Manipulating fat digestion & absorption to improve efficiency

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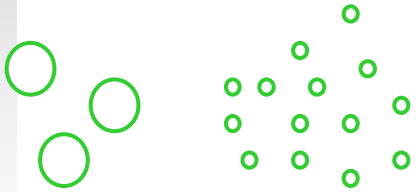
Kemin Industries (NZ) Ltd., Auckland, N.Z.

Introduction

- fats/oils are an important energy source, ie.
  - 24-35MJ ME/kg (10.5-14.5MJ ME/kg from cereals)
- fats/oils can supply essential fatty acids – linoleic acid
- added to mash feed via the mixer and/or sprayed on to pellets
- fat/oil types used largely determined by availability, quality considerations, cost & storage options at mills
- main fatty acids from the most commonly used fats/oils -
  - palmitic (C16:0) & stearic (C18:0)
  - oleic (C18:1) & linoleic (C18:2)

Digestion of Fats

Emulsification of fat globules into smaller particles

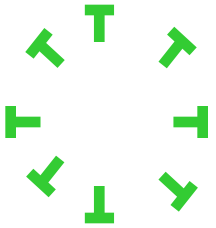


Enzymatic breakdown by lipase



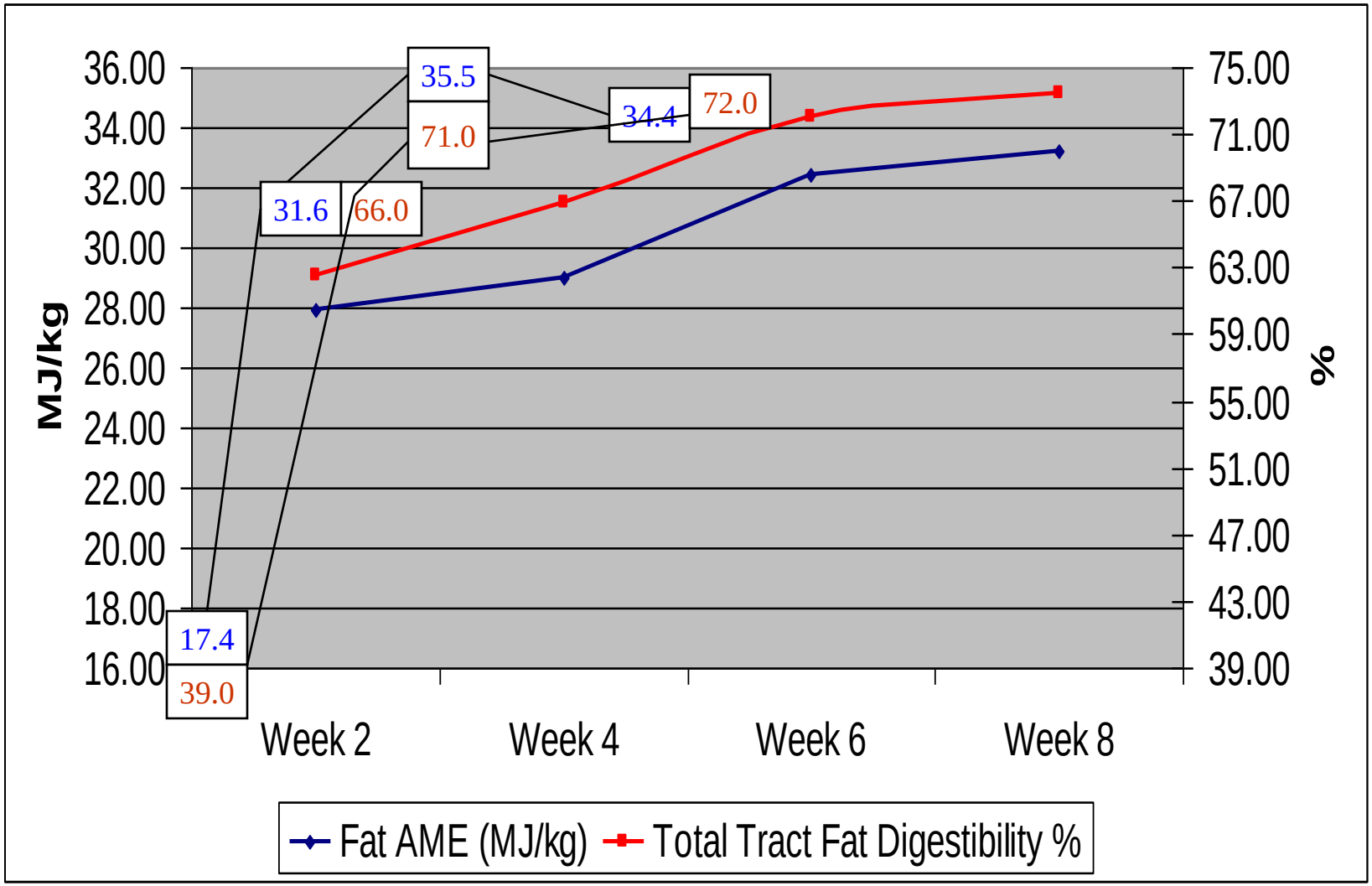
Tri- Di- Mono-glyceride

Micelle formation of fatty acids



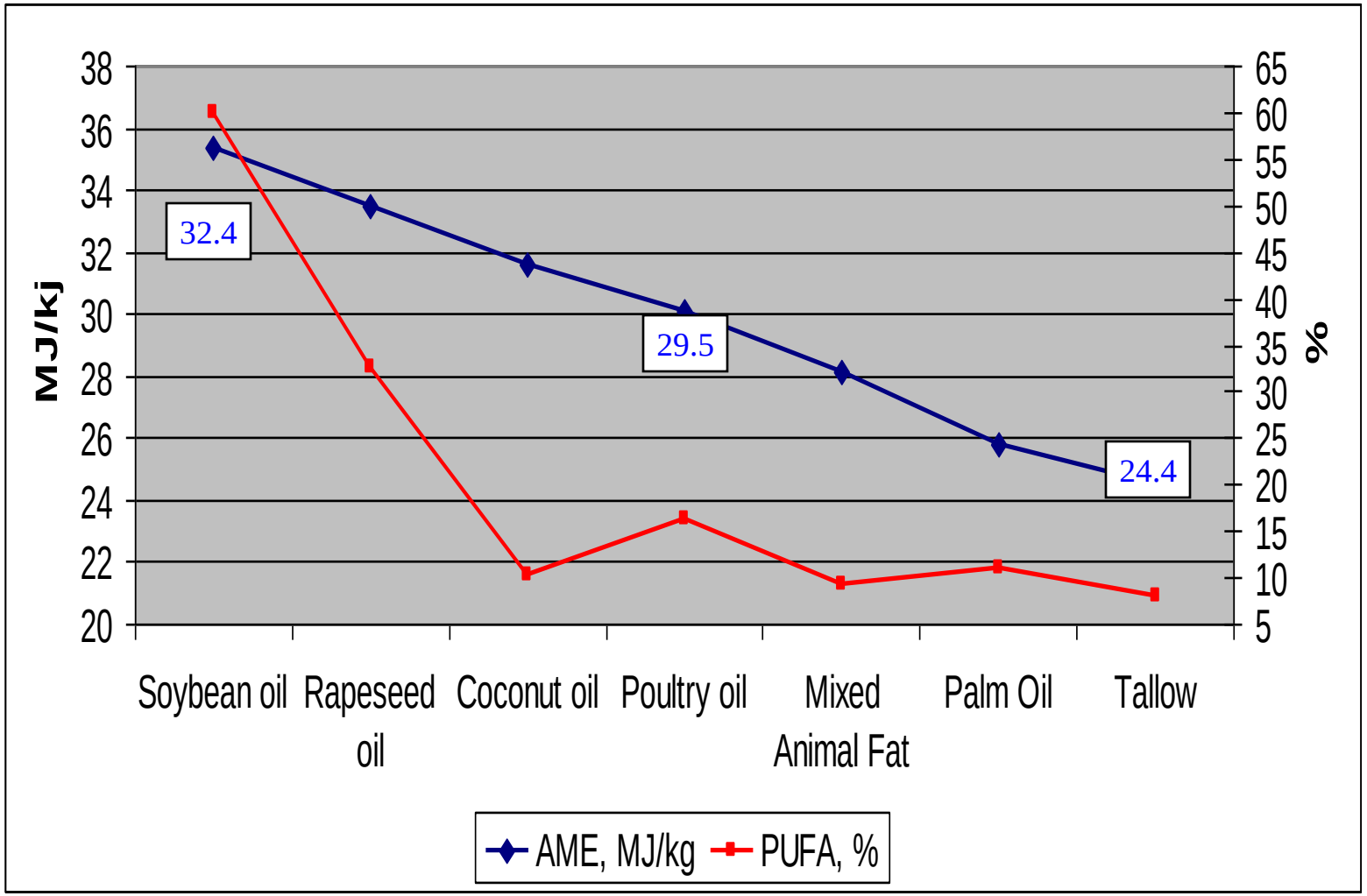
Diet fat digestibility and fat AME vs broiler age

