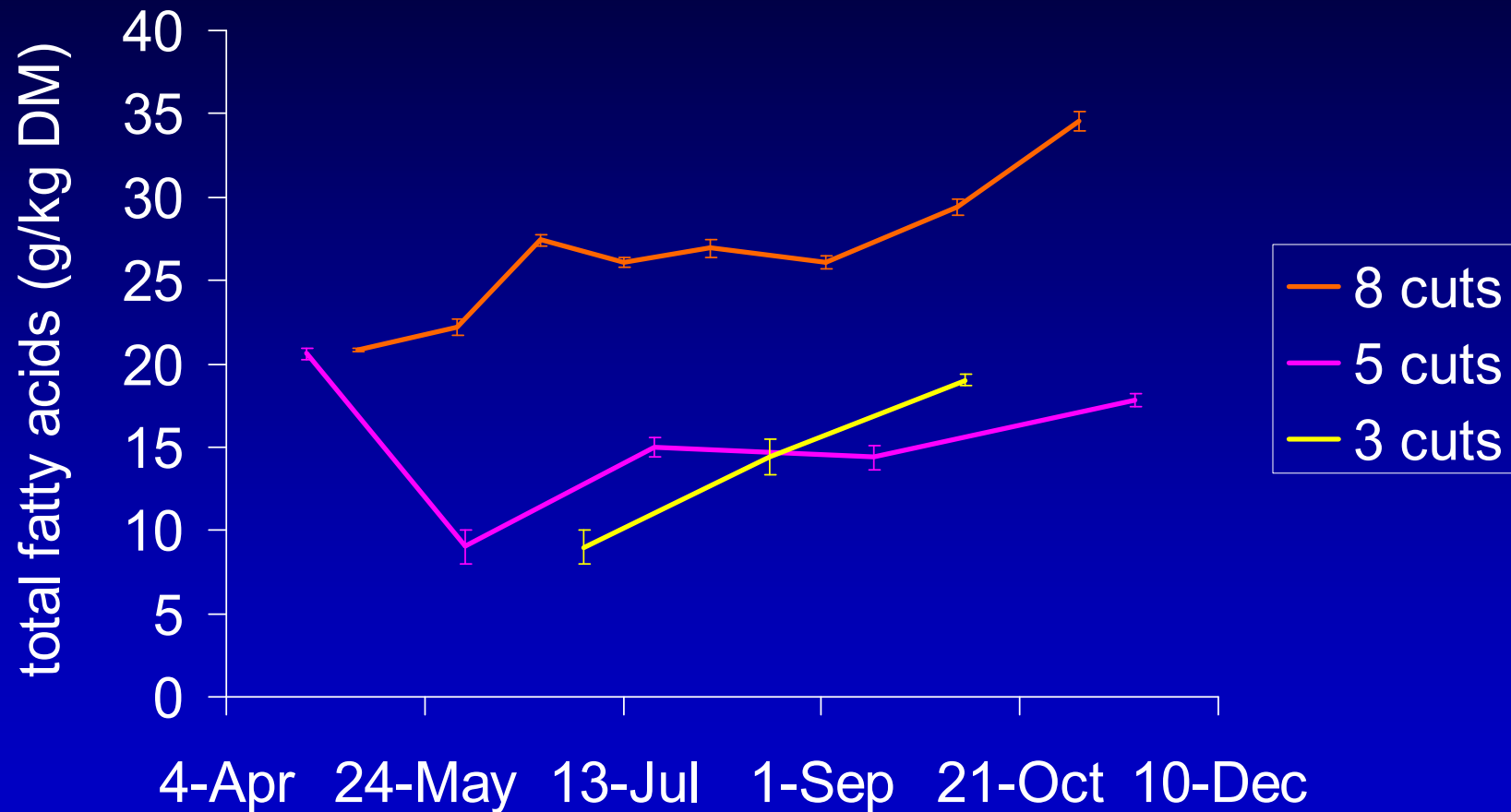
Genotype × Environment interaction

SED=0.38; P<0.001 (interaction)



Dewhurst et al. 2001

Effects of cutting date & intervals



Dewhurst et al. 2001, 2002

Lincoln University Dairy Farm





Supplement!! approx. 500 kg DM/cow/annum

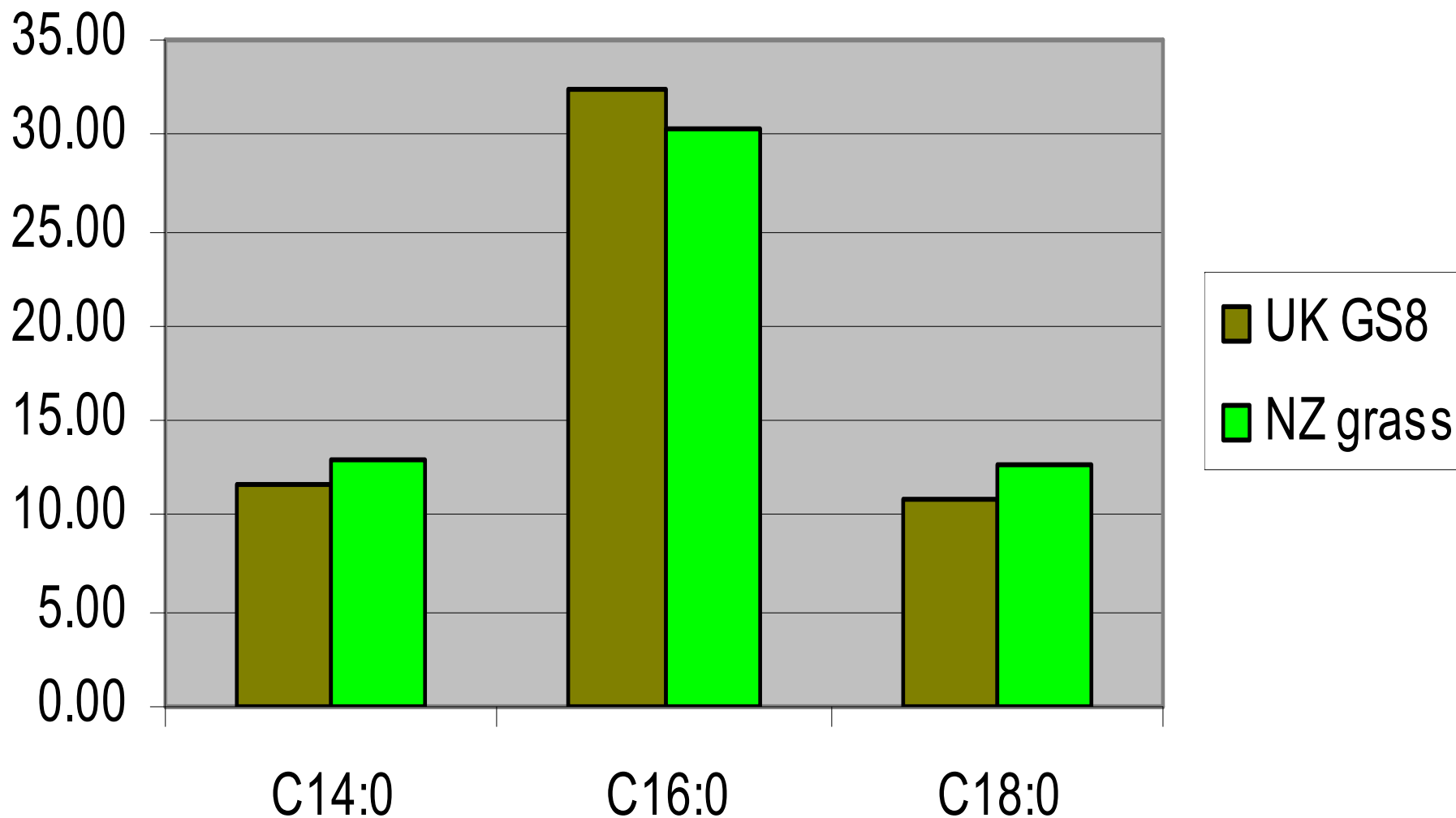




Pasture analysis: South Island of New Zealand

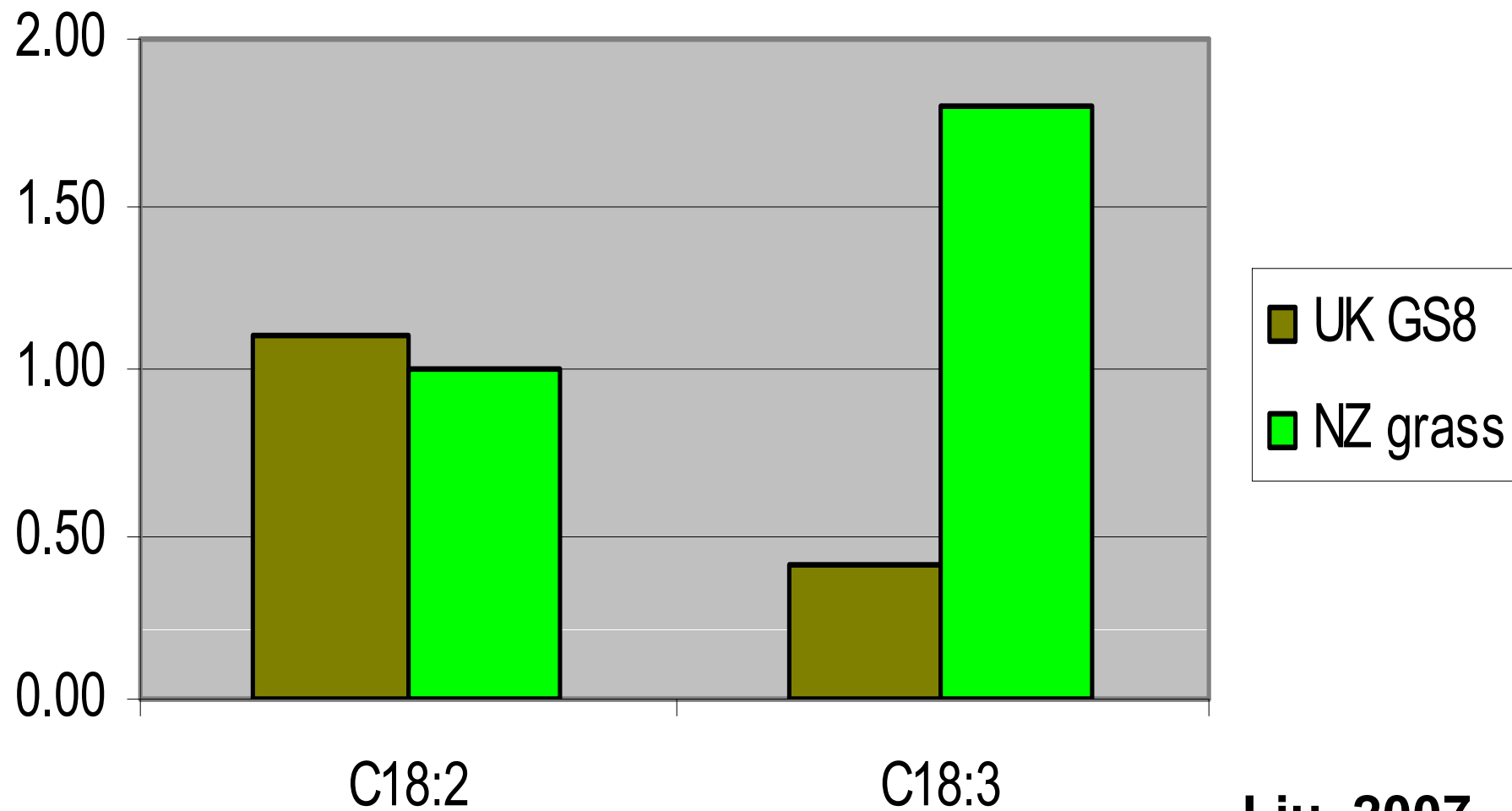
- 10% over 250 g CP per kg DM
- 15% over 300 g WSC per kg DM
- 7% less than 300 g NDF per kg DM

Effects on milk fatty acids (g/100g FA)



