

Achieving optimal omega-3 fatty acid status in the vegan population

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ABSTRACT

Vegan diets have been found to be low in alpha-linolenic acid (ALA) and to contain very little eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). These omega-3 polyunsaturated fatty acids (PUFAs) are required during synaptogenesis and photoreceptor membrane biogenesis during the perinatal period, response to injury to the nervous system, and retinal stimulation. Essential fatty acids (EFAs) have also been found to have cardioprotective properties and are believed to reduce the risk of hypertension, cancer, depression, and attention deficit hyperactivity disorders. Fish oil has been identified as being a major source of EPA and DHA in the Western diet. However, for the vegan population that does not consume fish, optimal omega-3 fatty acid status can be obtained by maximizing the conversion of ALA to EPA and DHA, and through supplementation of these EFAs derived from microalgae (i.e. *Schizochytrium sp.*), which are the primary sources of EPA and DHA in fish. Based on literature reviews, vegans should aim for 2-4 g ALA/d, and consider supplementing with a direct source of DHA (0.6g/d). Suggestions for how these levels can be achieved are presented.

INTRODUCTION

The discovery of the essentiality of long-chain polyunsaturated fatty acids (PUFAs) was made in 1929 when dermatitis in rats fed a fat-free diet was observed [1]. Today the consumption of fish and long-chain omega-3 fatty acids eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) (Fig. 1) have been associated with a reduced risk of cardiovascular disease, hypertension, cancer, depression, and attention deficit hyperactivity disorders [2-5]. The only direct sources of EPA and DHA are marine organisms such as marine phytoplankton and marine animals [5] (Fig. 2). As illustrated in Figure 3, EPA and DHA are synthesized from alpha-linolenic acid (ALA) obtained in plant foods through a series of elongation and desaturation reactions with an efficiency of approximately 5-10% and 2-5%, respectively in healthy individuals [6]. In addition to being an important structural component in the gray matter of the brain, DHA is also required during retinal stimulation and neurotransmission, and is positively associated with cognitive and behavioral performance [6-7]. Despite the beneficial effects of these long-chain PUFAs, vegan diets have been found to be low in ALA and to contain very little EPA and DHA [6]. Achieving optimal omega-3 fatty acid status in the vegan diet is therefore critical to the health of this population.

METHODOLOGY

The information on this poster was compiled from peer-reviewed literature sources, local food markets, and online dietary supplement providers.

RESULTS

It has been suggested that dietary intakes of approximately 0.45 – 0.65 g/d ALA, and 0.3 – 0.4g/d EPA+DHA are needed to prevent omega-3 fatty acid deficiency disease signs [5]. However, on the basis of special health benefits of these PUFAs, like the prevention of cardiovascular disease, recommended daily intakes of omega-3 fatty acids exceeding those to prevent deficiency disease signs have been made (Fig. 4). Tables 1 and 2 show fatty acid compositions of selected food items, and omega-3 fatty acid content of brand name foods, respectively. Due to the lack of pre-formed EPA and DHA in the vegan diet, diets rich in ALA have been tested in order to determine how effective high doses of ALA are in converting to EPA and DHA [5]. These studies indicate that high doses of ALA may provide a limited amount of EPA, but are very poor sources of DHA (Table 3). Figures 5 – 8 show how optimal omega-3 fatty acid status can be attained in the vegan diet.

