Long-chain PUFA from animals: do they have a role in human nutrition?

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Omega-3 fatty acids: functionality in food?

Ice cream made with long-chain PUFA from fish oil

The first reduced-fat i[redacted] has been created, claims US company Arthur D. Little Inc. The fish flavour of the refined fish oil added to the ice cream formulation is minimized by using both [redacted] and modifications to manufacturing technology.

EJLST (11) 103; 2001

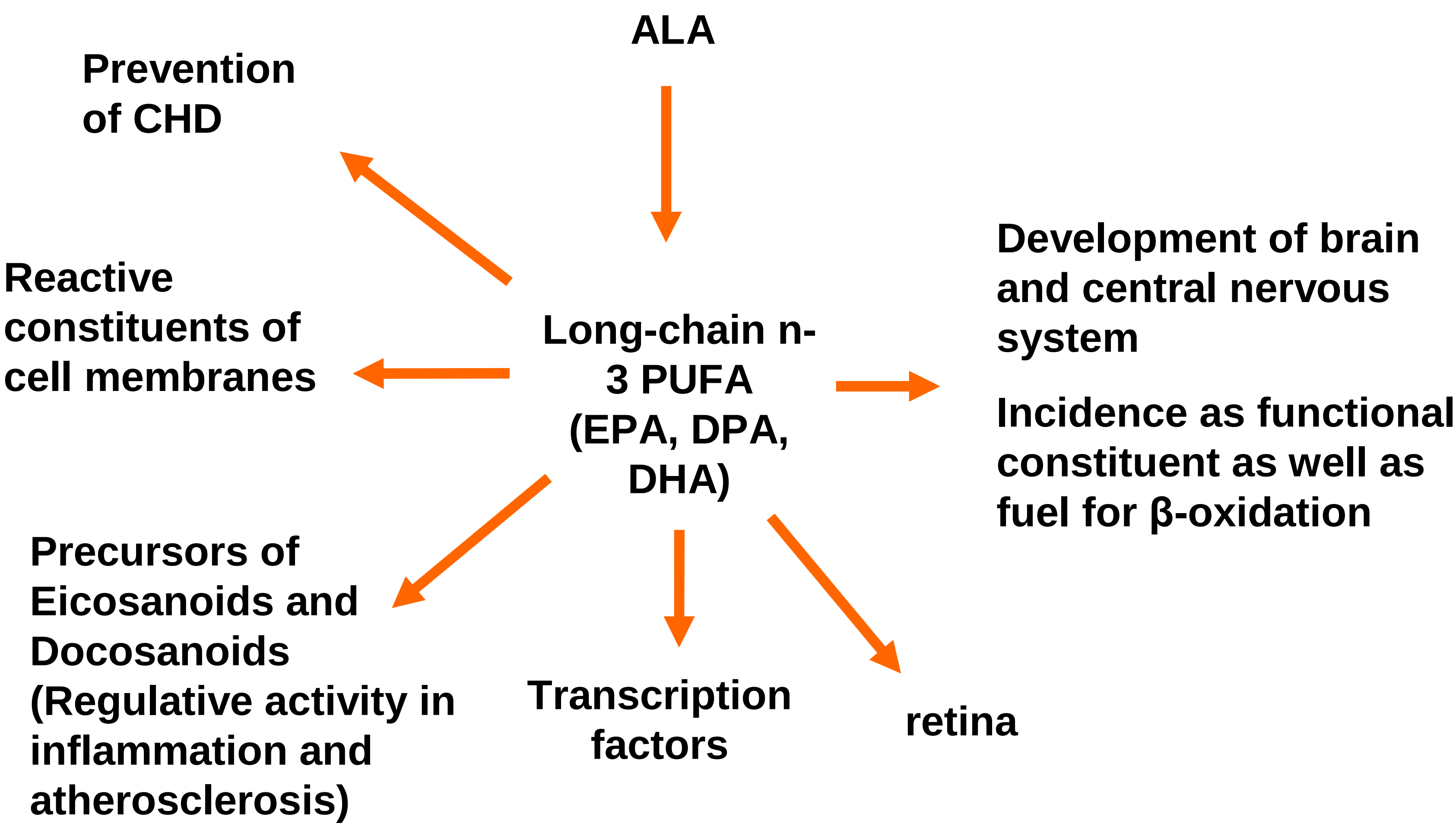
Omega-3 fatty acids: functionality in food?

Hauswirth, C.B et al. (2004)
High Omega-3 Fatty Acid Content in Alpine Cheese—
The Basis for an Alpine Paradox?
Circulation 109, 103–107.

Omega-3 fatty acids: functionality in food?