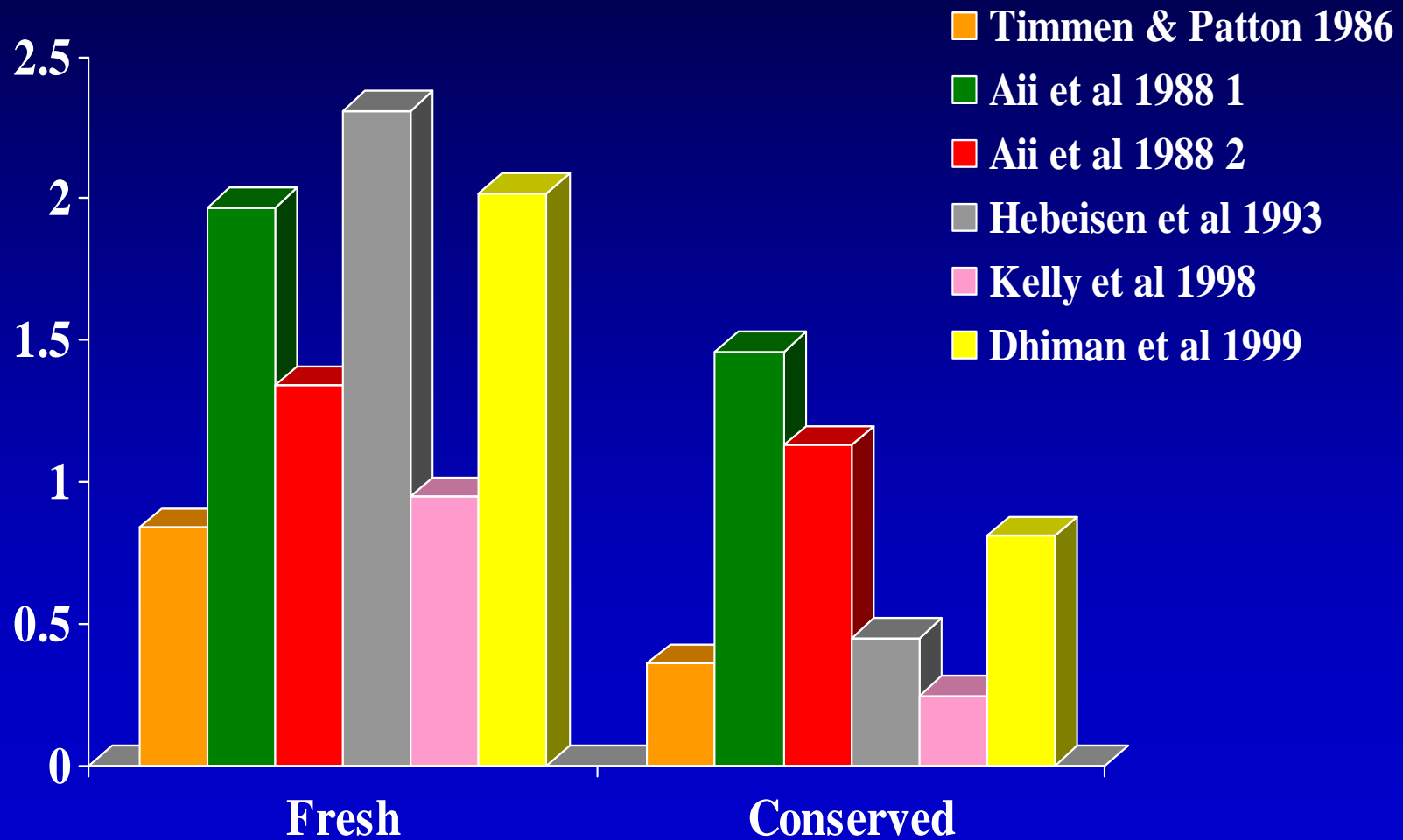
Liu, 2007

Effects on milk fatty acids (g/100g FA)



Liu, 2007

Fresh versus Conserved Forage and 18:3n-3 In Milk Fat (g/100g)



Shading herbage

	Not Shaded	Shaded	s.e.d.
Total fatty acids (g/kg DM)	23.1	19.0	1.256
C16:0 (g/kg DM)	5.13	4.89	0.111
C18:2 (g/kg DM)	2.96	2.27	0.141
C18:3 (g/kg DM)	12.61	9.52	0.977

Maximising delivery of PUFA from sward to milk

Sward



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Rumen



Biohydrogenation

Milk

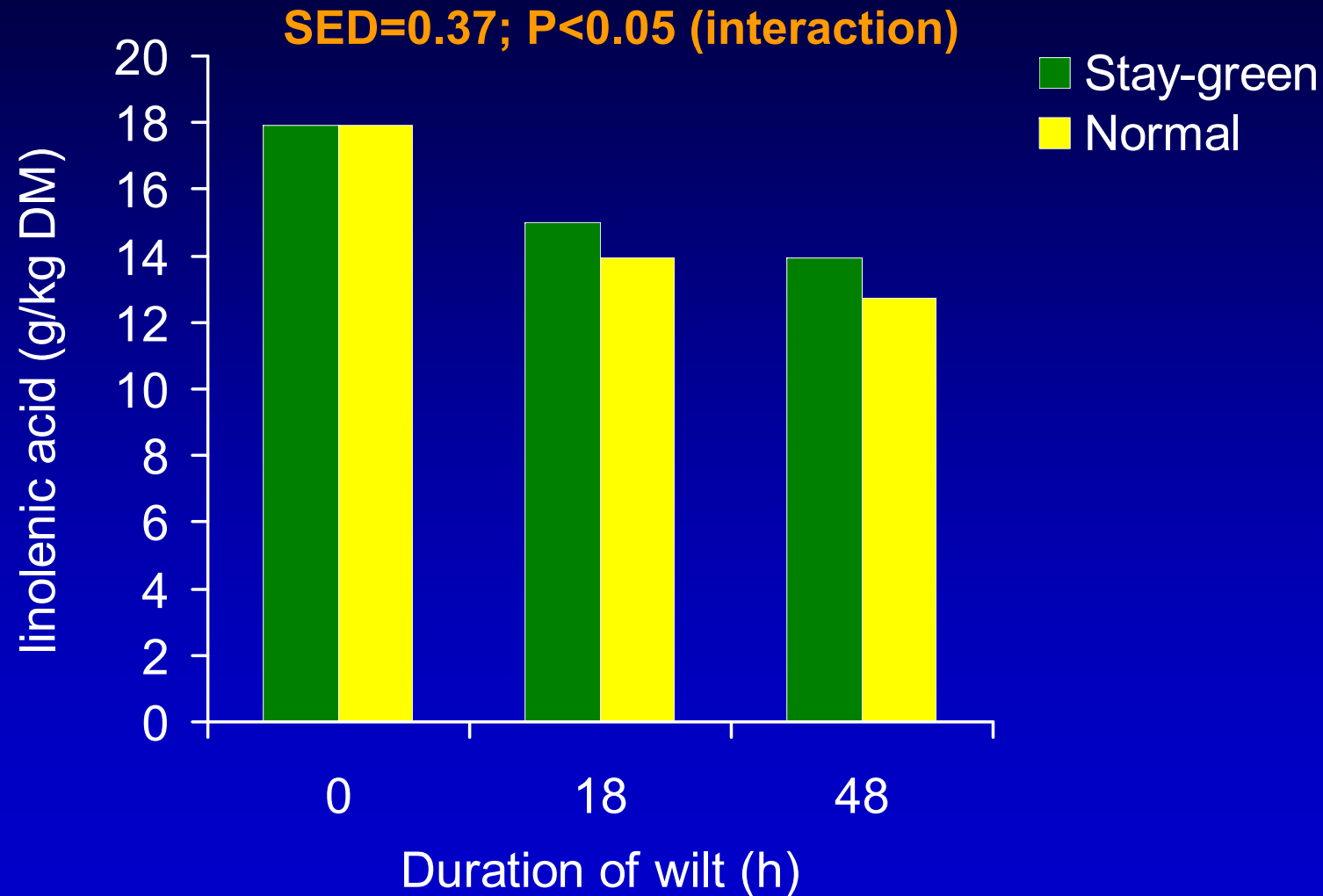
Wilting for silage (68 hours)

	unwilted	wilted	s.e.d.	<i>P</i>
total fatty acids (g/kg DM)	28.3	20.9	0.88	<0.001
C16:0 (g/kg DM)	6.11	5.59	0.27	NS
C18:2 (g/kg DM)	3.56	2.56	0.027	<0.001
C18:3 (g/kg DM)	15.94	9.94	0.717	<0.001

Stay-green grasses



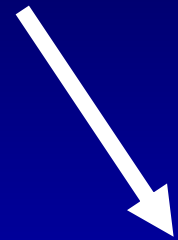
Loss of linolenic acid during wilting



Dewhurst *et al.* 2002

'Green odour' plant defence

Polyunsaturated fatty acid (e.g. 18:3)