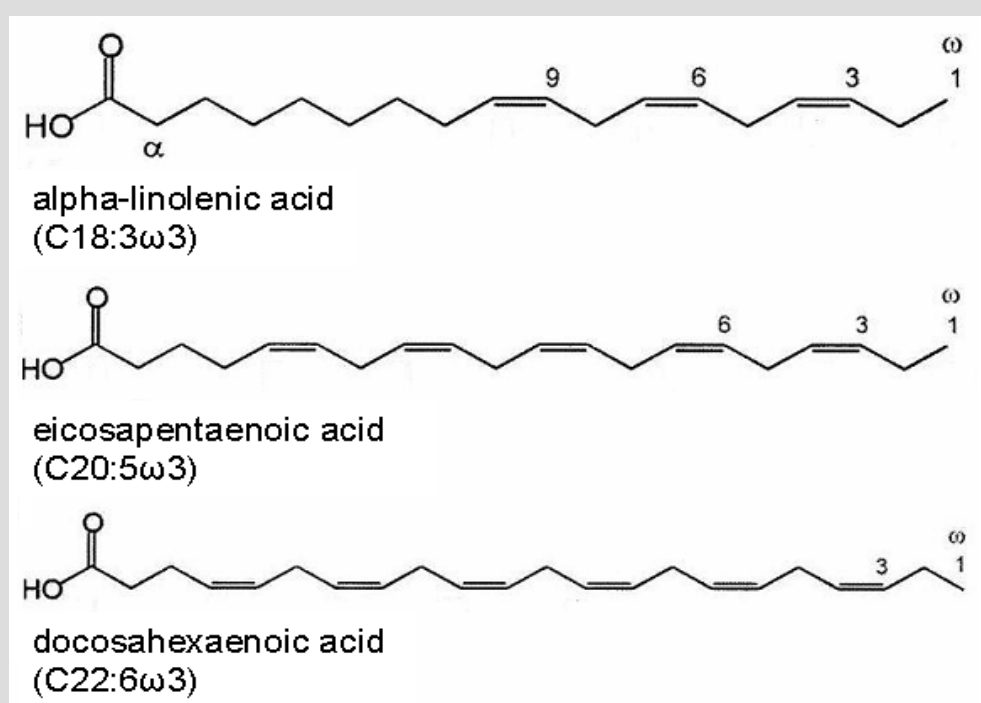


Figure 1: Structural formulas for C18:3 ω 3 alpha-linolenic acid (ALA), C20:5 ω 3 eicosapentaenoic acid (EPA), and C22:6 ω 3 docosahexaenoic acid (DHA). The first number before the colon gives the number of carbon atoms in the molecule. The second number gives the number of double bonds. ω -3 Indicates the position of the first double bond in a given unsaturated fatty acid molecule. Adapted from reference 4.

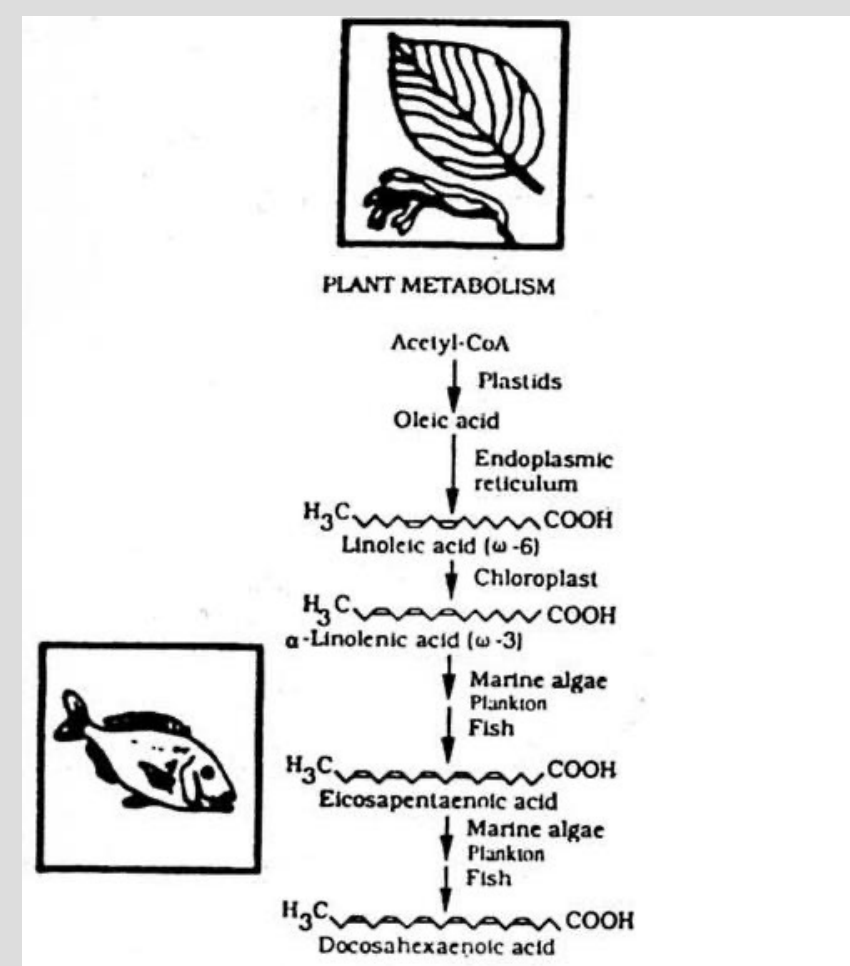


Figure 2: Origin of omega-3 and omega-6 unsaturated fatty acids. Adapted from reference 4.