('animal fat', Scheele et al, 1997; 5 fats,Tancharoenrat et al, 2010)



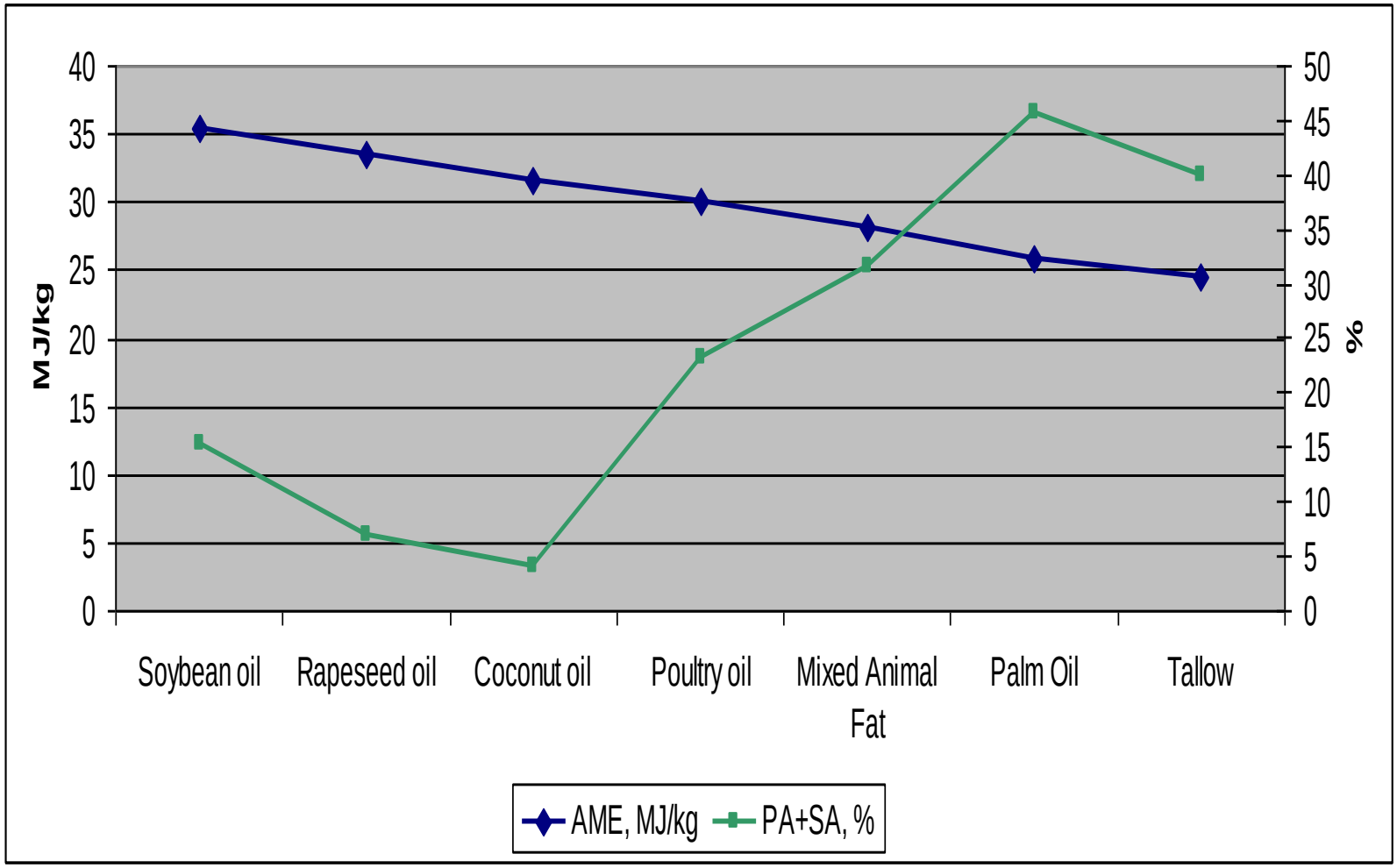
AME values in 4 week old broilers vs PUFA%