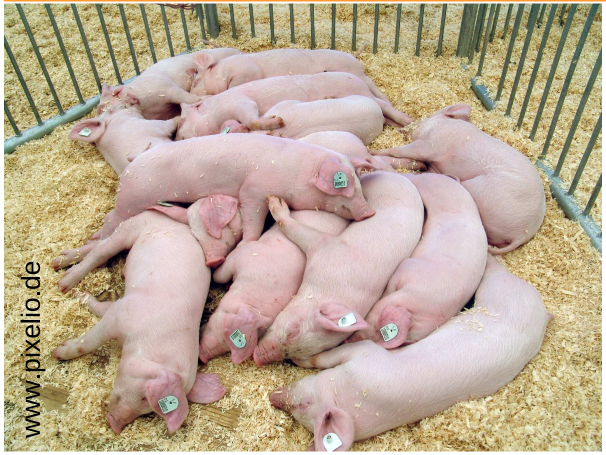
- α-linolenic acid (ALA): C18:3n-3 - a typical terrestric plant fatty acid
- Eicosapentaenoic acid (EPA): C20:5n-3 – derived from ALA in mammals / part of marine fats
- Docosapentaenoic acid (DPA): C22:5n-3 – derived from EPA in mammals / part of marine fats
- Docosahexaenoic acid (DHA): C22:6n-3 – derived from DPA in mammals / large part of marine fats

Omega-3 fatty acids: functionality in food?



Reviewed in: Simopulos, 2000; Sinclair et al., 2002

Omega-3 fatty acids in animal products: what do we have to offer?



Effect of feeding a 25g/kg-linseed-diet to growing pigs

%	Muscle			
	Neutral lipids		Phospholipids	
Diet	control	linseed	control	linseed
ALA	0.26	1.05	0.8	3.0
EPA	0.03	0.04	1.1	3.1
DPA	0.06	0.12	1.8	3.0
DHA	0.05	0.05	1.5	1.3

Sottnikova, 2008

Omega-3 fatty acids in animal products: what do we have to offer?

Porcine meat and fat:

Balancing firmness and stability vs. „healthy fatty acid“ contents

	Control	porcine lard	Olive-oil	soybean-oil
PUFA (%)	14.7	15.0	14.0	25.4
C18:3n3 (ALA) (%)	0.93	0.94	0.92	2.0
C18:2n6 (%)	12.1	12.0	11.8	21.1
Oxidative stability (h)	4.33	4.10	4.59	2.36
firmness (g)	151	114	56	53

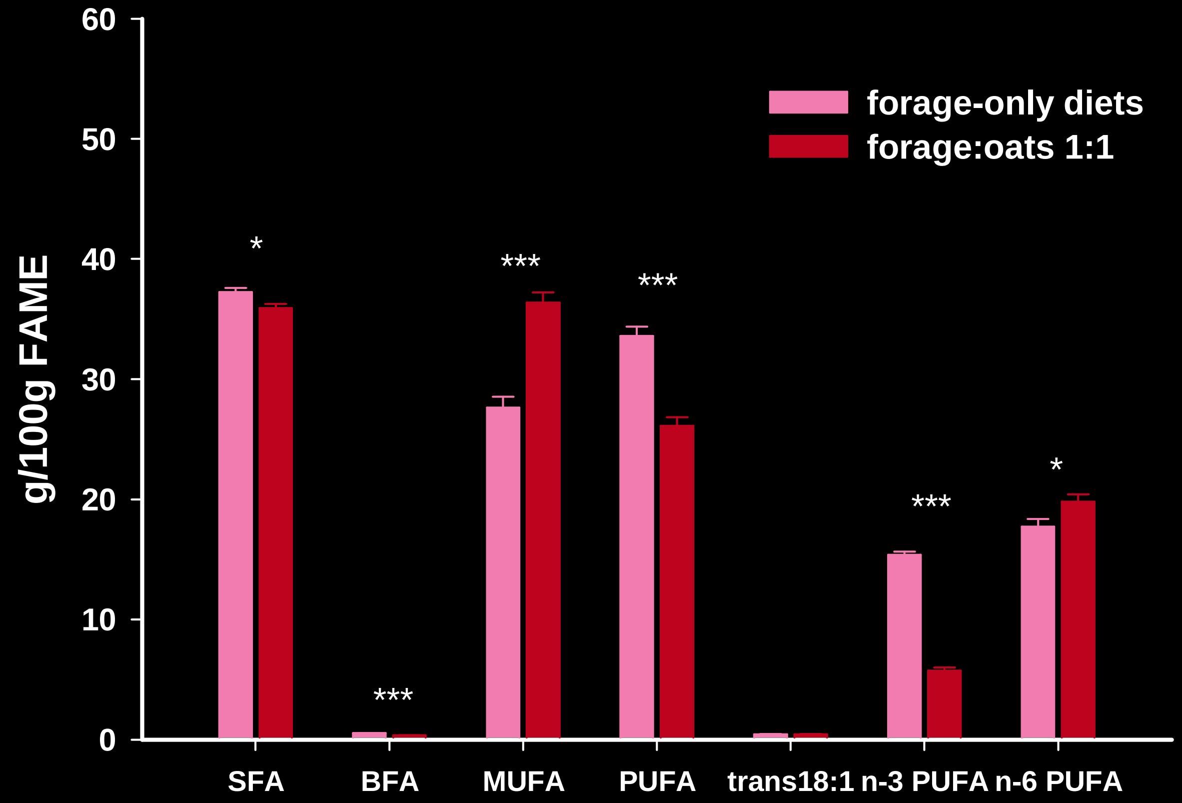
Gläser et al., 2002

Concentrations of n-3 FA in eggs (mg / g yolk)

	ALA	DHA	n6/n3
Free-ranging	6.9	6.6	1.3
Supermarket-Egg	0.5	1.1	19.9
Flax-Egg	21.3	5.1	1.6
Fishmeal-Egg	4.1	6.5	6.6

adapted from Simopoulos, 2000

Omega-3 fatty acids in animal products: what do we have to offer?