Lipoxygenase

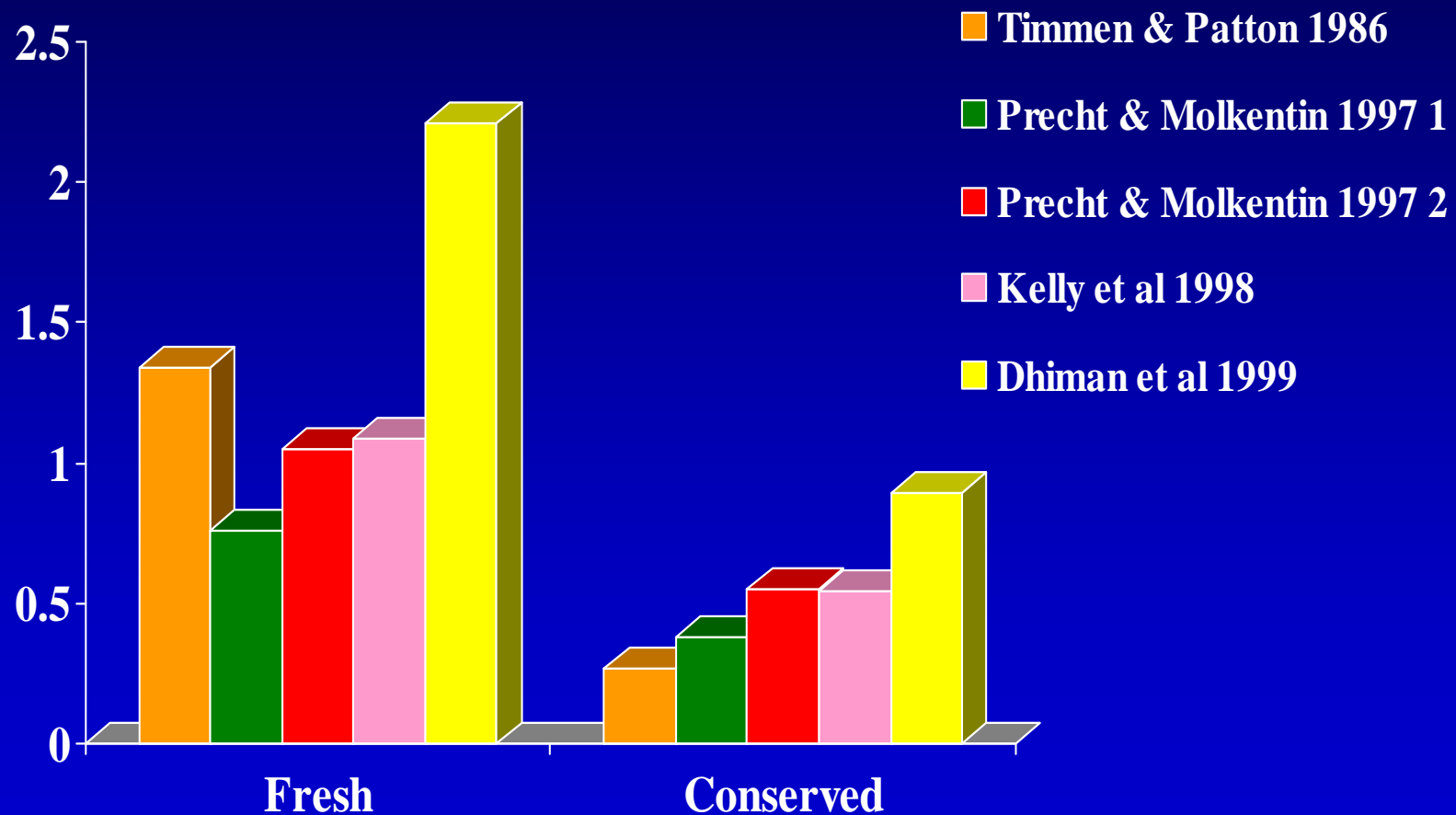
Fatty acid hydroperoxide



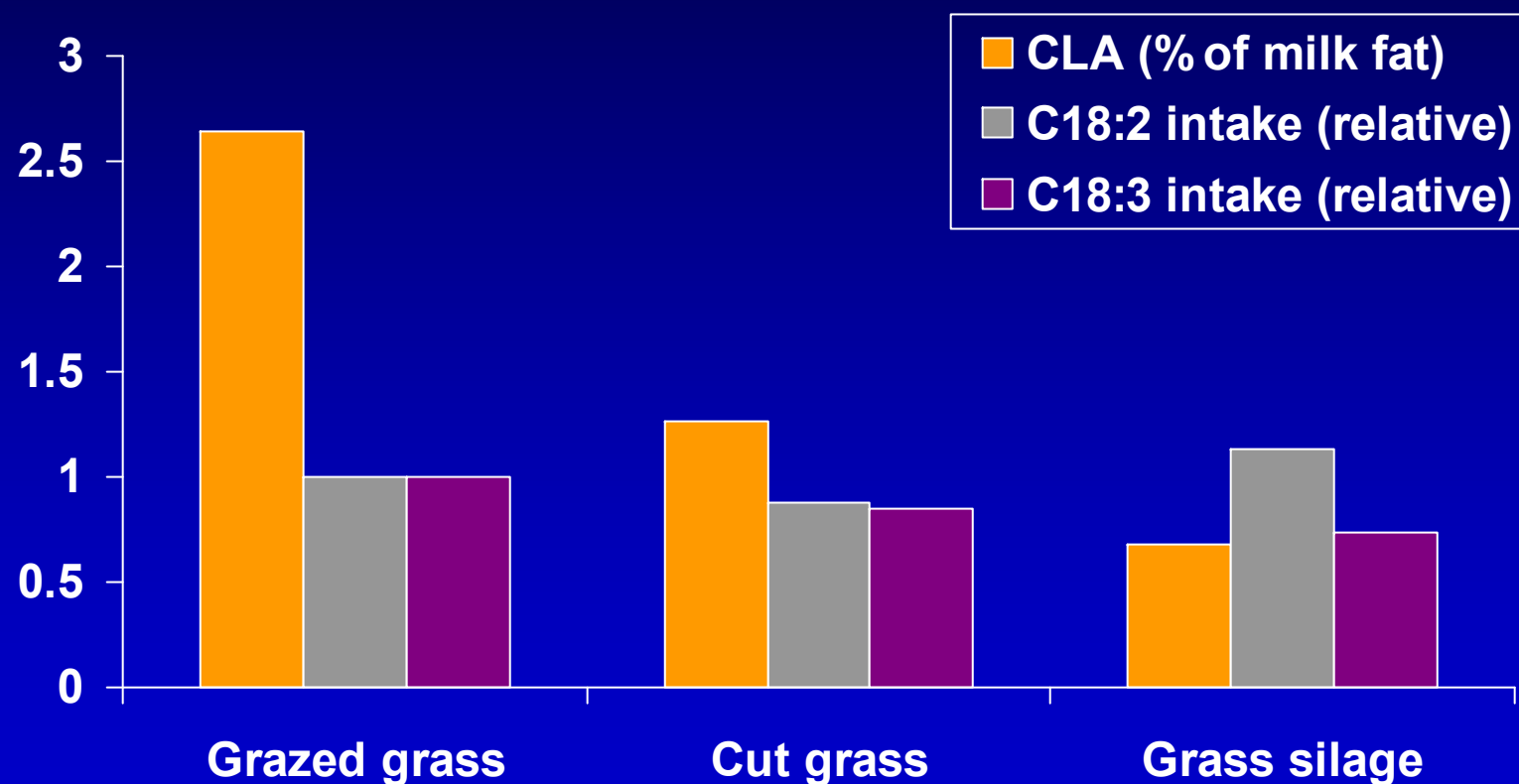
Fatty acid hydroperoxide lyase

C6 and C9 aldehydes and alcohols (e.g. hexenal)

Fresh versus Conserved Forage and CLA In Milk Fat (g/100g)



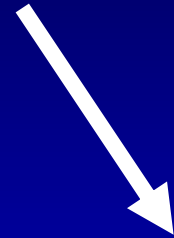
Wilting and ensiling effect on CLA (% of milk fatty acids)



Offer *et al.*, 2002

'Green odour' plant defence

Polyunsaturated fatty acid (e.g. 18:3)



Lipoxygenase

Fatty acid hydroperoxide



Fatty acid hydroperoxide lyase

C6 and C9 aldehydes and alcohols (e.g. hexenal)

Grass Boluses



Perennial ryegrass

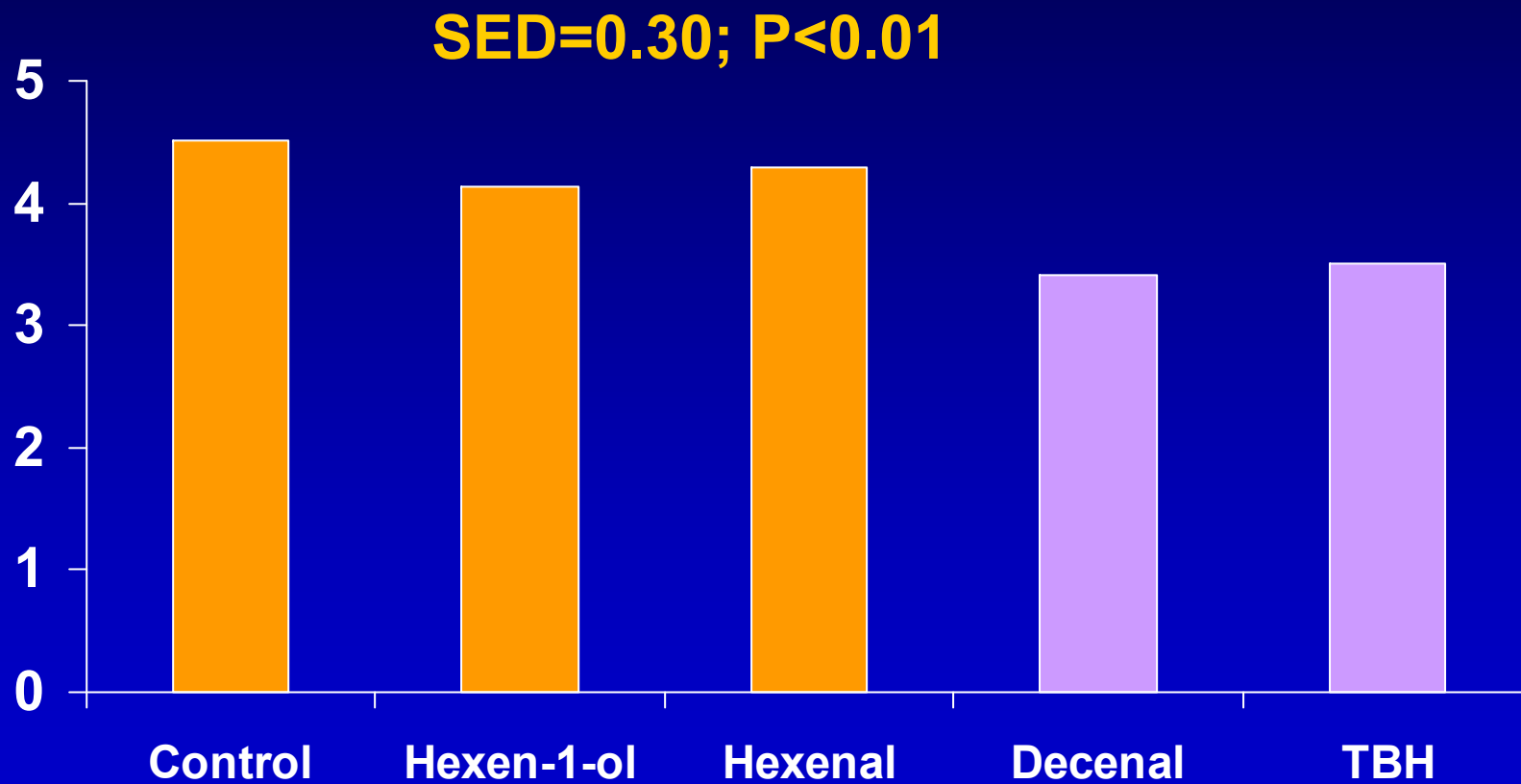


Tall fescue

Effects of volatiles (50 μ M) on *in vitro* fermentation

- *tert* butyl hydroperoxide
- *cis*-2 Hexen-1-ol
- Hexanal
- *trans*-2 Hexenal
- *trans*-2 Decenal

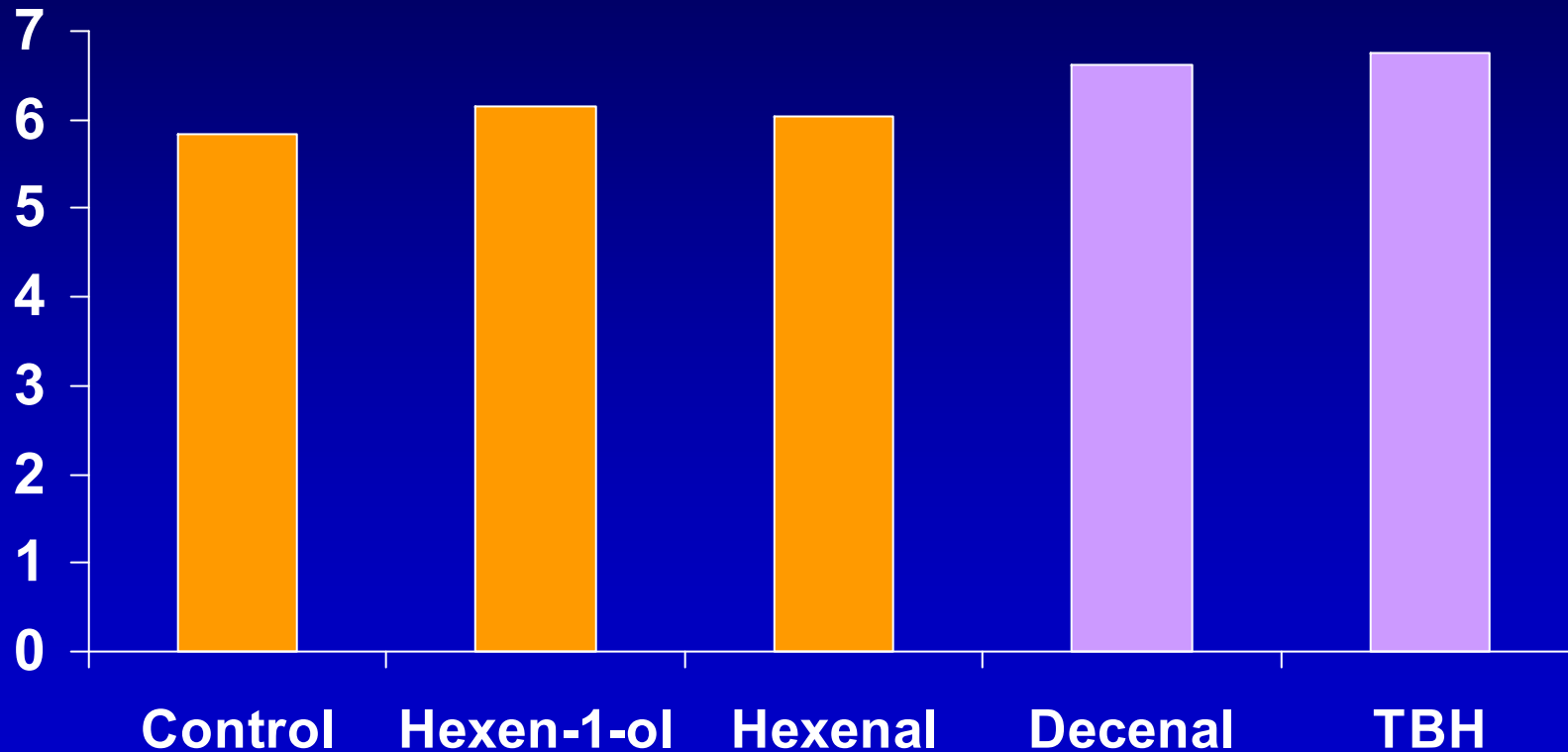
Odd- and branched chain fatty acids (% of total)



Lee et al., 2007

Trans-11 C18:1 (% of total)

SED=0.18; P<0.01



Lee et al., 2007

Silage additives

	control	formic acid	formalin	s.e.d.
total fatty acids (g/kg DM)	24.8	25.5	23.5	0.61**
C16:0 (g/kg DM)	6.03	5.68	5.83	0.152
C18:2 (g/kg DM)	3.07	3.16	2.96	0.113
C18:3 (g/kg DM)	13.10	13.77	11.96	0.404***

