Plant-based diets in paediatrics: Do they provide adequate omega-3 fatty acids?

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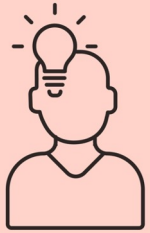
Objectives of this talk

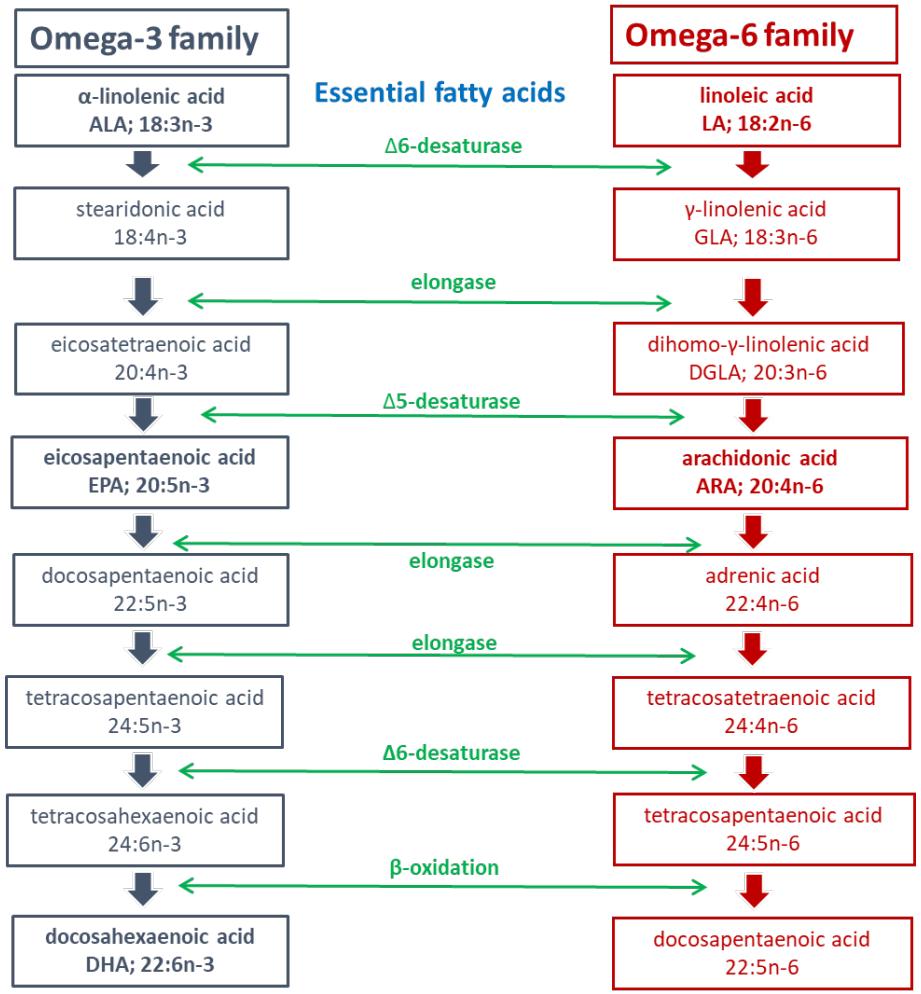


You will gain an understanding of: The challenges and nutritional considerations in ensuring adequate intake of omega-3 fatty acids from plant-based diets in paediatric populations.

You will become aware of: The dietary sources of omega-3 fatty acids and their roles in early childhood development, as well as potential consequences of deficiency.

You will be able to: Provide guidance to parents who are raising their children on plant-plant based diets on how to ensure adequate omega-3 fatty acid intake.

What are omega-3 fatty acids?