Fatty acid patterns in meat of rabbits fed different diets

N-3 fatty acids in rabbit meat **Leiber et al., 2008**

Omega-3 fatty acids in animal products: what do we have to offer?

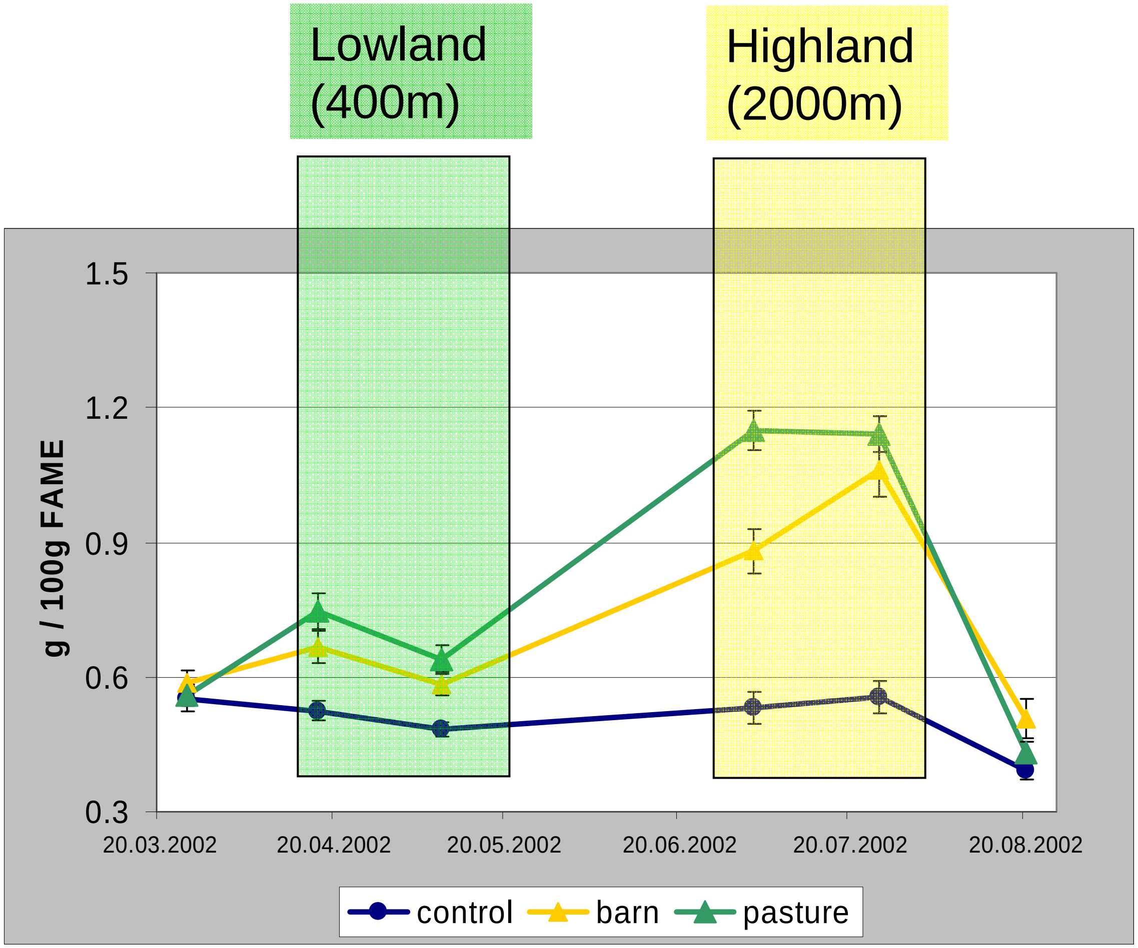
N-3 Fatty Acids in beef (mg/100g *musculus l.d.*)

	Pasture beef	Conven-tional beef	Grass only	Grass + conven-tional conc.	Grass + linseed conc.
C18:3n-3 (ALA)	22.9[a]	12.2[b]	33.3	27.8	31.2
C22:5n-3 (DPA)	14.3[a]	8.8[b]	20.8	19.9	19.9
C22:6n-3 (DHA)	1.7	1.1	2.55	2.50	2.42
Total n-3	49[a]	27[b]	75	66	71
n-6/n-3	1.7[b]	5.0[a]	1.25[b]	1.45[a]	1.33[b]