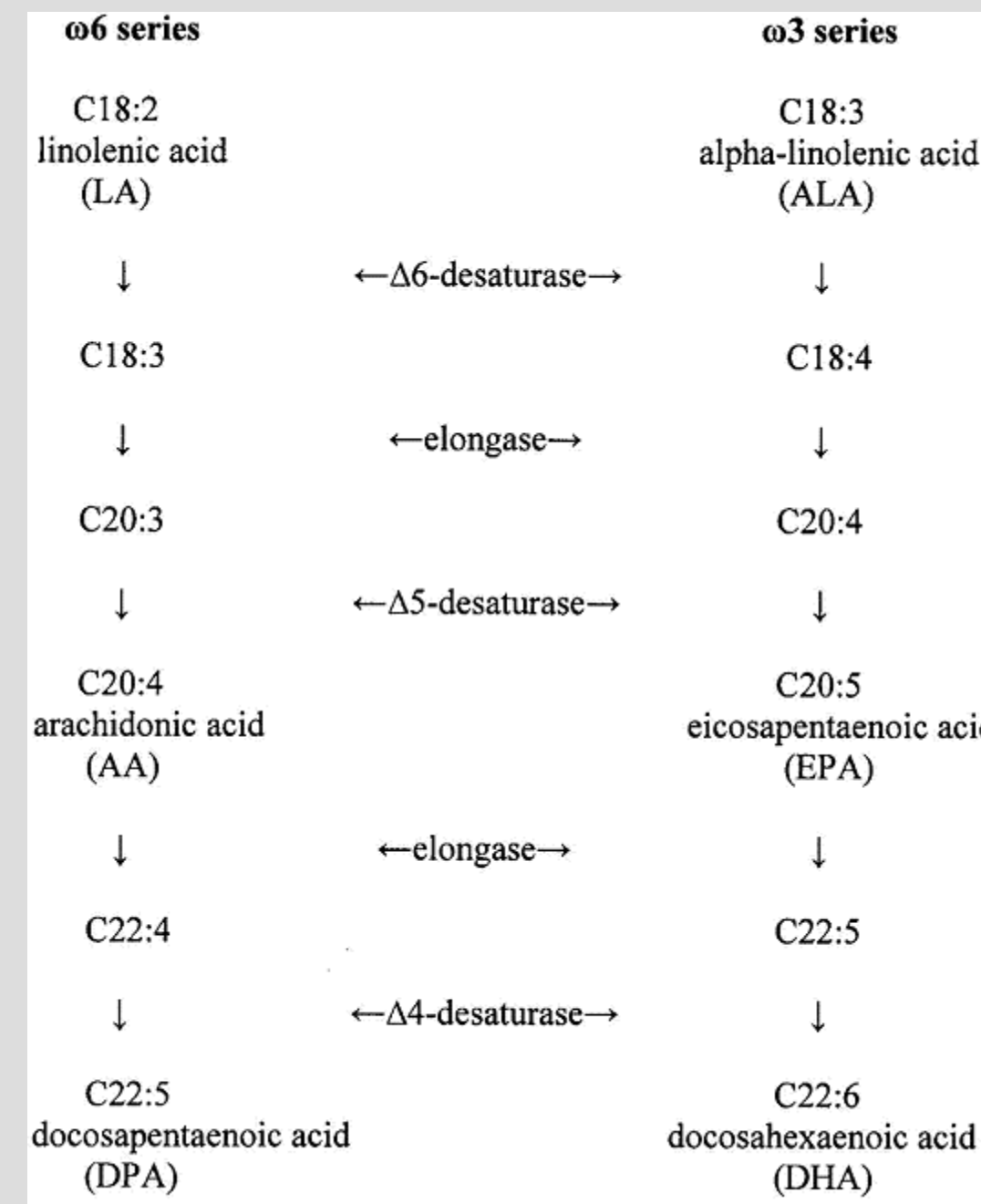


Figure 3: Metabolic pathway of omega-6 and omega-3 fatty acids to their long chain metabolites. Illustration shows that omega-6 and omega-3 fatty acids utilize the same enzymes during desaturation (addition of double bonds) and elongation (extension of the carbon chain). Adapted from reference 5.

Table 1: Fatty acid composition of selected foods. Note that required long-chain omega-3 fatty acids EPA and DHA come only from marine sources. Adapted from reference 9.