** $P < 0.01$; *** $P < 0.001$

Maximising delivery of PUFA from sward to milk

Sward



Breeding and management

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Wilting

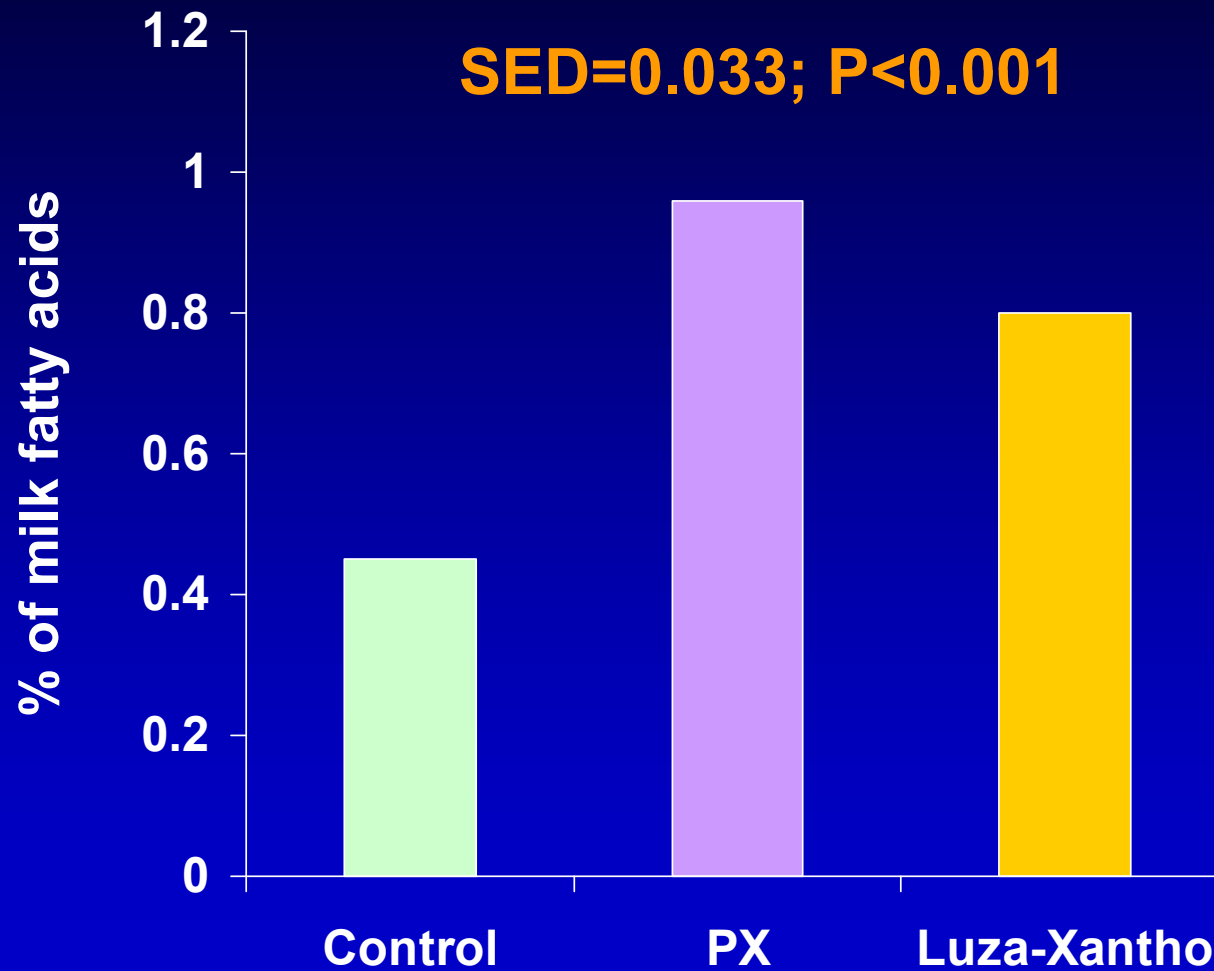
Rumen



Biohydrogenation

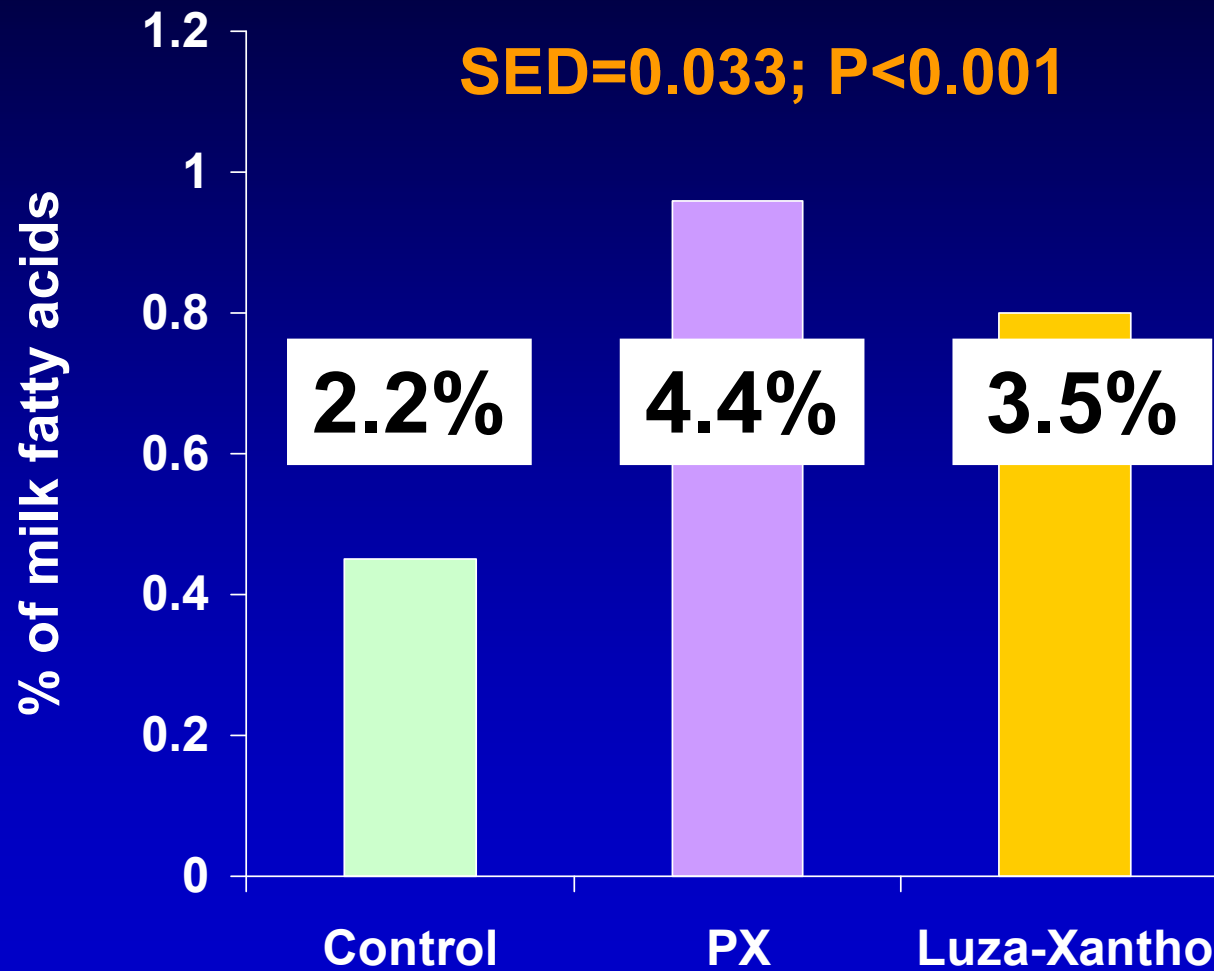
Milk

Alfalfa products and C18:3 in milk



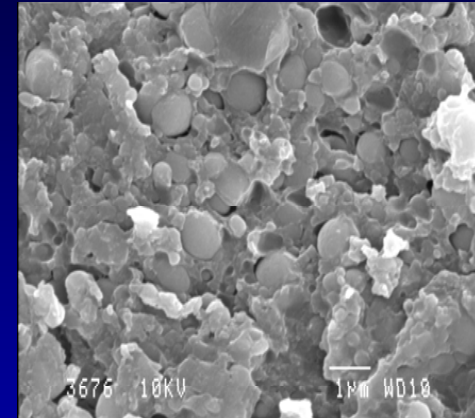
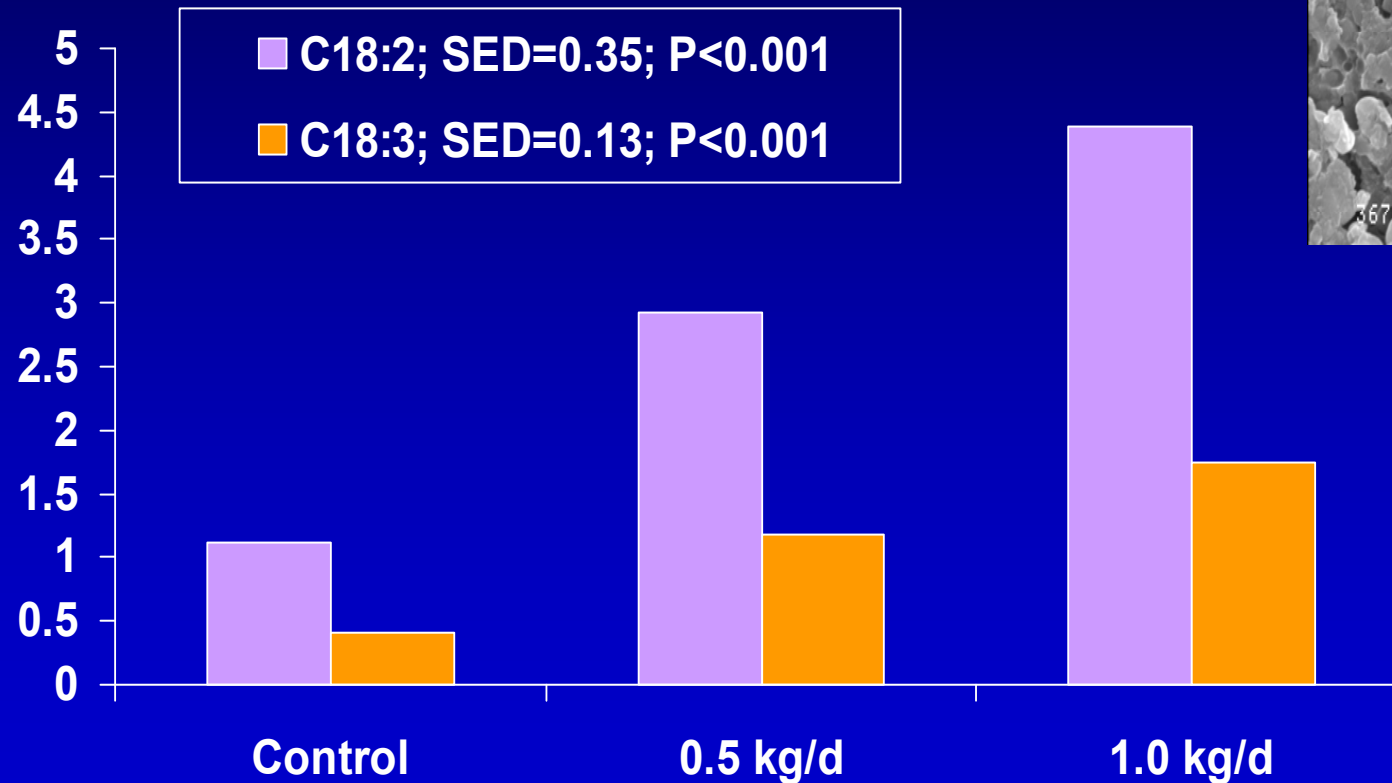
RJ Dewhurst unpublished

Alfalfa products and C18:3 in milk



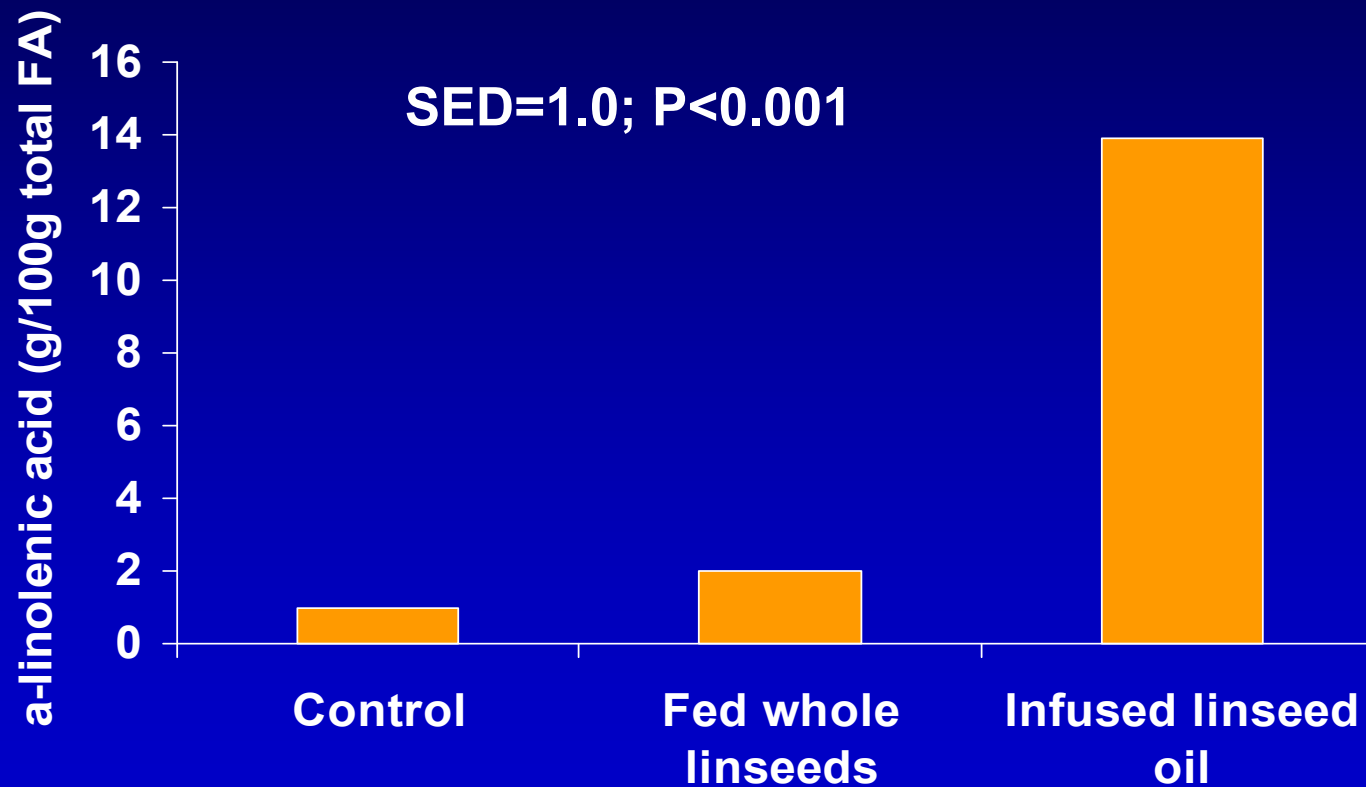
RJ Dewhurst unpublished

Effect of a protected lipid supplement on PUFA in beef muscle (% of total FA)