Razminowicz et al., 2006

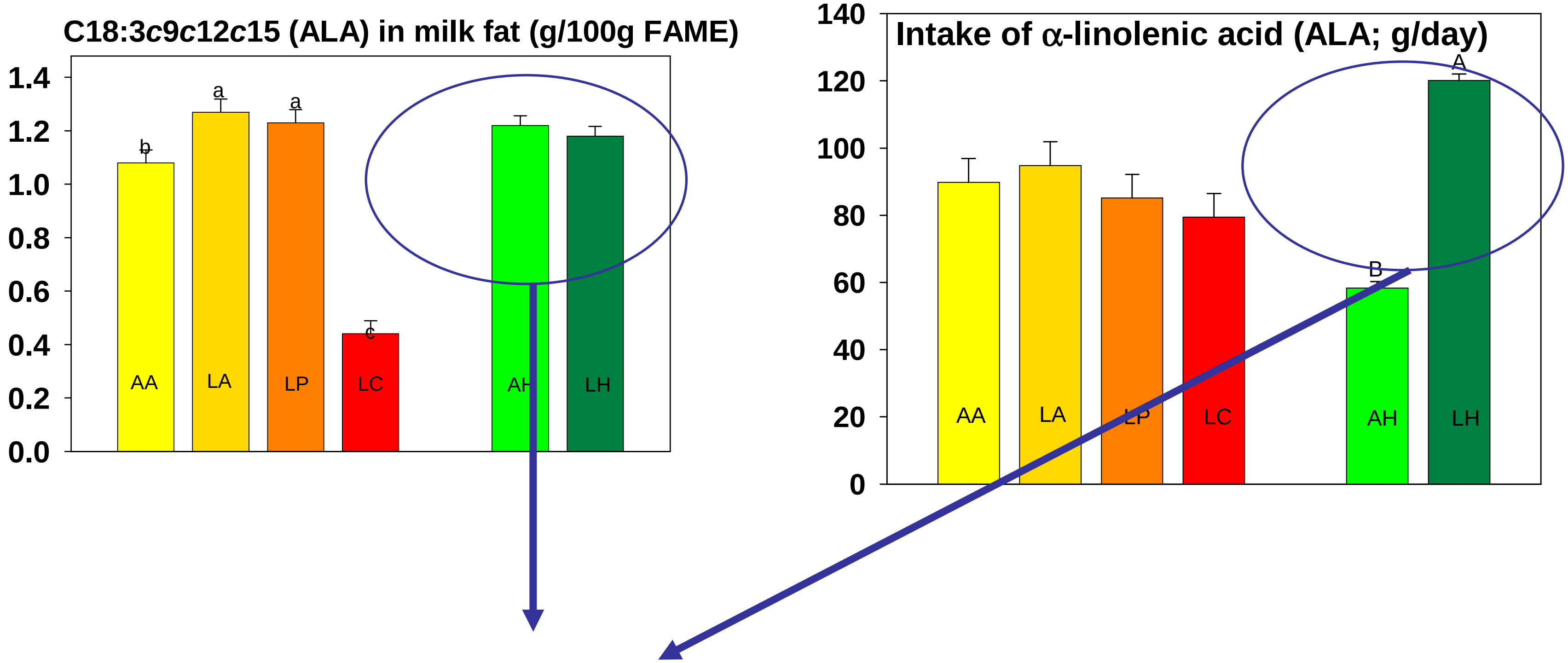
Razminowicz et al., 2008

Omega-3 fatty acids in animal products: what do we have to offer?



Concentrations of ALA in milk (g / 100g FAME)

