Vegetarians and omega-3 fatty acids: a review of the options

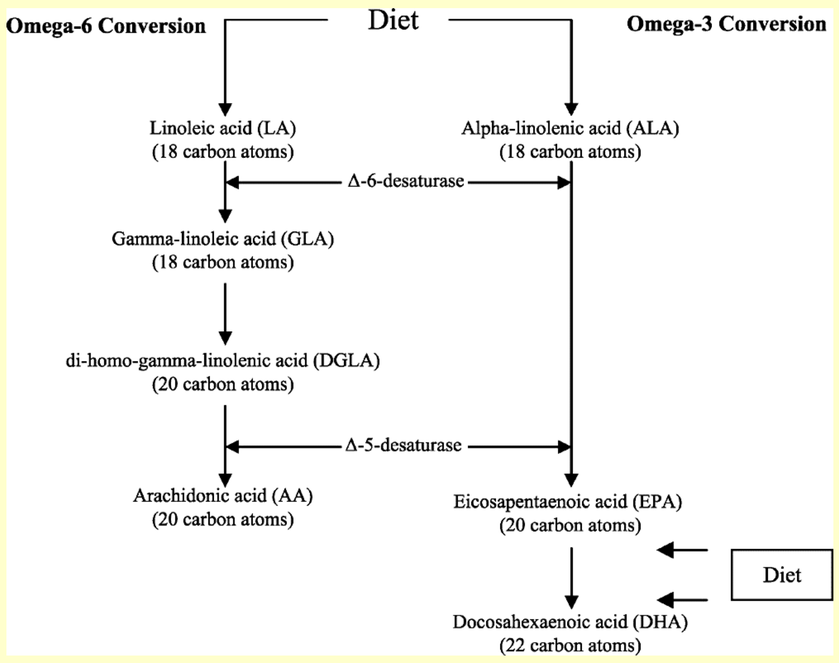
K.E. Lane *, E.J. Derbyshire, W. Li and C.J. Smith

*E-mail: k.lane@mmu.ac.uk

Manchester Metropolitan University, Department of Food & Tourism Management, Manchester M14 6HR, United Kingdom

Background

Figure 1. The long chain polyunsaturated fatty acid metabolic pathway



(Kirby *et al*., 2009)

- Vegetarians account for around 6% of the population and popularity is increasing (Mintel 2008; FSA 2008, Craig 2009)
- The removal of animal products from the diet can increase the risk of dietary deficiencies (Bailey 2009)
- Vegetarian diets are significantly lower in long chain omega-3 (*n*-3) fatty acids (LC3PUFA) than typical omnivorous diets (Conquer and Holub, 1997)
- DHA is entirely absent from vegan diets (Sanders 2009)
- Alpha-linolenic acid (18:3*n*-3; ALA) is currently the main vegetarian source of LC3PUFA
- In the metabolic pathway ALA becomes eicosapentaenoic acid (20:5*n*-3; EPA) and docosahexaenoic acid (22:6*n*-3; DHA), although conversion is limited (Dephilippis and Sperling, 2005).
- EPA is anti-thrombotic and thought to confer cardiovascular protection (Metcalf *et al.*, 2007)
- DHA has been linked to eye and brain development and is important for visual, cognitive and cardiovascular health (Arterburn *et al.*, 2007)
- Oily fish is currently the richest source of EPA and DHA
- Some of the richest vegetarian sources of *n*-3 are oils obtained form flaxseed, walnut, echium seed and algae (Breivik 2007)

Methods

Pubmed was searched for high quality, English-language, peer reviewed intervention studies published in the last ten years.

Search terms included: bioavailability, supplement, ALA α-linolenic acid, alpha-linolenic acid and the current richest sources flaxseed, walnut, echium and algae.

Human intervention (HI) and randomised controlled (RCT) studies that measured bioavailability with suitable blood analytes (blood plasma and/or erythrocytes) were selected.

Results & Discussion

Table 1. Studies using vegetarian LC3PUFA sources

Author	Study Design	Source and dose	No/type of subjects	Time period	*n* -3 changes after intervention (X= not measured; - = decreased; + = increased; N/S = not significant)					
					PL ALA	PL EPA	PL DHA	RBC ALA	RBC EPA	RBC DHA
Barcelo-Coblijn *et al.* (2008)	RCT with Canadian fire-fighters.	Flaxseed oil 1.2 to 3.6g/d (0.6 to 1.8g ALA)	62 M & F	12 weeks	+	+	N/S	+	+	N/S
François *et al.* (2003)	HI with breast feeding mothers	Flaxseed oil 20g (10.7g ALA)	7 F	4 weeks	+	+	N/S	+	+	N/S
Cao *et al.* (2006)	RCT using healthy subjects	Flaxseed oil (3.5g/d ALA)	20 M & F	8 weeks	+ (N/S)	+ (N/S)	N/S	N/S	+	N/S
Harper *et al.* (2006)	RCT with non healthy subjects	Flaxseed oil 5.2g/d, 3g/d ALA	49 M & F ill health	26 weeks	+	+	N/S	X	X	X
Kaul *et al.* (2008)	RCT with healthy subjects	Flaxseed oil 2g/d (1g/d ALA)	86 M & F	12 weeks	+	N/S	N/S	X	X	X
Surette *et al.* (2004)	HI in subjects with mild to moderately high cholesterol	Echium seed oil 15g/d (3g ALA)	11 M & F	4 weeks	+	+	N/S	X	X	X
Zhao *et al.* (2004)	RCT in healthy subjects with elevated cholesterol levels	English walnut oil 15g/d (1.5g ALA)	23 M & F	6 weeks (per diet)	+	+	N/S	X	X	X
Arterburn *et al.* (2007)	RCT with healthy subjects	Algae DHA oil 1g/d (DHA)	96 M & F	4 weeks	X	+ (N/S)	+	X	+ (N/S)	+
Sanders *et al* . (2006)	RCT with healthy subjects	Algae DHA oil 1.5g/d (DHA)	79 M & F	4 weeks	X	X	+	X	X	+
Geppert *et al.* (2006)	RCT using healthy vegetarians	Algae DHA oil 2.28g/d (0.94g/d	106 M & F vegetarian	8 weeks	X	+	+	X	+	+