Scollan *et al.* 2003

Manipulating milk fatty acids



Petit et al. 2002

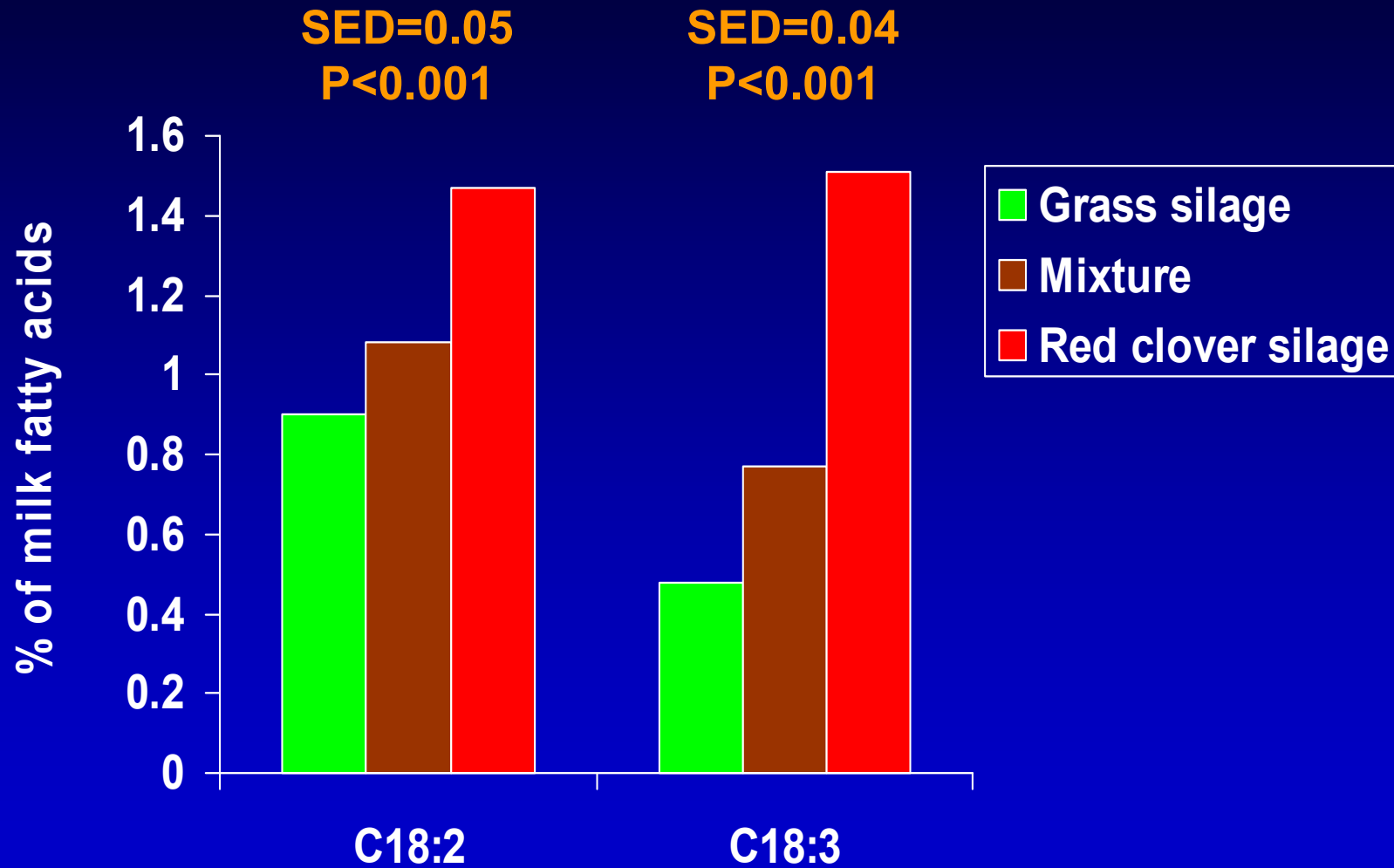
Highest levels of milk PUFA

- linoleic acid (35%): encapsulated safflower oil (Chilliard *et al.*, 2000)
- α -linolenic acid (20%): protected (CSIRO) linseed oil (McDonald and Scott, 1977)
- eicosapentaenoic acid (1.4%): fish oil infused post-rumen (McConnell *et al.*, 2004)
- docosahexaenoic acid (2.2%): protected (CSIRO) fish oil (Gulati *et al.*, 2003)

Highest levels of milk CLA

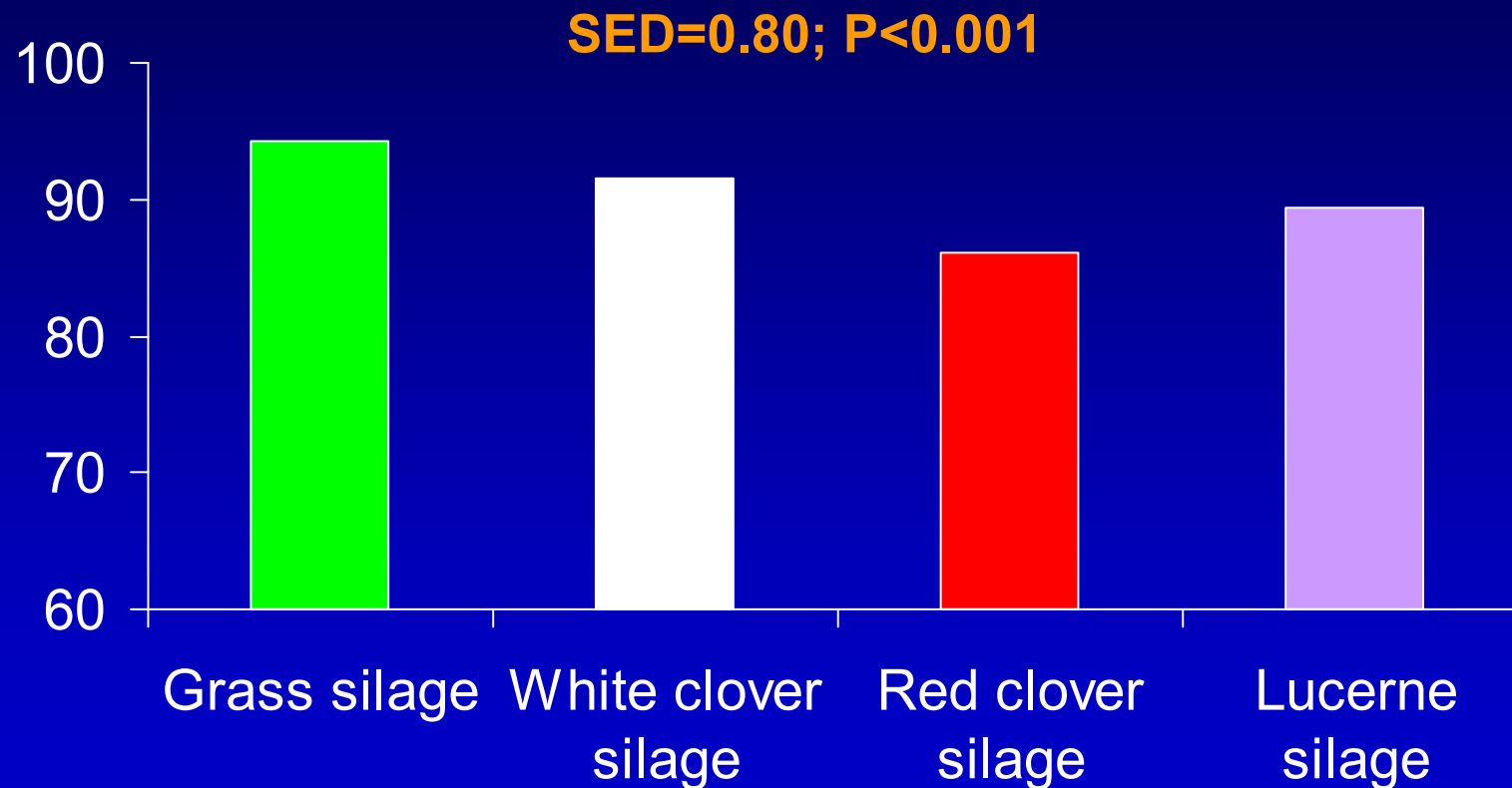
- CLA (6.4%): abomasal infusion of CLA (Chouinard *et al.* 1999)
- *trans*-10, *cis*-12 CLA (0.7%): abomasal infusion of *trans*-10, *cis*-12 CLA (Baumgard *et al.*, 2001)