Omega-3 fatty acids in ruminants

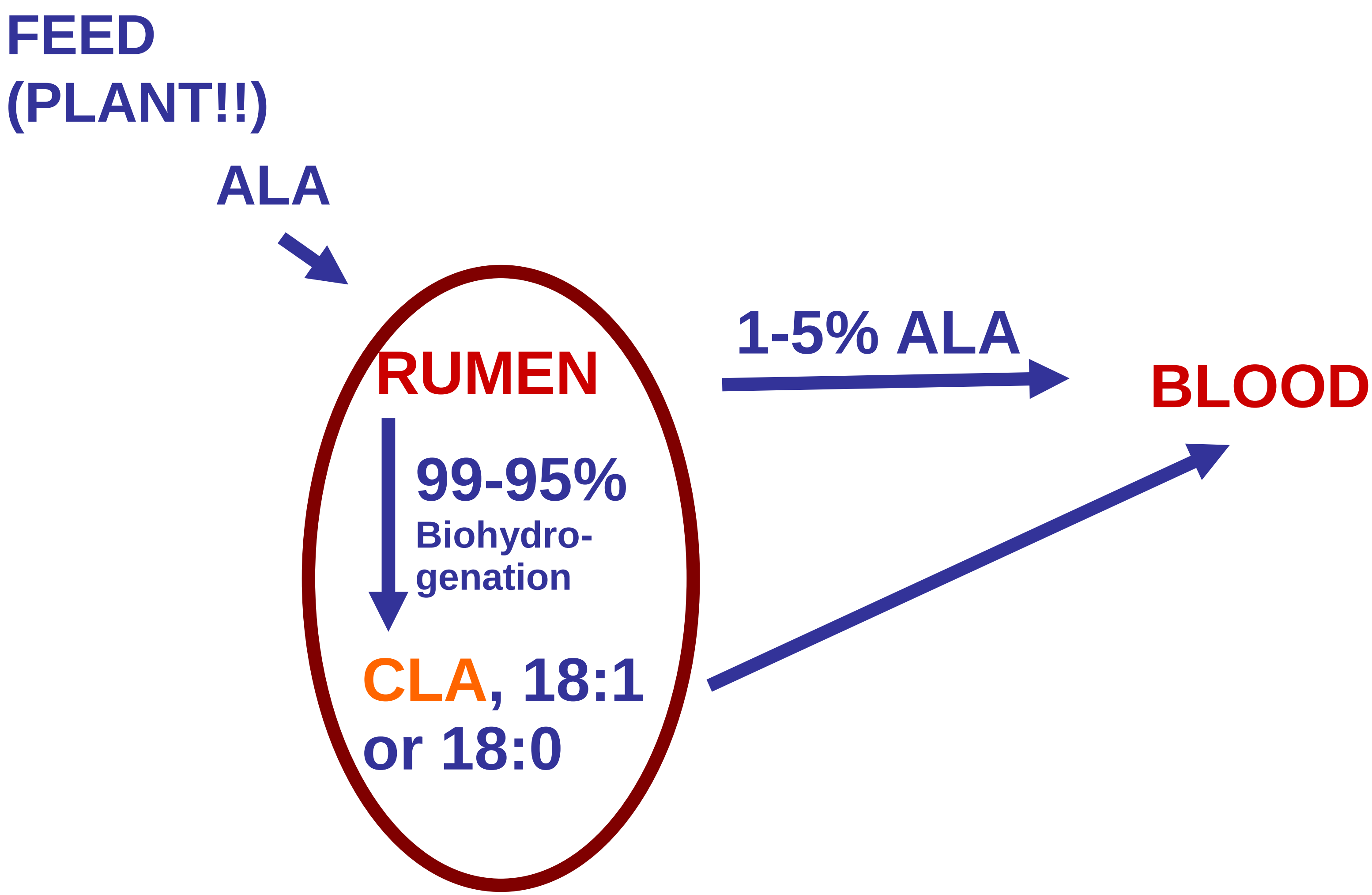


Conclusion: despite different ALA-intakes: no difference in output with the different forages(*in this experiment*)!

Where has it gone to??

Leiber et al., 2004

ALA in milk or beef is a „survivor“ of the ruminal fermentation



Omega-3 fatty acids in animal products: …..

N-3 contents in different animal products (mg/100g raw product)

	Wild salmon	Grass beef	Beef Sirloin conv.	Beef sirloin U.S.	Pork chop	Rabbit fed forage	Cheese convent	Cheese alpine
ALA	**50**	**33.3**	**39**	**16**	**57**	**246**	**241**	**516**
DPA	**120**	**20.8**	**23**	**14**	**14**	**45**	**38**	**54**
DHA	**629**	**2.6**	**2**	**nd**	**2**	**15**	**nd**	**4**

Hamilton et al., 2005 **Gerber, 2008** **Leiber et al., 2005**

Razminowicz et al., 2008 **Leiber et al., 2008**

Omega-3 fatty acids in animal products: …..

Hypothetic daily intakes of n-3 FA with milk products of different origin

mg/day	Milk prod. conv	Milk prod. alpine	Difference
ALA	**350**	**612**	**398**
EPA	**42**	**54**	**12**
DPA	**55**	**78**	**23**
DHA	**-**	**6**	**6**

How much salmon? (g/day)
796
3
19
1

Calculated from Leiber et al., 2005; ZMP, 2007 [France]; Hamilton et al., 2005

Omega-3 fatty acids in animal products: …..

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Relation of the difference to daily intake of french men (median) (%)
43
10
34
3

Calculated from Leiber et al., 2005; ZMP, 2007 [France]; Astorg et al., 2004

Omega-3 fatty acids in animal products: …..

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EPA	**42**	**54**	**12**
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Relation of the difference to daily intake of french men (lower 5th percentile) (%)
67
44
69
9

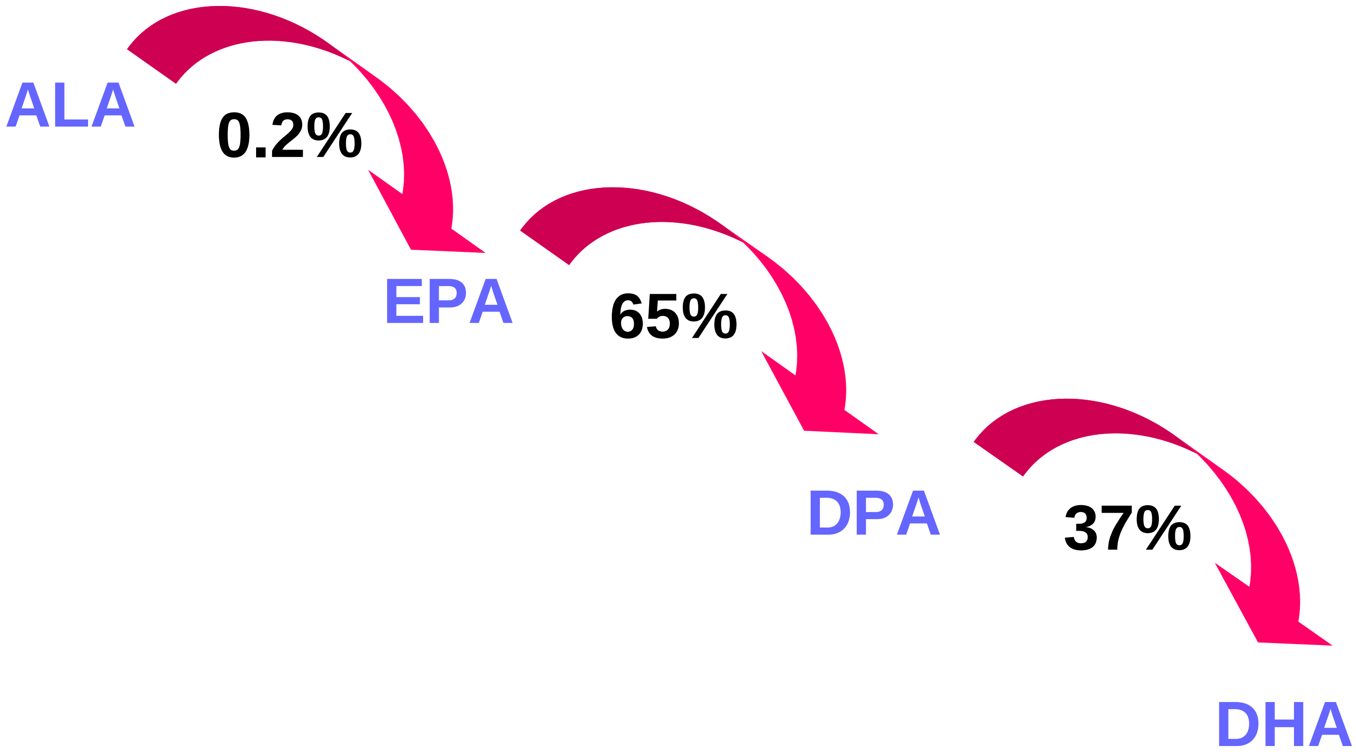
Calculated from Leiber et al., 2005; ZMP, 2007 [France]; Astorg et al., 2004