Key: RCT= Randomised control trial, SB= Single blinded, DB= Double blinded, M= Male, F= Female, PL= Plasma, RBC = Red blood cells

Adapted from Lane *et al* (2012)

Table 2. Intakes of LC3PUFA in vegans and omnivores

	Male		Female	
Fatty acid	Vegan	Omnivore	Vegan	Omnivore
ALA	1.8±0.37	1.0±0.017	1.2±0.22	1.1±0.02
EPA	ND*	0.02±0.05	ND*	0.09±0.02
DHA	ND*	0.42±0.23	ND*	0.04±0.02

ND = not detected, **P*<0.01, two-sample *t*-test compared with value for same gender (Adapted from Sanders 2009)

- Non fish sources of LC3PUFA are particularly important for vegetarians
- Conversion of the essential fatty acid ALA to EPA and DHA from foods or supplements is ineffective
- Oils produced from marine-algae sources are fully vegetarian and suitable for vegans; they could be used to provide a direct, vegetarian source of DHA
- Unlike the other vegetarian sources algae oil supplements and fortified foods gave increases in plasma and erythrocyte DHA levels using relatively small doses
- Bioavailability was greater for an algae oil fortified food than supplements
- Algae oils were well tolerated; adverse event monitoring in the studies revealed an excellent safety and tolerability profile
- As algae oils do not occur in regular foods, a nutritional vehicle would be necessary to incorporate them into the diet
- Suitable foods appropriate for fortification or enrichment with algae oils need to be identified and evaluated

Conclusions

- Non fish sources of LC3PUFA are particularly important for vegetarians.
- Conversion of the essential fatty acid ALA to EPA and DHA from foods or supplements is ineffective, leading scientists to seek further direct sources in the form of algae oils.
- Interventions using algae oil have been successful in terms of DHA bioavailability, although further research is necessary to evaluate dosages and suitability for the enrichment of functional foods.

References

Arterburn *et al.* (2007) Bioequivalence of docosahexaenoic acid from different algal oils in capsules and in a DHA fortified food, *Lipids*, Vol. 42, pp 1011 – 1024. Bailey N. (2009) Current choices in omega-3 supplementation, *British Nutrition Foundation, Bulletin*, Vol. 34, pp 85 – 91. Breivik H. (2007) *Long-Chain Omega-3 Speciality Oils*, Bridgwater, The Oily Press. Conquer and Holub (1997) Dietary docosahexaenoic acid as a source of eicosapentaenoic acid in vegetarians and omnivores, *Lipids*, Vol. 32, No. 3, pp 341 – 345. Craig W.J. (2009) Health effects of vegan diets, *The American Journal of Clinical Nutrition*, Vol. 89, pp 1627S – 1633S. DeFilippis N.P. and Sperling S. (2006) Understanding Omega-3's, *American Heart Journal*, Vol. 151, pp 564 – 570. Food Standards Agency (FSA) (2008) *Consumer Attitudes Survey 2007: England Summary Report*, Consumer Attitudes to Food Standards: Wave 8 England Summary Report, London, Taylor Nelson Sofres, 282008. Francios *et al.* (2003) Supplementing lactating women with flaxseed oil does not increase docosahexaenoic acid in their milk, *American Journal of Clinical Nutrition*, Vol. 77 pp 226 – 233. Kirby *et al.* (2009) 'Benefits of omega-3 supplementation for schoolchildren: review of the current evidence'. *British Educational Research Journal*, Vol. **36**, Issue 5, pp. 699-732. Lane *et al.* (2012) Bioavailability and potential use of vegetarian omega-3 fatty acids: a review of the literature, *Critical Reviews in Food Science and Nutrition*, (accepted for publication 08.06.2011, in production) Metcalf *et al.* (2007) Effects of fish supplementation on myocardial fatty acids in humans, *American Journal of Clinical Nutrition*, Vol. 85, pp 1222 – 1228. Mintel (2008) *Attitudes towards vegetarianism*, London, Mintel International Group . Sanders, T.A. (2009) 'DHA status of vegetarians'. *Prostaglandins Leukot Essent Fatty Acids*, Vol. **81**, Issue 2-3, pp. 137-41.