Red clover effect on milk PUFA



Dewhurst *et al.* 2003

Biohydrogenation of alpha-linolenic acid (%): dairy cows

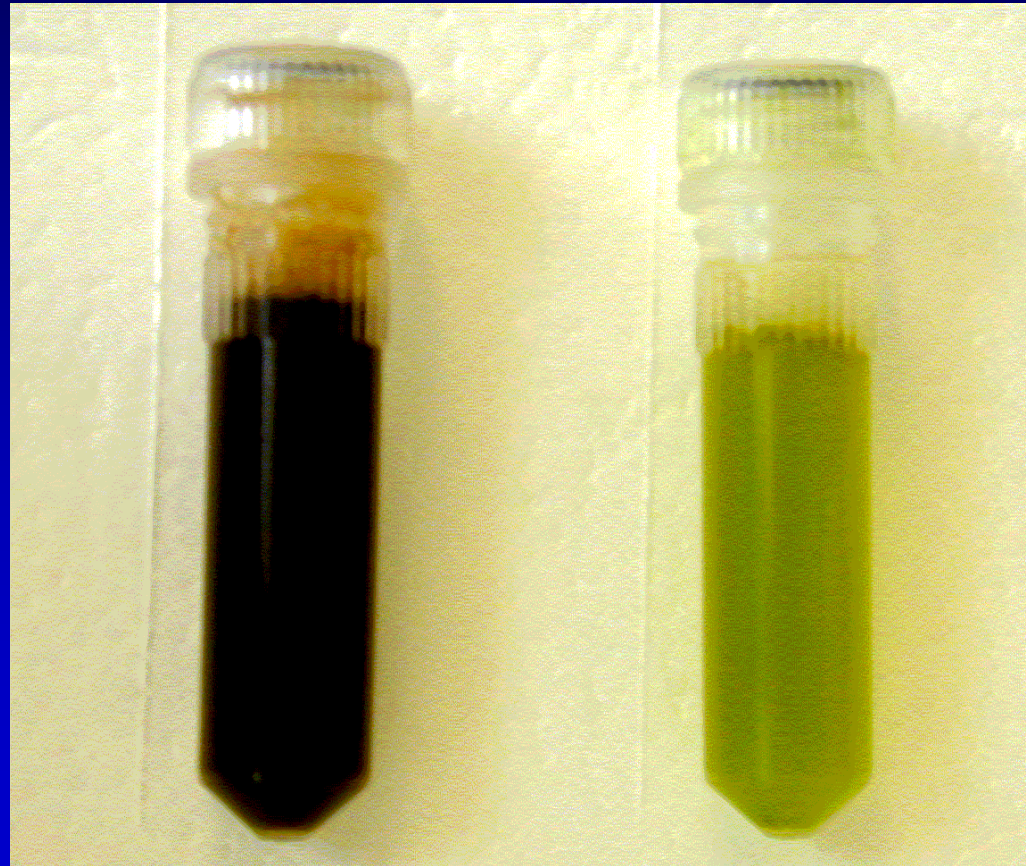


Dewhurst et al., 2003

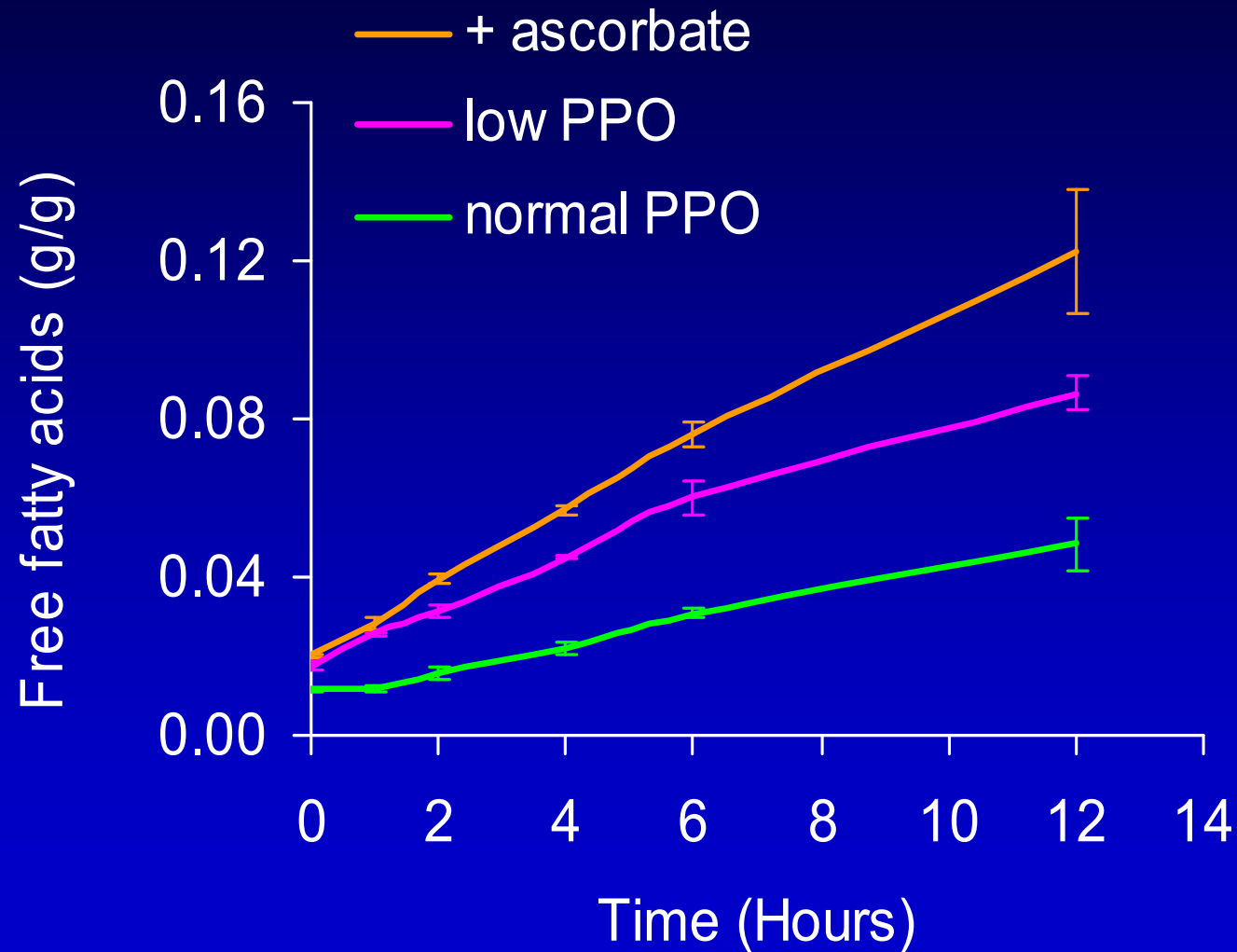
Polyphenol oxidase in red clover

Normal Red Clover

Low PPO Red Clover

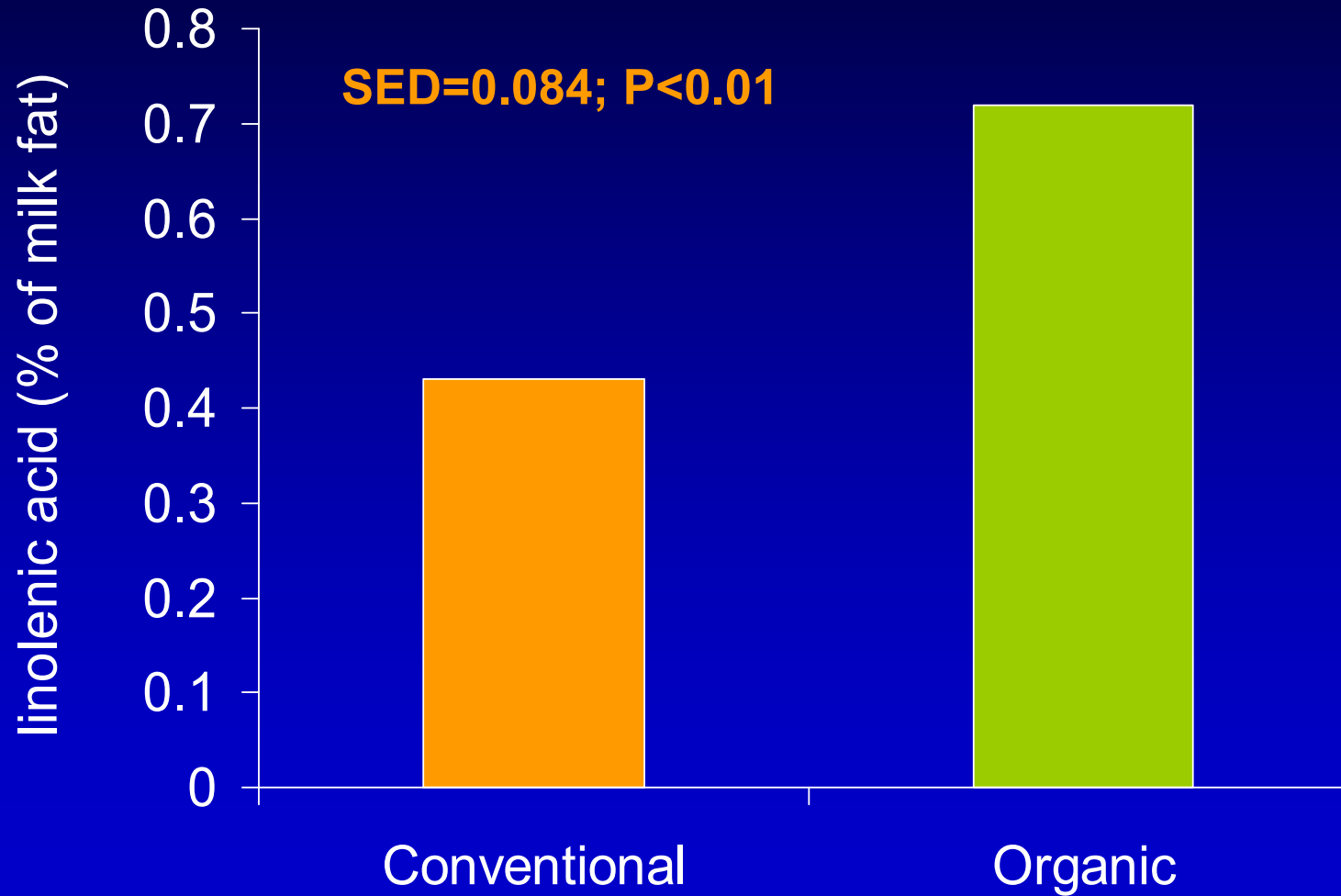


PPO and lipolysis in red clover

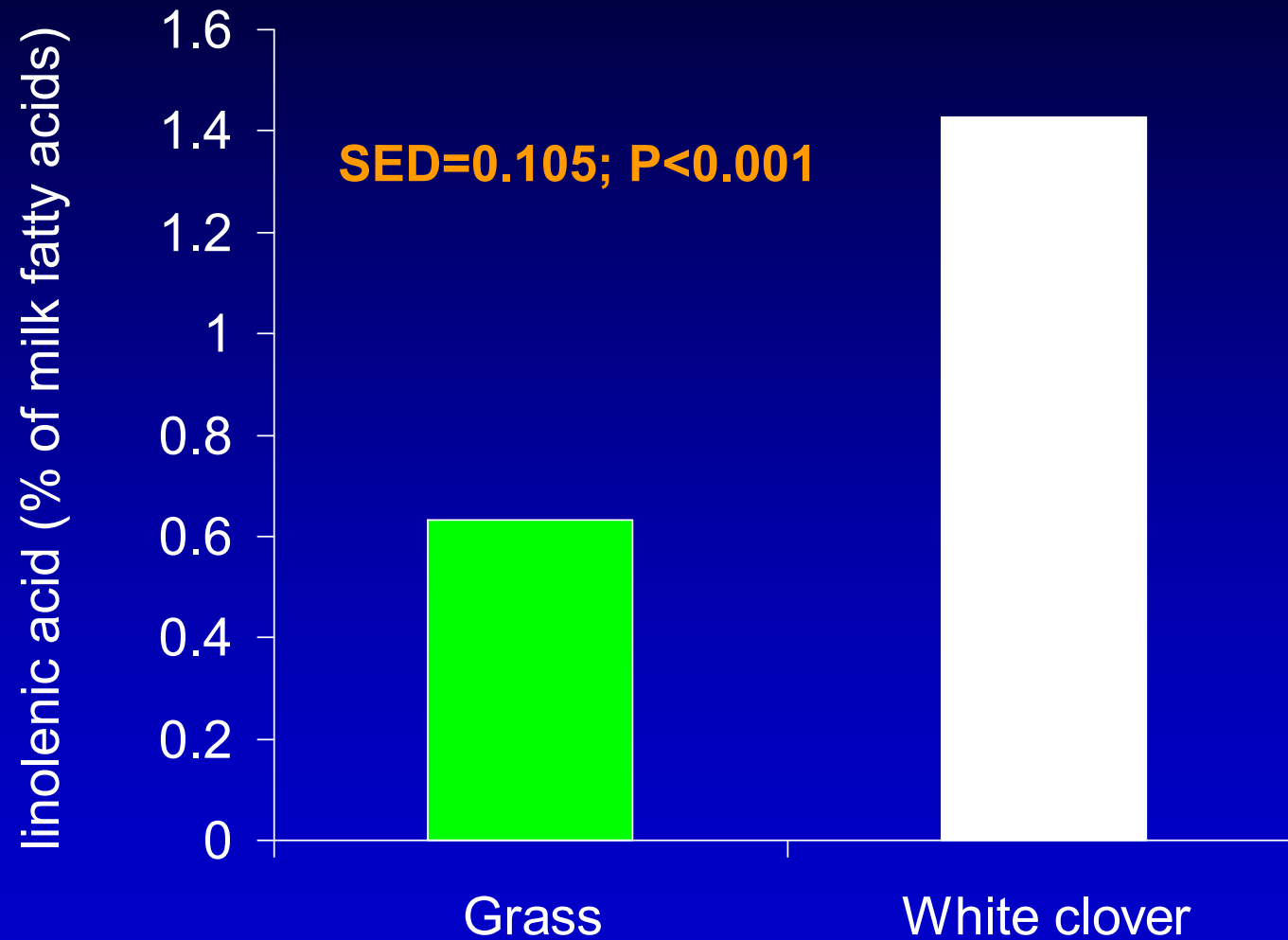


Lee et al., 2004

Alpha-linolenic acid in organic milk



Grazed herbage and milk C18:3



RJ Dewhurst, unpublished



Effects of fat sources on pregnancy rates

	Megalac	Linseed	SE	Sig.
linolenic acid (n-3) % of blood fatty acids	12.0	19.6	0.54	*
pregnancy rate to first service (%)	50	87		*

Petit et al., 2001

Effects of red clover silage on conception rate of heifers

	Grass silage	Red clover silage
pregnancy rate to first service (%)	43	76

“The possibility that red clover silage may enhance fertility needs further study”

Austin et al., 1982

Effects of red clover silage on conception rate of cows

	Grass silage	Red clover silage
pregnancy rate to first service (%)	29	55
pregnany rate to 4 services (%)	80	88

Thomas *et al.*, 1985

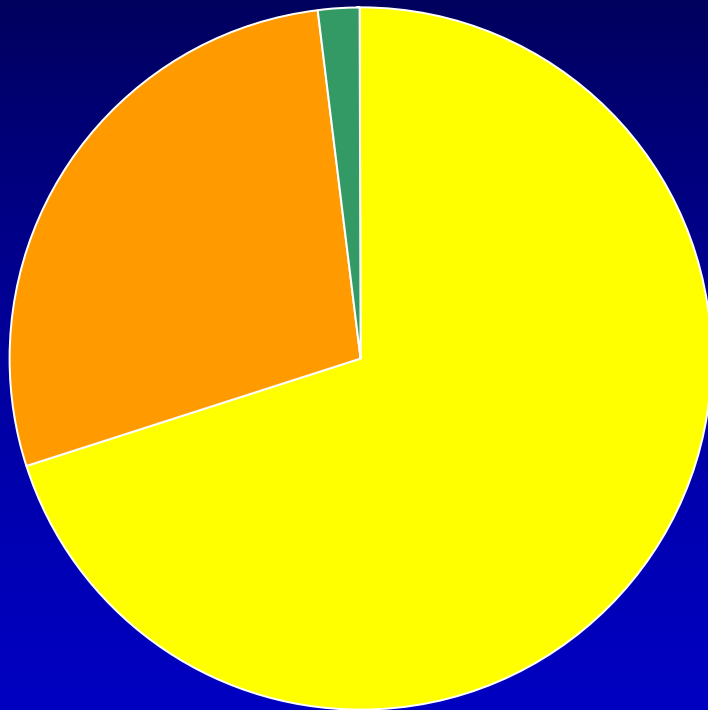
Prostaglandins are synthesised from fatty acids

- Two sorts of fatty acids (n-6 and n-3)
- n-6 fatty acids are precursors of the '2-series' prostaglandins
- n-3 fatty acids are precursors of the '3-series' prostaglandins
- 3-series prostaglandins have lower activity