Omega-3 fatty acids in animal products: …..

…. does α-linolenic acid help?

To what extent ALA is converted to long-chain n-3 PUFA?

Effects of dietary α-linolenic acid (ALA)



(estimated from plasma concentrations)

Estimated efficiency of conversion of n-3 FA (Pawlosky et al., 2001)

Effects of dietary α-linolenic acid (ALA)

Differential distribution of n-3 FA in rabbits‘ tissues

Tissue	Perirenal adipose tissue		Muscle tissue	
Diet	grass	grass+oats 1:1	grass	grass+oats 1:1
Total n-3 (%)	22.13	7.19	15.11	6.07
Long-chain n-3 in total n-3 (%)	2.8	3.5	24	27

(calculated from Leiber et al., 2008)

Effects of dietary α-linolenic acid (ALA)

Effect of feeding a 25g/kg-linseed-diet to growing pigs

%	Muscle				Brain	
	Neutral lipids		Phospholipids			
Diet	control	linseed	control	linseed	control	linseed
ALA	0.26	1.05	0.8	3.0	nd	nd
EPA	0.03	0.04	1.1	3.1	0.05	0.11
DPA	0.06	0.12	1.8	3.0	0.28	0.56
DHA	0.05	0.05	1.5	1.3	9.66	9.81

Sottnikova, 2008

Effects of dietary ALA and DHA

	Control diet	High ALA	High DHA	Very high DHA
Retinal phospholipids	8.7[c]	16.4[b]	17.6[b]	25.5[a]
Brain phospholipids	8.6[c]	11.5[b]	11.5[b]	15.0[a]
Heart phospholipids	0.30[c]	0.75[b]	5.67[a]	5.60[a]

DHA concentrations in phospholipids (% of total phospholipid fatty acids)

Conclusion on the effects of animal source n-3 fatty acids

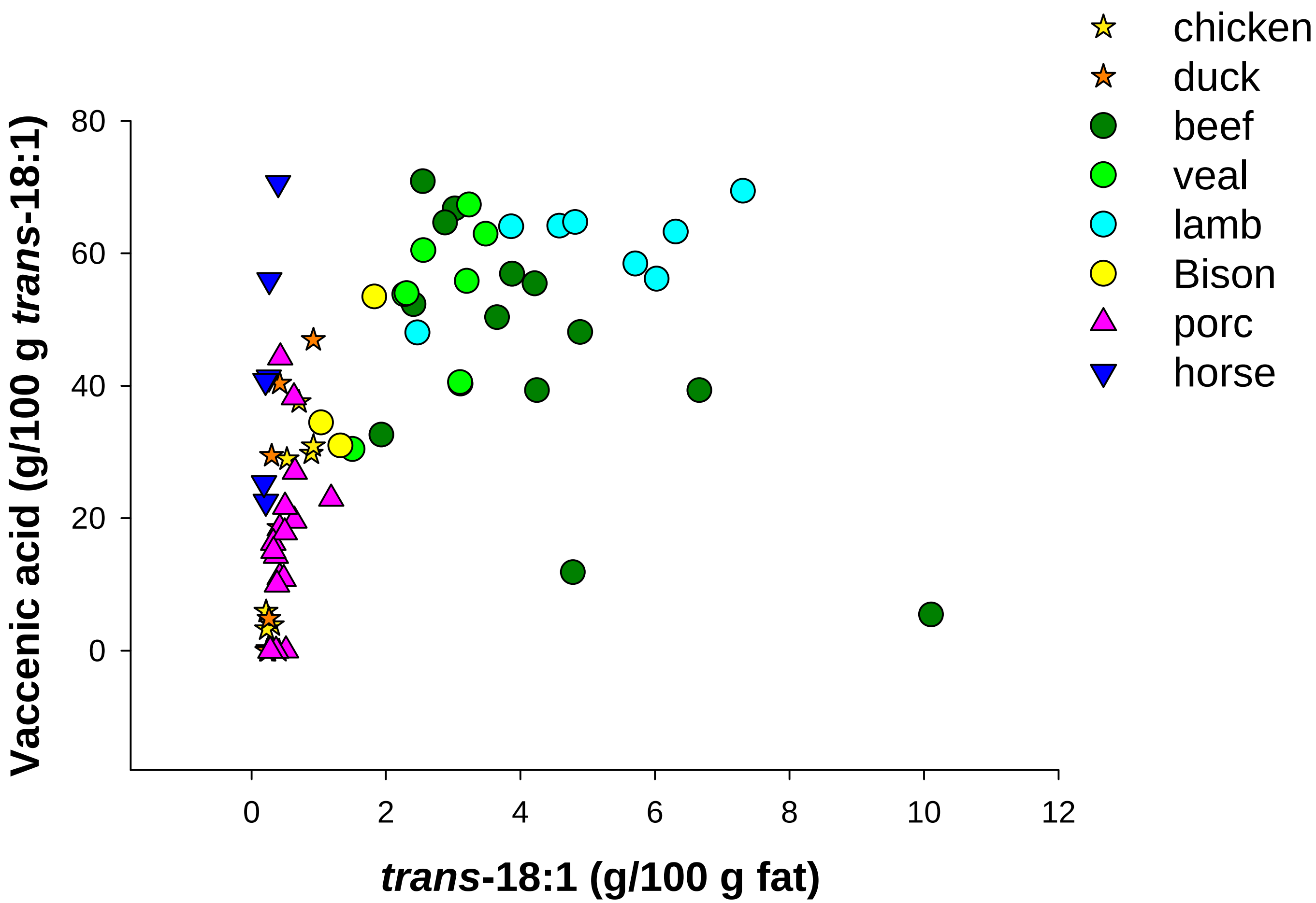
-**Animal nutrition may largely influence the ALA contents of food products, but, only to a much lesser degree, the long-chain PUFA (EPA, DPA, DHA).**