Food/serving size	wt (% of total fat)	w3 (% of total fat)	ALA (g)	EPA (g)	DHA (g)
Canola oil, 1 Tbsp	23%	11%	1.6	0	0
Corn oil, 1 Tbsp	57%	0%	0	0	0
Flaxseed oil, 1 Tbsp	16%	57%	8.0	0	0
Olive oil, 1 Tbsp	9%	1%	0.8	0	0
Peanut oil, 1 Tbsp	33%	0%	0	0	0
Soybean oil, 1 Tbsp	51%	7%	0.9	0	0
Flaxseed, ground, 2 Tbsp	16%	57%	3.8	0	0
Walnuts, 1oz (¼ cup)	58%	14%	2.6	0	0
Avocados, 1 med	12%	1%	0.25	0	0
Walrusme, 100g	8%	46%	0.001	0.186	0
High fish, 3oz	2%	23%	0.1	0.5	0.8
Low fish 8oz, 3oz	6%	50%	0	0.1	0.15



Figure 5: Daily dietary recommendation for obtaining essential omega-3 fatty acids. Option 1: i) 2 tsp. flax oil, ii) two vegan DHA capsules (0.3g of DHA each)



Figure 6: Option 2: i) 1 tsp. flax oil, ii) 1/4 cup of shelled walnuts, iii) two vegan DHA capsules (0.3g of DHA each)



Figure 7: Option 3: i) 1 tsp. flax oil, ii) 2 tsp. of ground flaxseed, iii) two vegan DHA capsules (0.3g of DHA each)



Figure 8: Option 4: i) 1/4 cup of shelled walnuts, ii) 2 tbsp. ground flaxseed, iii) two vegan DHA capsules (0.3g of DHA each)