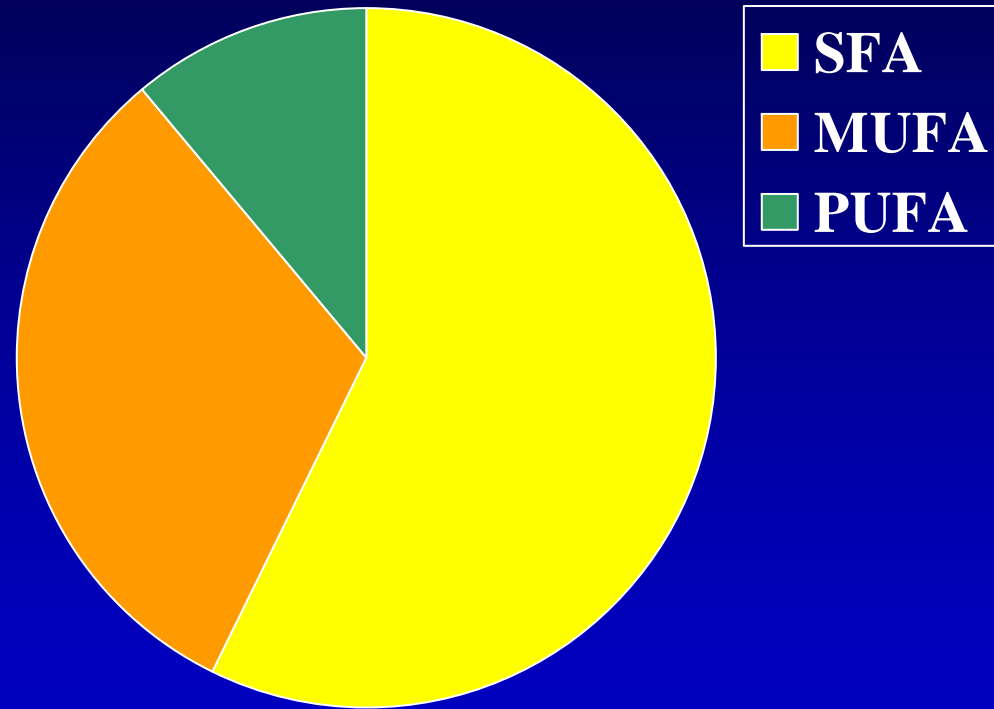
Effects on plasma LDL cholesterol

Normal milk



4.49 mmol/L

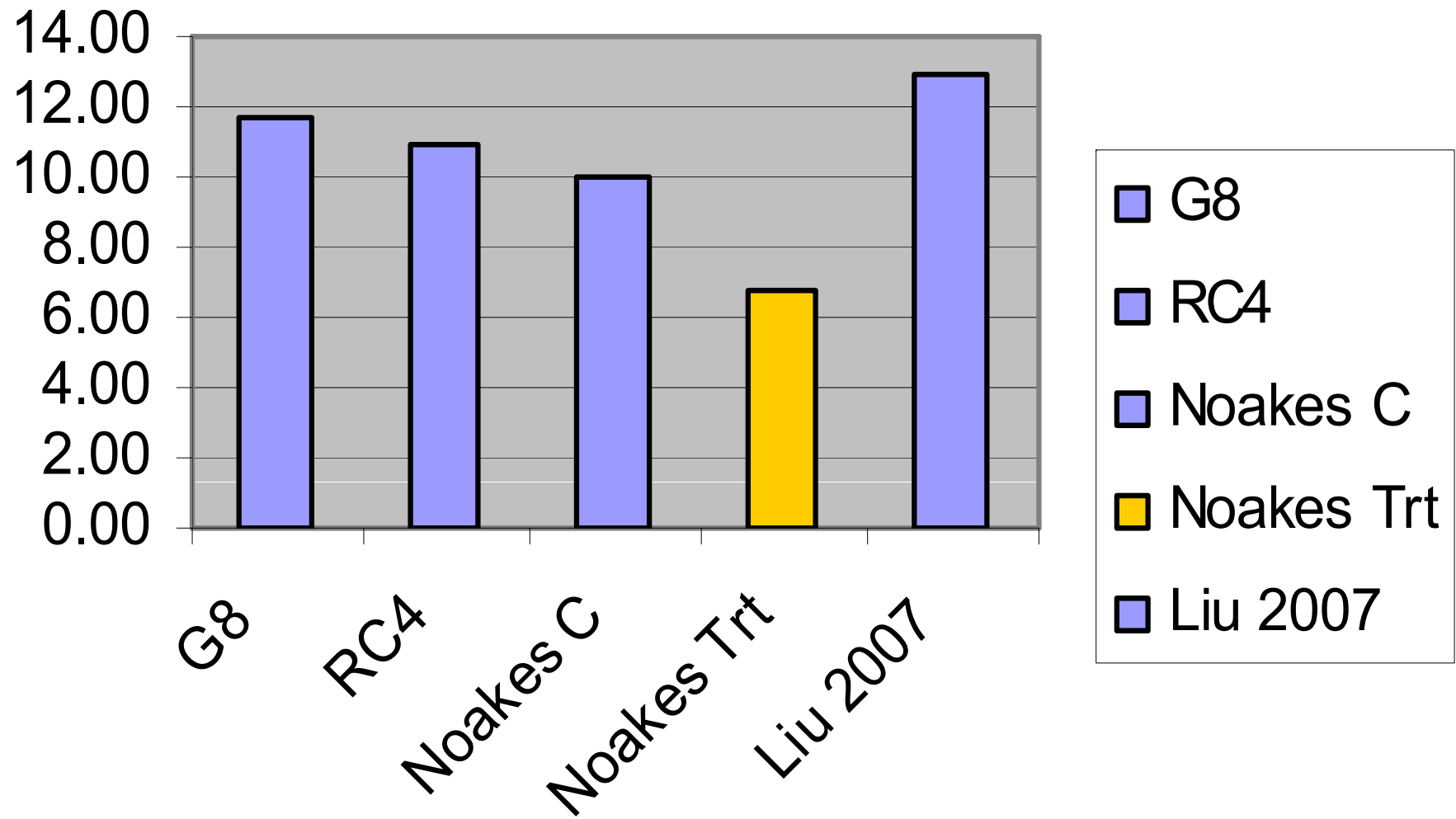
Modified milk



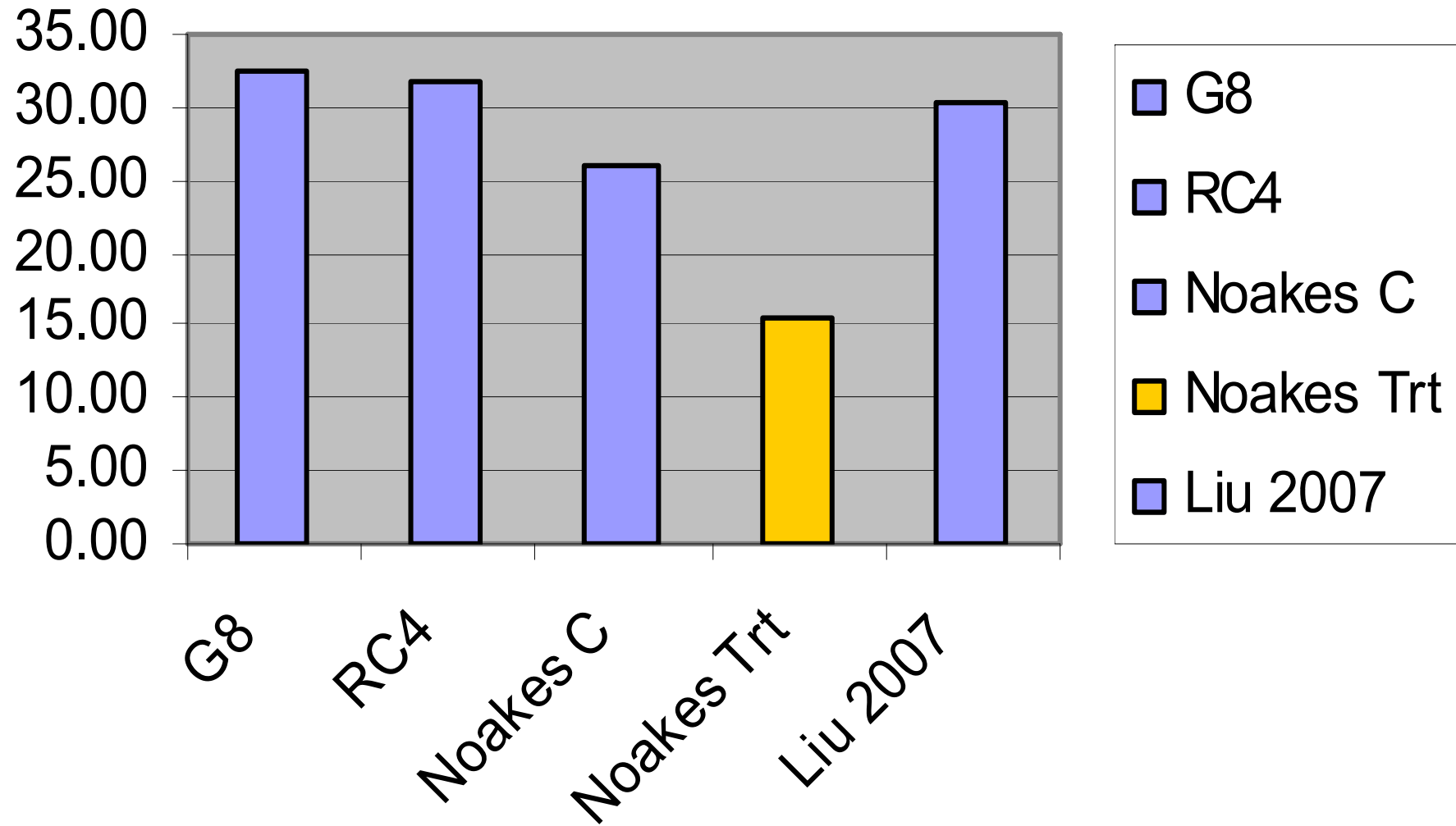
4.25 mmol/L

Noakes et al. 1996

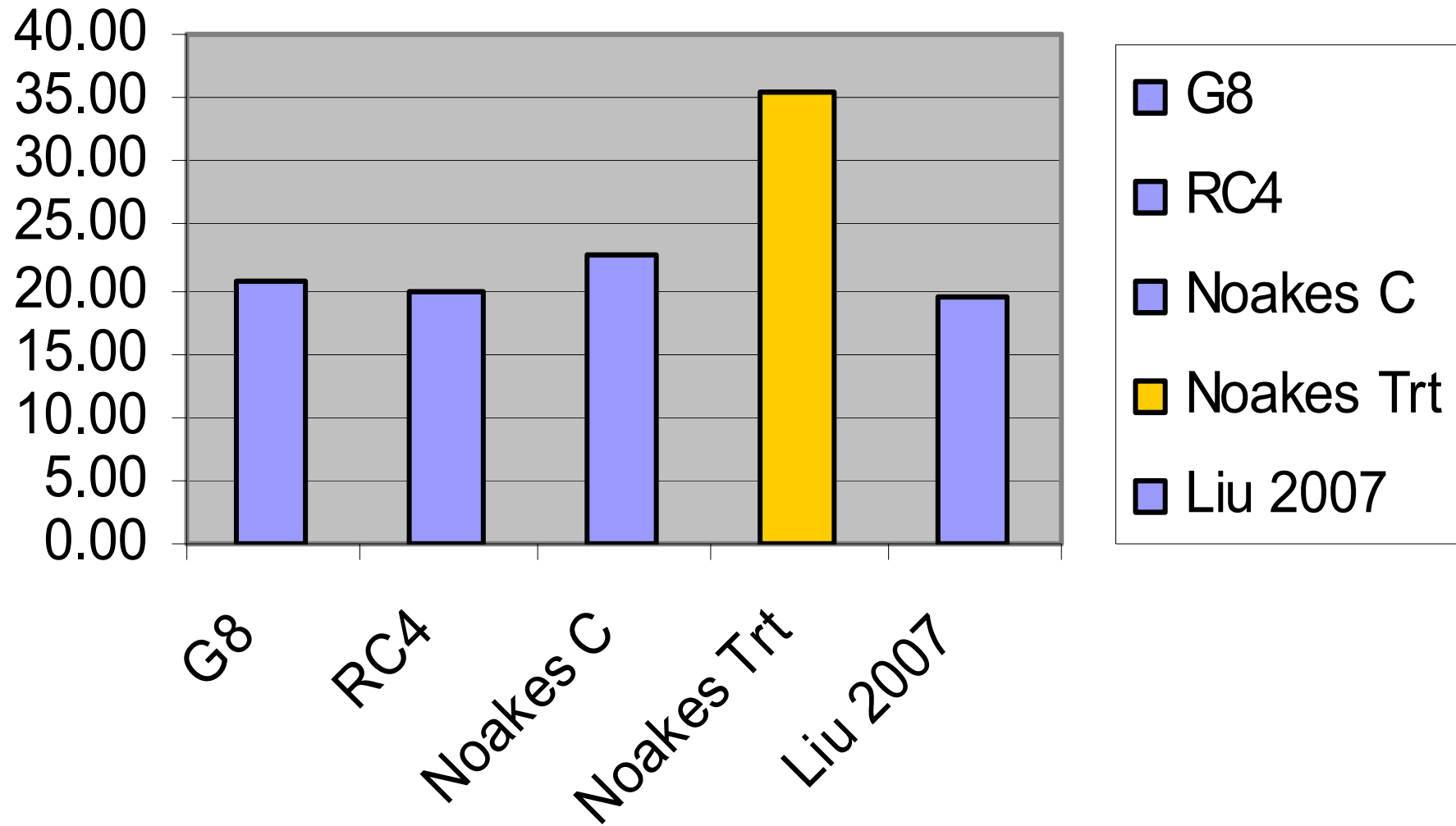
C14:0 (g/100g FA)