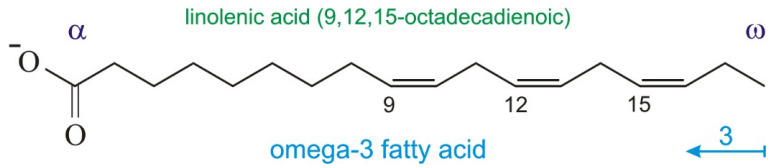


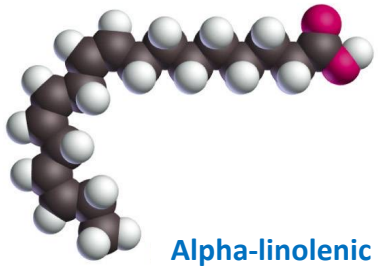
- Omega-3 (n-3) and n-6 polyunsaturated fatty acids (PUFA) cannot be synthesized by the body *de novo*

  → The precursor PUFAs, **alpha-linolenic acid** (**ALA**; 18:3n-3) and **linoleic acid** (**LA**; 18:2n-6) are **essential** and need to be provided by the diet

- ALA and LA can be metabolized to longer-chain PUFAs by a series of linked desaturation and elongation reactions

  → Mainly in the liver





Alpha-linolenic acid

an 18-carbon fatty acid with two double bonds

Is there a need for dietary long-chain PUFAs?

Conversion of ALA to longer-chain PUFAs in humans is inefficient!

α-linolenic acid (ALA)

Conversion rate:
ALA → EPA: 1-20 %
ALA → DHA: 0.5-9 %

Desaturation
Elongation

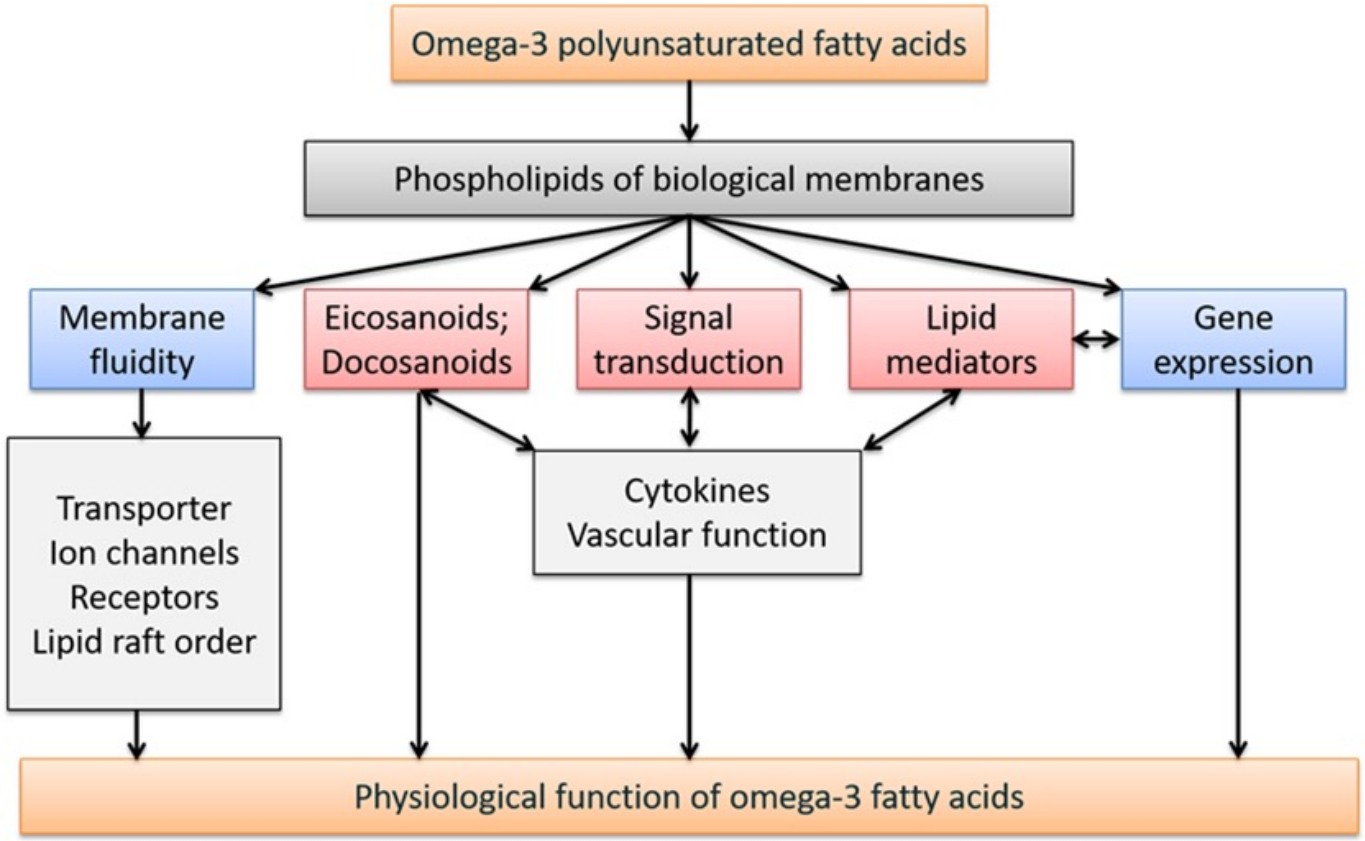
- **High dietary n-6 FA intake (competition for enzymes)**
- Male sex
- *trans* FAs
- Genetic variation
- **Preformed DHA/EPA (end-product inhibition)**
- **Lack of co-factors (zinc, iron, vit B6)**