-**Increased ALA intakes do increase mainly EPA and DPA but to a lesser extent DHA.**

-**The effects of dietary ALA on long-chain n-3 PUFA significantly differ between tissues.**

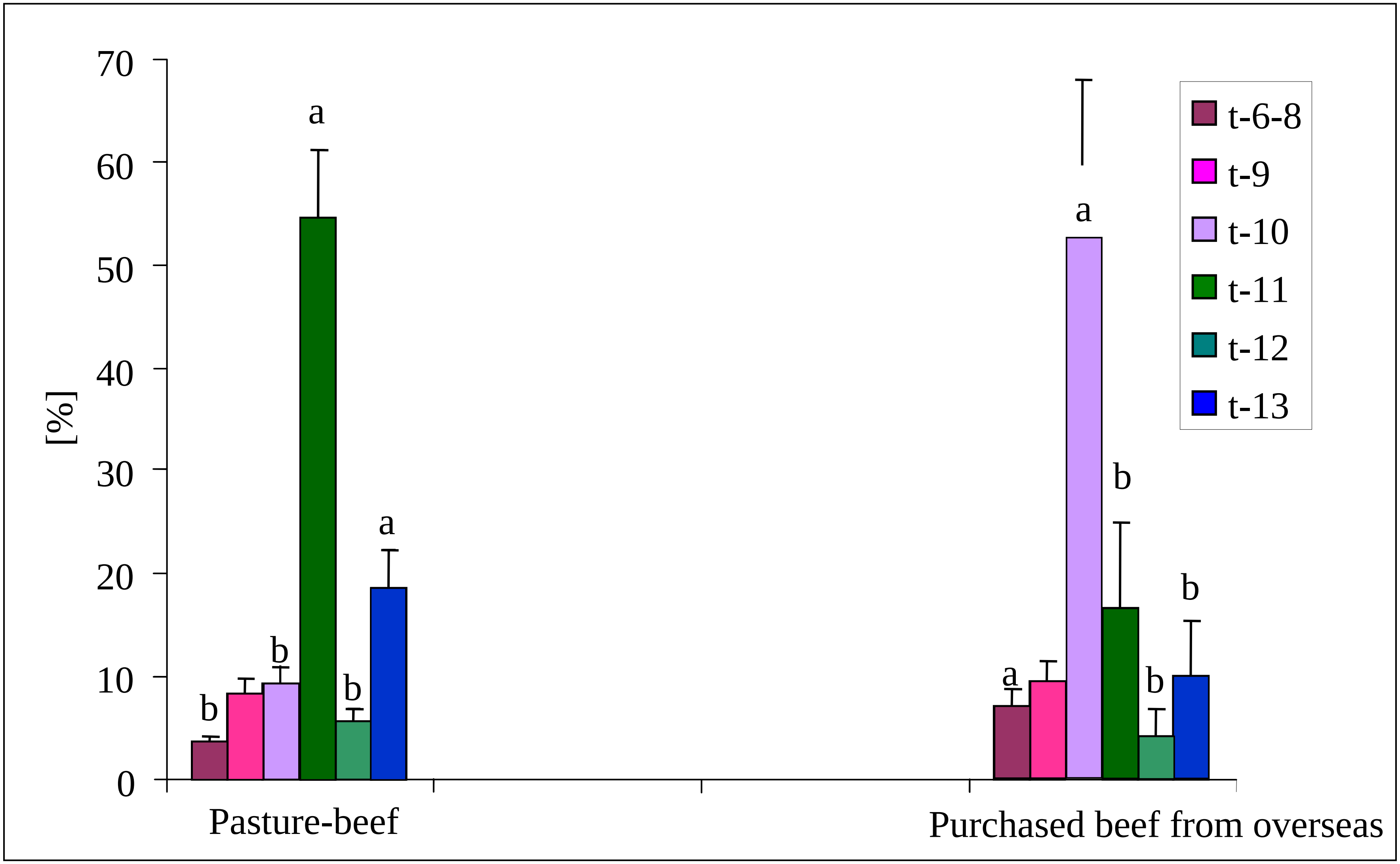
-**Evaluation of ALA effects is only possible in the respective target tissues, or, even more precisely, in the target function.**