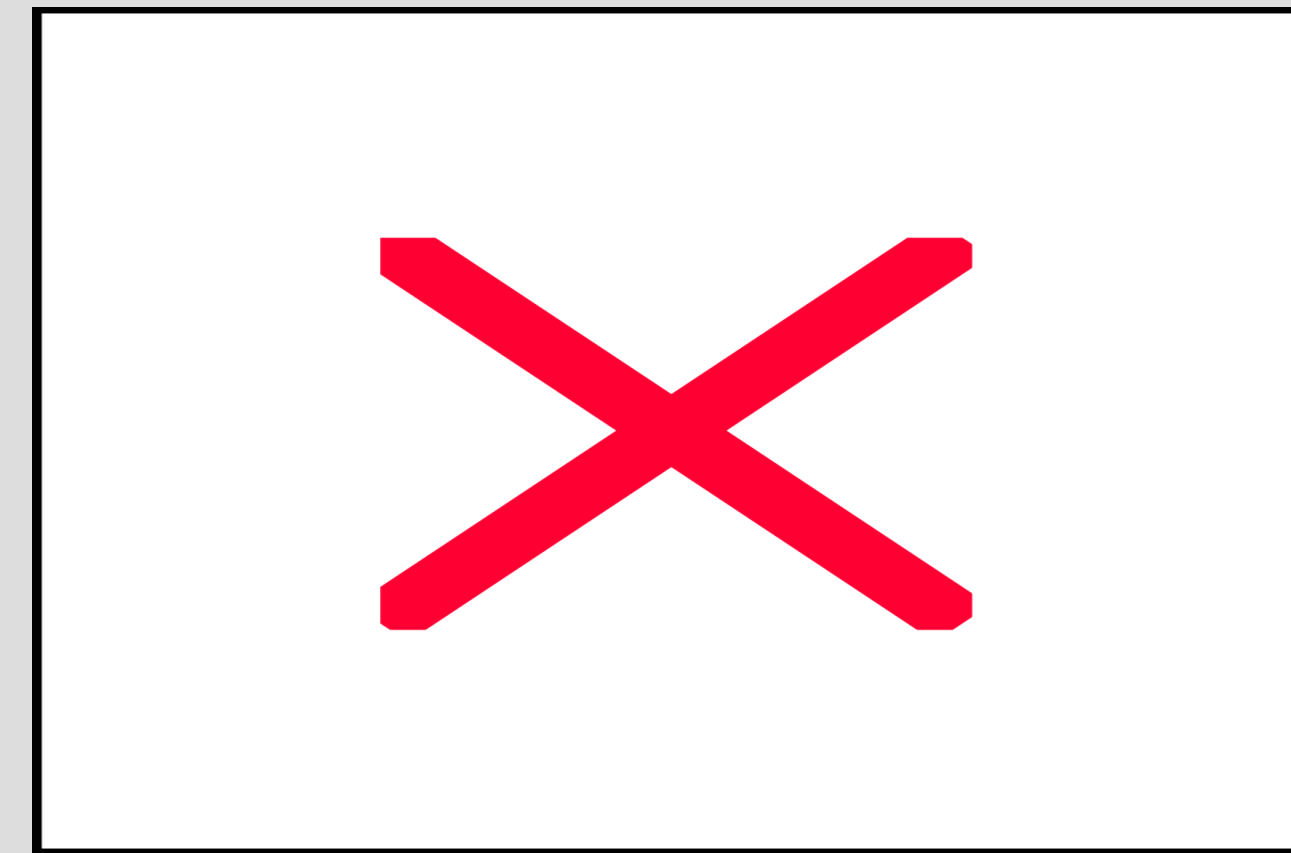


Figure 4: US population's current intake and recommended intakes of alpha-linolenic acid (ALA), and eicosapentaenoic acid (EPA) plus docosahexaenoic acid (DHA) expressed as grams/day; References: US current intake [5], NIH (National Institute of Health Working Group) [10], BNF (British Nutrition Foundation) [10], NHLBI (National Heart, Lung and Blood Institute) [4].

Table 2: Omega-3 fatty acid composition of brand name products.

Source/serving size	ALA (g)	EPA (g)	DHA (g)
Nature's Bounty® Flax oil, 1 tsp	2.6	0.0	0.0
Diamond-shelled walnuts, ¼ c	2.5	0.0	0.0
Bob's Red Mill ground flaxseed, 2 Tbsp	2.4	0.0	0.0
Deva Vegan Omega-3 DHA, 1 capsule	0.0	0.0	0.2
O-Mega-Zen™	0.0	0.0	0.3
Vegan DHA, 1 capsule	0.0	0.2	0.1
Daily Source-natural fish oil, 1 capsule	0.0	0.2	0.1
Nature's Bounty® omega-3 fish oil	0.0	0.2	0.1

Table 3: Concentrations of EPA and DHA in blood plasma and platelets in response to intake of ALA-rich vegetable oil in strict vegans. Adapted from reference 5.

Reference	Supplement	Results (usually as % of total fatty acids)
Sanders and Roshanai 1983	flaxseed oil (9.4g/d ALA), 2 weeks	Platelets: EPA from 0.6±0.10 to 1.2±0.18; DHA from 3.0±0.33 to 2.9±0.09
Sanders and Younger 1981	flaxseed oil (6.5g/d ALA), 2 weeks	Plasma: EPA from 0.3 to 1.0; DHA from 1.3 to 1.3 Platelets: EPA 0.3 to 0.3; DHA from 0.9 to 1.2
Kestin <i>et al</i> 1990	flaxseed oil (9g/d ALA), 6 weeks	Plasma: EPA from 0.7 to 1.4; DHA from 1.4 to 1.6
Cunnane <i>et al</i> 1995	flaxseed oil (9g/d ALA), 4 weeks	Plasma: EPA from 0.9±0.4 to 1.3±0.2; DHA from 3.6±1.0 to 3.5±1.0

DISCUSSION

Omega-3 fatty acid status in vegans can be improved by 1) maximizing the conversion of ALA to EPA and DHA, and 2) providing a direct source of DHA (DHA is the most prominent fatty acid in the brain and retina, and is most effective in lowering plasma triglyceride concentrations.) [5, 6]. Dietary factors that inhibit the conversion of ALA to EPA and DHA include high omega-6 fatty acid intakes [5], excessive intakes of trans fats [6], and nutritionally inadequate diets in terms of total calories, protein, vitamins and minerals [9]. Due to the fact that omega-3 and omega-6 fatty acids compete for the same conversion enzymes, high omega-6 fatty acid intake can reduce the conversion of ALA by as much as 40% [5]. For this reason, it has been suggested that an adequate ratio of omega-6/omega-3 for vegans is in the range of 2:1- 4:1 [6]. omega-6 rich foods include corn oil, safflower oil, sunflower oil, soybean oil, and processed foods containing these oils, while omega-3 rich foods include flaxseed oil, flaxseed, avocados, dark green leafy vegetables, and seaweed [9]. In order to reduce omega-6 contributors, the primary fat in the diet should come from monounsaturated fats such as olive oil and whole plant foods [6].

CONCLUSION

By consuming a variety of whole plant foods, reducing the omega -6/omega-3 to a range between 2:1 and 4:1, eliminating the consumption of trans fats, consuming foods rich in omega-3 fatty acids (2-4 g ALA/d), and using a direct source of DHA (0.6 g/d) from marine microalgae, optimal omega-3 fatty acid status can be achieved in the vegan population [4, 6, 9-10].

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