(Scheele et al, 1997; Tancharoenrat et al, 2010)



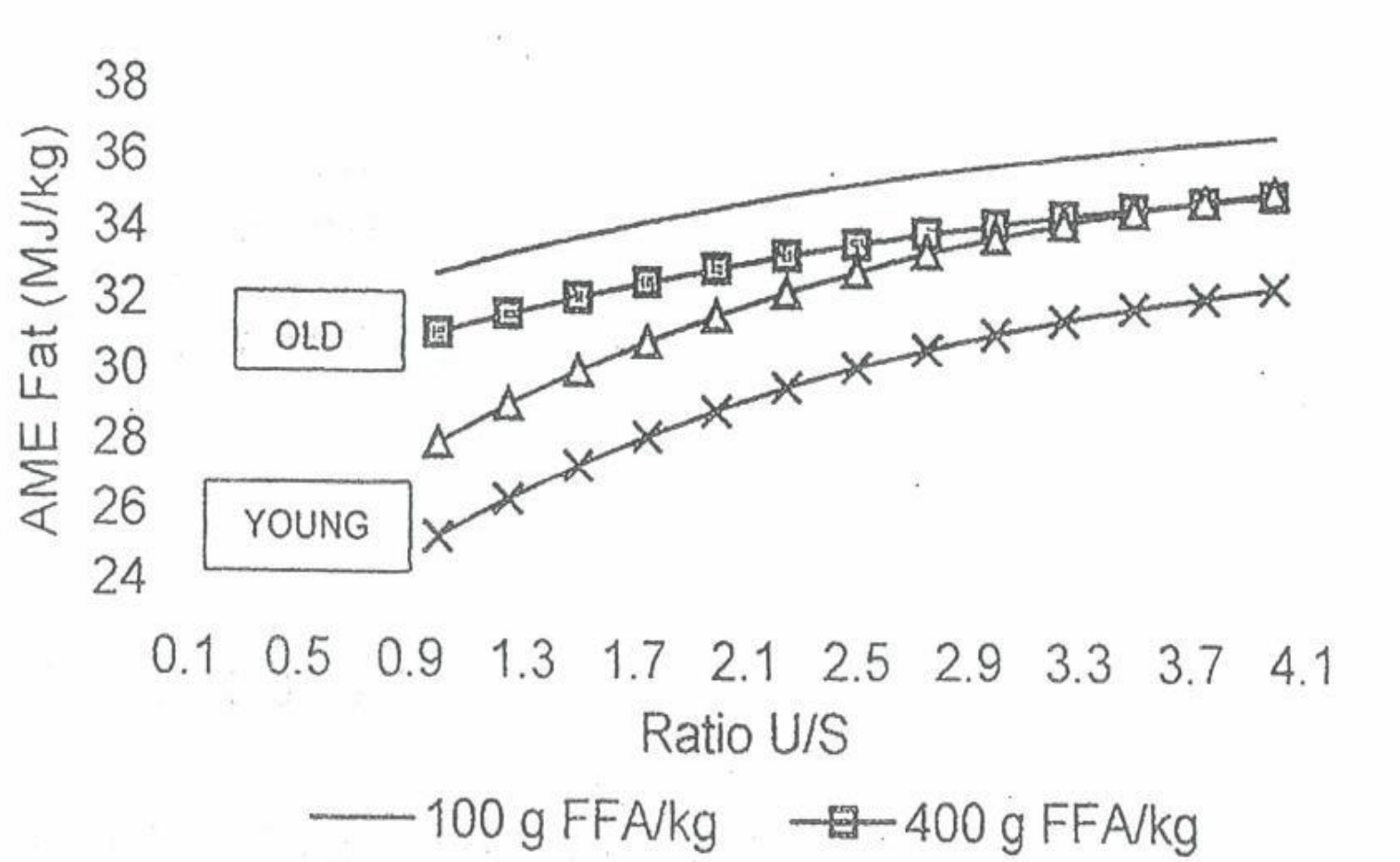
AME values in 4 week old broilers vs palmitic (C16:0) + stearic acids (C18:0)