trans-Fatty acids in animal products



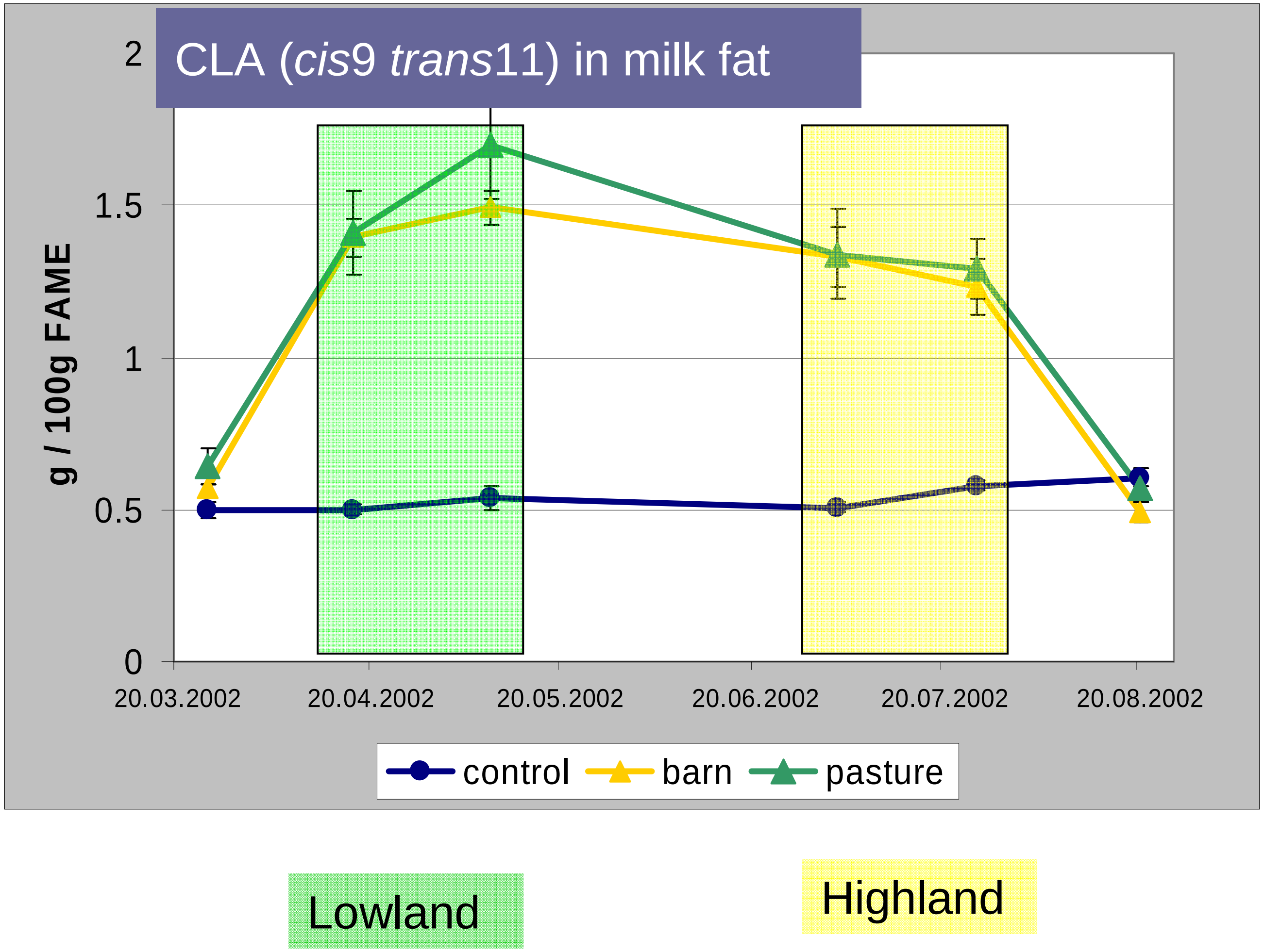
Wenk et al., 2008

trans-Fatty acids in animal products



(SCHEEDER et al., 2006)

CLA in animal products



Leiber et al., 2005

Conclusion

• Unsaturated fatty acids in animal products are still an issue for the improvement of nutritional quality of these products

• Of course, some effects may be still overestimated, but it seems too early to give final answers

• Additionally, fatty acid profiles are useful indicators for different digestive and metabolic processes, particularly in ruminants

• The fatty acid story may provide links to other important issues of the recent agricultural debate – and this opens horizons, also for the animal nutrition research

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