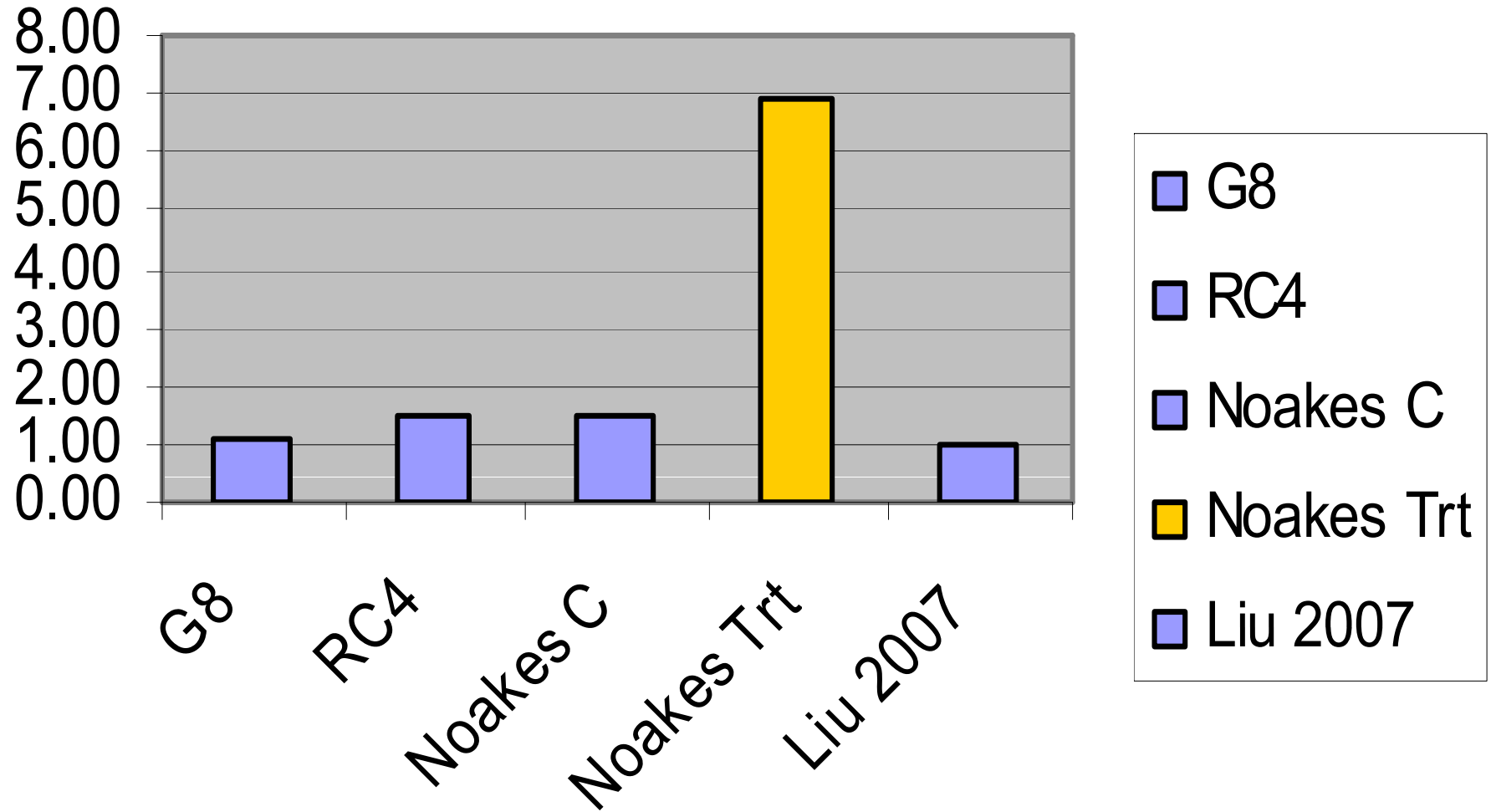
C16:0 (g/100g FA)



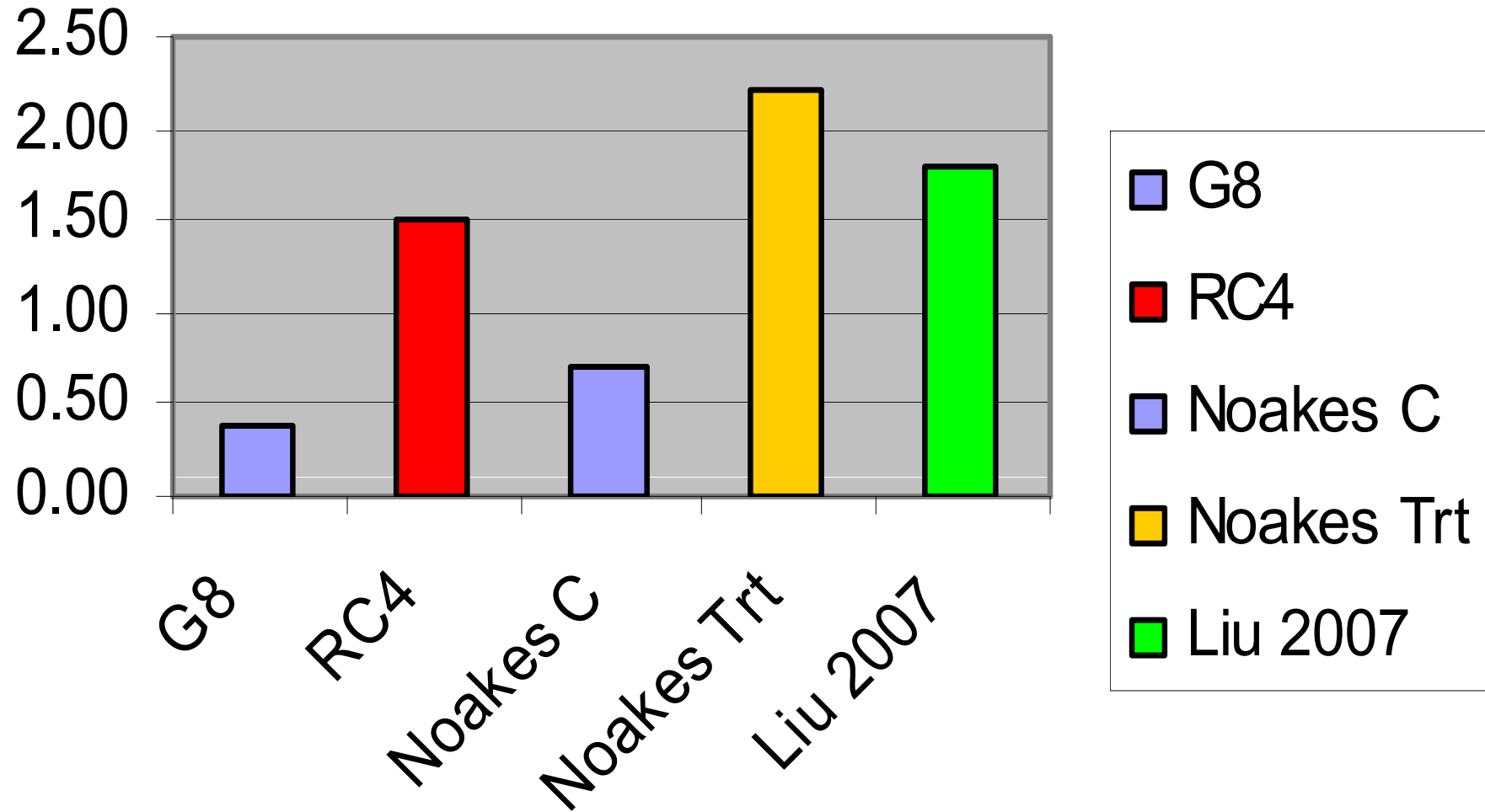
C18:1 (g/100g FA)



C18:2 (g/100g FA)



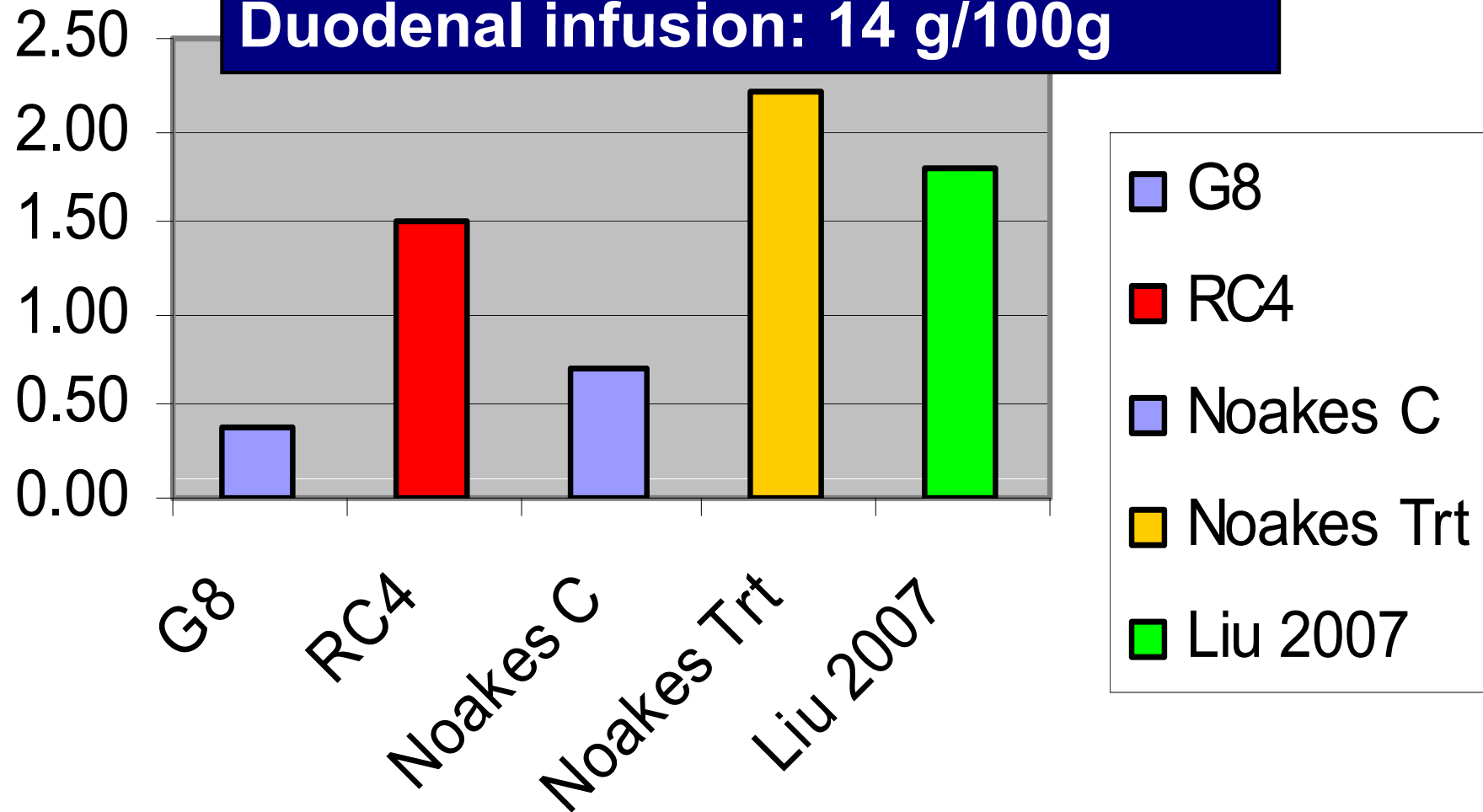
C18:3 (g/100g FA)



C18:3 (g/100g FA)

CSIRO product: 20 g/100g

Duodenal infusion: 14 g/100g



Summary: herbage fatty acids

- Around two-thirds of fatty acids in grass and clover are α -linolenic acid
- Major effects of season and management
- Modest loss of fatty acids during wilting
- Only small effects of ensiling and silage additives

Summary: milk fatty acids

- Leafy herbage increases CLA and α -linolenic acid in milk
- Red clover silage increases α -linolenic acid in milk
- Herbage effects are much smaller than can be achieved with fat supplements
- Altering milk fatty acids affects animal functions, as well as healthiness and other quality attributes of milk/products