(Scheele et al, 1997)



Influence of degree of saturation (U/S) & FFA % on AME of fats for 2 & 6 week old broilers

(Wiseman, 1999)



Broiler AME responses to oxidation of lipid sources

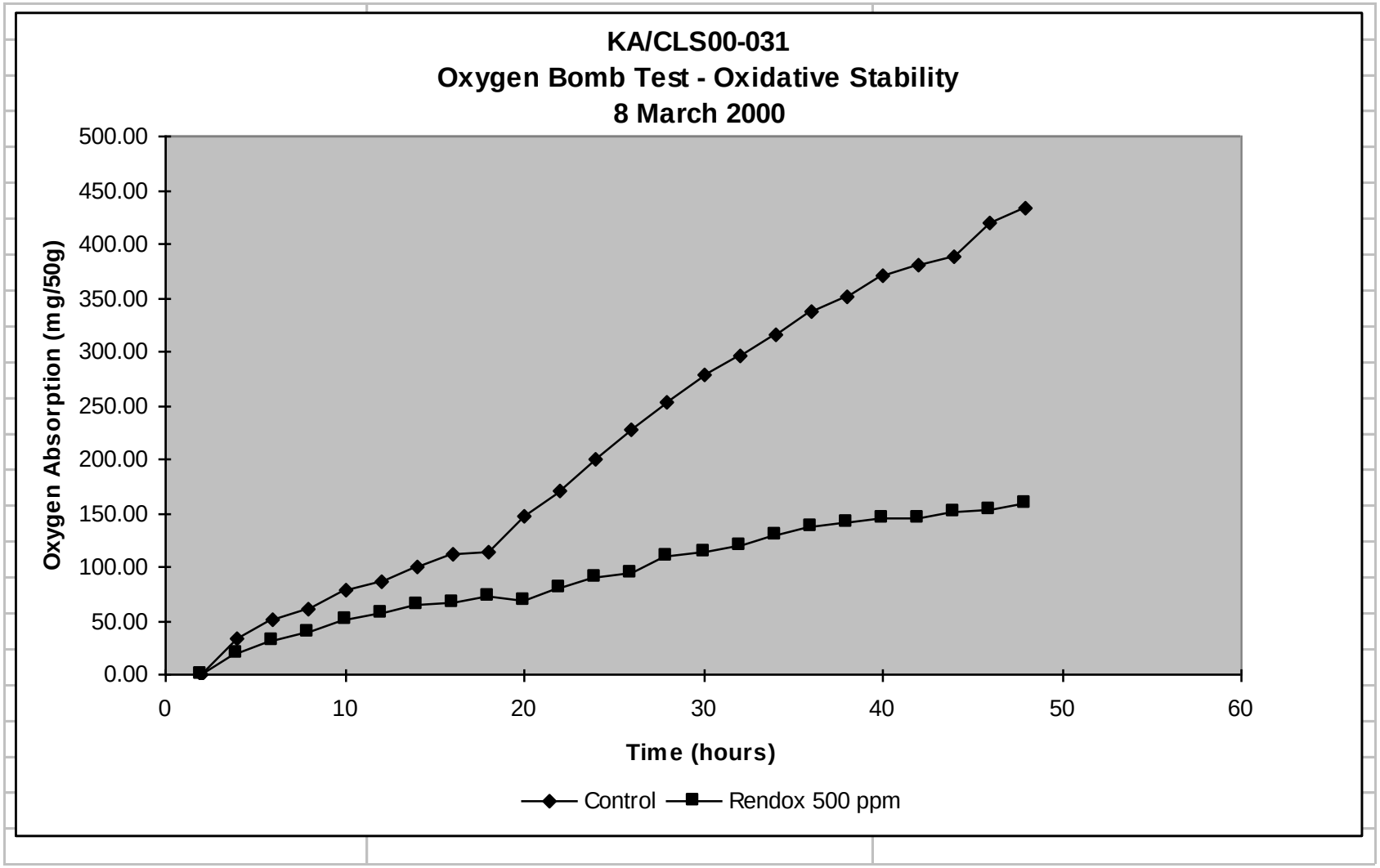
Reference	Lipid	'Fresh'	'Oxidised'	Change MJ/kg	Change %
Racanicci et al., 2003 (AME @ day 31-34)	Poultry fat	PV=0.78 38.7MJ/kg	PV=4.17 32.5MJ/kg	-6.2MJ/kg	-16.0%