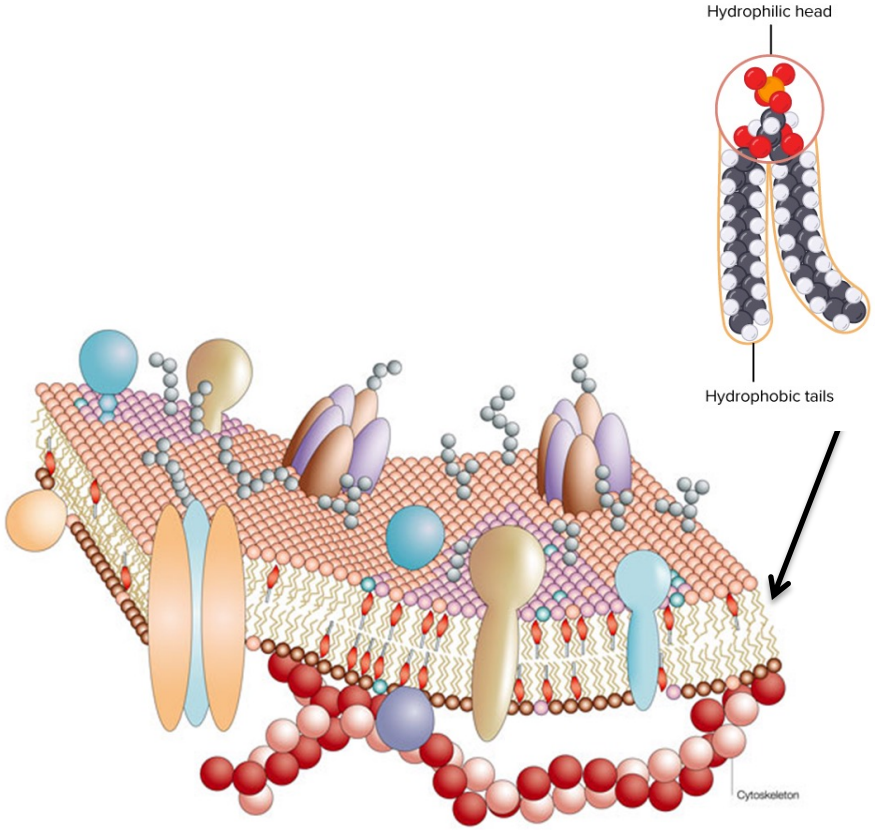
Eicosapentaenoic acid (EPA)
Docosahexaenoic acid (DHA)

Burdge *et al.* (2004) *Curr Opin Clin Nutr Metab Care*

What are the physiological roles of n-3 PUFA in the body?

n-3 PUFA play key roles in the structure and function of human tissues (including brain and retina) and immune function.