-Fat AME responses in broiler chickens to oxidation (Pesti et al, 2002)

AOM stability at 20h: r = 0.92 (P=0.001)

Iodine value: r = 0.92 (P=0.001)

Controlling oxidation of fats/oils: tallow



Dietary fat digestibility & diet AME response to enzyme addition in diets for laying hens (Spain, 2005) & broiler chickens (N.Z., 2003)

Bird type	Treatment	Fat digestibility, %	AME, MJ/kg
Laying hens @ 35 weeks	Control + enzyme	75.5[a] 79.1[b]	10.78[a] 11.04[b]
Broiler chickens @ 4 weeks	Control + enzyme	- -	13.49[a] 14.14[b]

- Maisonnier et al, 2003 -
  - guar gum addition to broiler diets increased intestinal viscosity & decreased dietary fat digestibility;
  - this –ve effect on fat digestibility was reversed with sodium taurocholate (a bile salt)

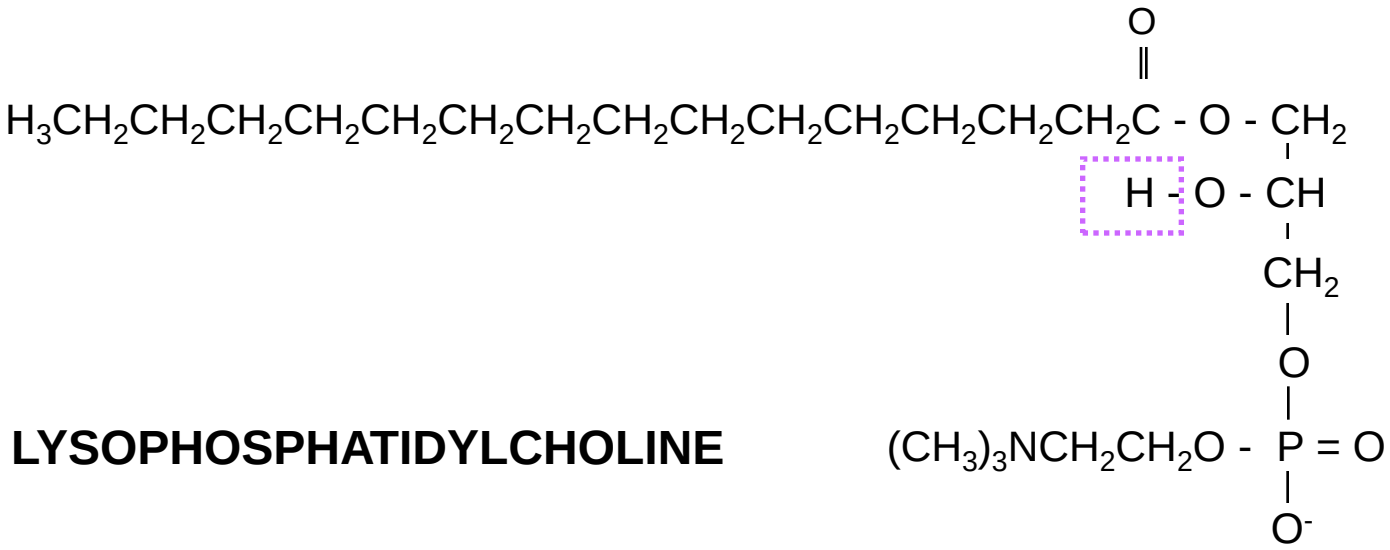
Critical Micellar Concentrations (mM)

(from 'Biochemistry', 1984. Ed. G.Zubay. Pub. Addison-Wesley)

Emulsifier	Critical Micellar Concentration
Sodium dodecyl laurel sulphate	8
Deoxycholate (bile salt)	4
Lysophospholipids	0.02 – 0.2



PHOSPHATIDYLCHOLINE



LYSOPHOSPHATIDYLCHOLINE

Broiler chicken response to gut emulsifier

(sorghum/wheat, MBM, SBM, tallow diets, 12.6 & 13.0 MJ AME/kg); Qld DPI Poultry Research Centre, Australia 2005)

Measure	0-21 days		0-42 days	
	Control	Emulsifier	Control	Emulsifier
Weight gain, g	862	860	2836	2863
FCR	1.296[a]	1.266[b] (-3)	1.656[a]	1.618[b] (-4)
Excreta fat (g/kg DM)				
-males	66.4	45.7	66.1	56.9
-females	79.9	41.7	53.6	55.5

Ileal digestibility effects of emulsifier

(40-45kg pigs, van Barneveld et al, 2003)

Diet: barley, peas, MBM, fish meal, blood meal, full fat soy, beef tallow, 13.8MJ DE & 0.7g.avail.lys./MJ DE;

Digestibility of all amino acids except for threonine & glycine were significantly increased.

Nutrient	Control	Emulsifier
Protein	70%a	80%b (P<0.05)
Lysine	75%a	83%b (P<0.05)
Energy	65%a	73%b (P<0.10)
DE to end of ileum	11.75MJa	13.49b (P<0.10)

Effect of emulsifier on broiler performance from soy oil and tallow diets: 0-21 days

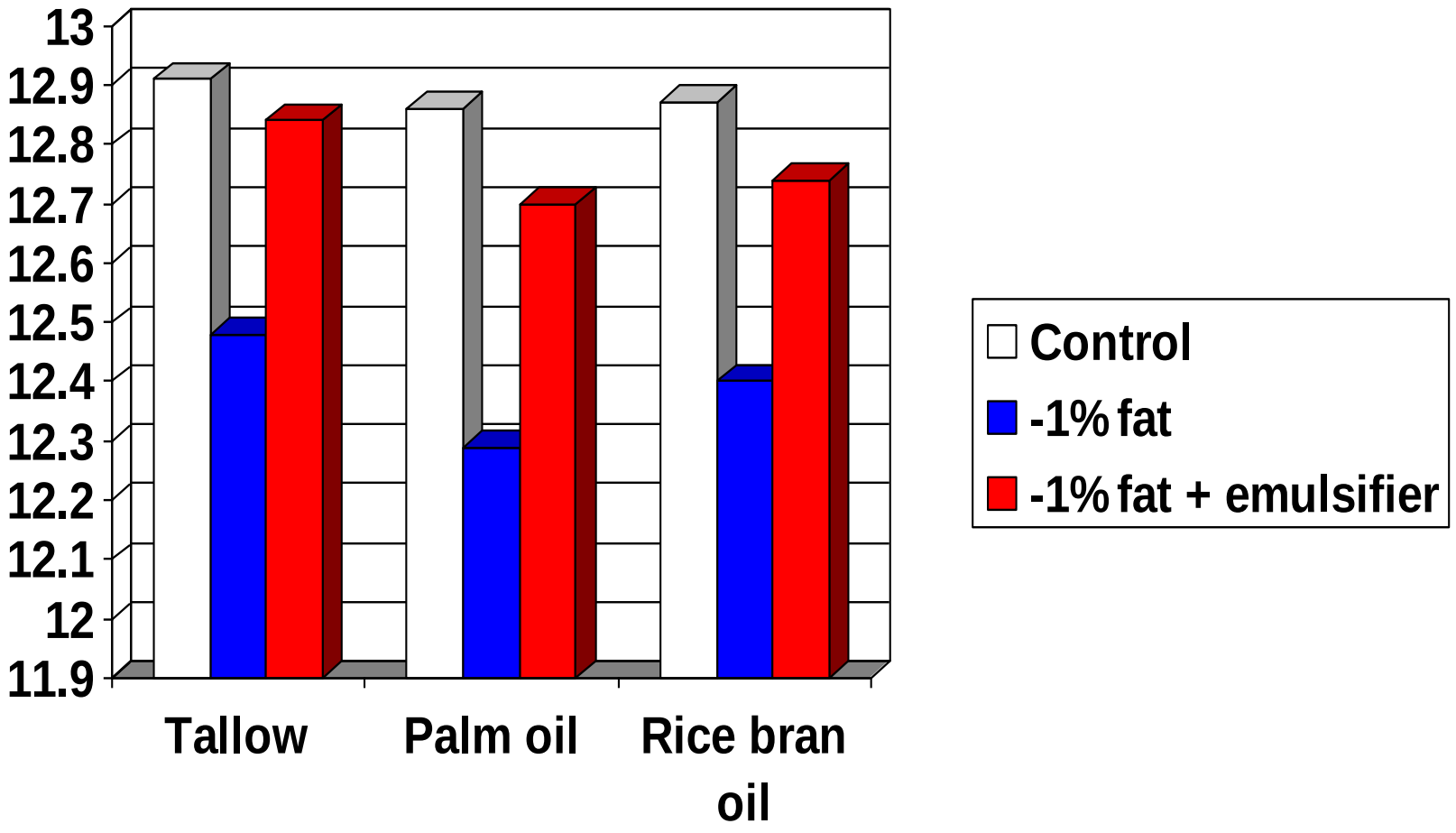
(Othman et al, 2008; Massey Univ., NZ)

	0-21 days		0-35 days	
	Weight gain (g/bird)	FCR	Weight gain (g/bird)	FCR
Tallow	966	1.49	2396	1.61
Tallow + emulsifier	963	1.42 (-7)	2434	1.53 (-8)
Soy oil	1012	1.38	2448	1.53
Soy oil + emulsifier	1031	1.36 (-2)	2432	1.49 (-4)
Tallow	965[a]	1.46[a]	2415[a]	1.57
Soy oil	1022[b]	1.37[b] (-9)	2440[b]	1.51 (-6)
- emulsifier	989	1.44[a]	2433	1.51[a]
+ emulsifier	997	1.39[b] (-5)	2422	1.57[b] (-6)

Effect of emulsifier on AME in broiler chickens fed 3 different fat sources (Massey Univ., 2008)

Measure	AME (MJ/kg)		
	Tallow (3.8%)	Palm oil (3.2%)	Rice bran oil (3.5%)
Normal AME	12.91[a]	12.86[a]	12.87[a]
Reduced AME (-1% fat)	12.48[b]	12.29[b]	12.40[b]
Reduced AME + emulsifier	12.84[a](+0.36)	12.70[a](+0.41)	12.74[a](+0.34)

Effect of emulsifier on AME in broiler chickens fed 3 different fat sources



Malaysia: broiler integrator (2008)

Ross 308; 4 x 21,000 bird sheds per treatment; 39 days

Treatment	Mortality, %	Liveweight, kg	FCR
Control – diets with 2.0 - 2.5% palm oil	3.77	1.76	1.77
	3.09	1.73	1.74
	4.18	1.91	1.65
	2.70	1.79	1.94
	Ave. 3.44	Ave. 1.80	Ave. 1.77
Treatment – diets with 0.8% palm oil removed + emulsifier	2.98	1.84	1.52
	2.13	1.83	1.72
	3.71	1.79	1.63
	2.40	1.79	1.77
	Ave. 2.81	Ave. 1.81	Ave. 1.66

UK: Broiler integrator (2008)

- Ross 308
- 3 x 30,000 bird sheds per treatment
- wheat based diets with 1.8%, 2.0%, 2.75% & 4.8% soy oil
- emulsifier ascribed 0.25MJ/kg diet & amino digestible acid values
- both diets formulated to the same specifications

Measure	Standard diet	Emulsifier diet
Weight at 36 days, kg	2.01	1.98
FCR	1.72	1.69
Mortality, %	2.6	2.2

Emulsifier in laying hen diets: FCR & egg size

- Univ. of Glasgow & Roche study (Bain, Wakeman & Solomon, Montreal WPSA meeting)
  - 16 week study (20-36 weeks)
  - wheat-barley based diets
  - 4% soy oil w/wo emulsifier
  - 4% fat blend w/wo emulsifier
  - no emulsifier effect on egg size in soy oil diet, but
  - significant increase (P=0.038) in egg size with emulsifier in fat blend diet

Summary

- fat/oil AME affected by:
  - bird age → different AME values
  - U:S fatty acid ratio → fat type/description
  - Free Fatty Acid level → fat type/description
  - microbial deconjugation of bile salts → antibiotics
  - Peroxide Value → antioxidants
  - ileal viscosity → enzymes
  - intestinal emulsification → emulsifiers