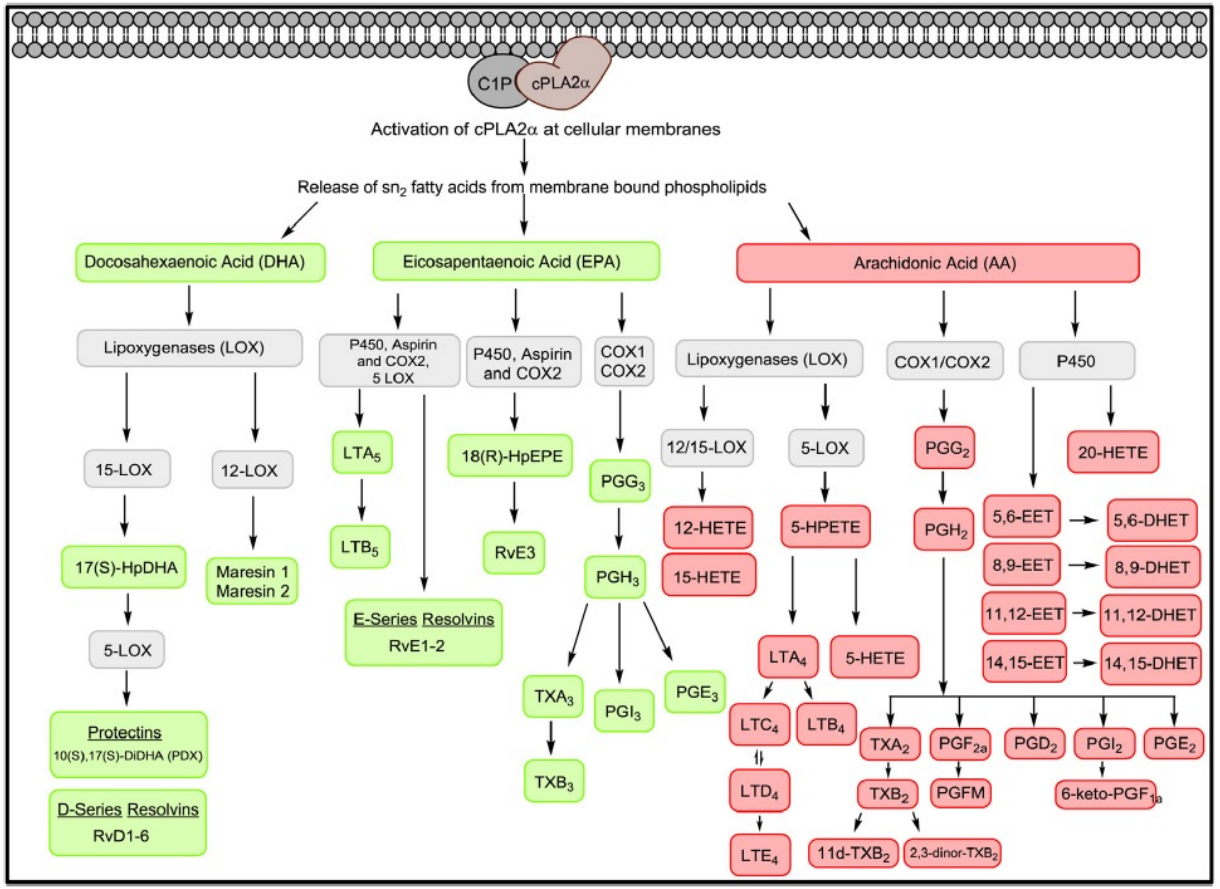




Baumgartner (2016), Handbook of Lipids in Human Function: Fatty Acids. Oxford: Academic Press & AOCS Press

PUFAs are precursors for bioactive lipids

n-3 PUFA are precursors for **anti-inflammatory and inflammation-resolving** bioactive lipids.



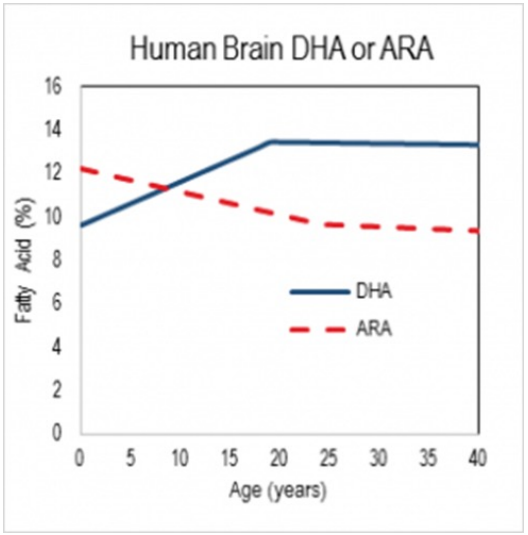
- Eicosanoids and docosanoids:
  - Prostaglandins
  - Thromboxanes
  - Leukotrienes
- Specialized pro-resolving mediators (SPMs):
  - Resolvins
  - Protectins
  - Maresins

Stephenson *et al.* (2017) *Trans Res.*

N-3 PUFA play important roles in brain and retinal development

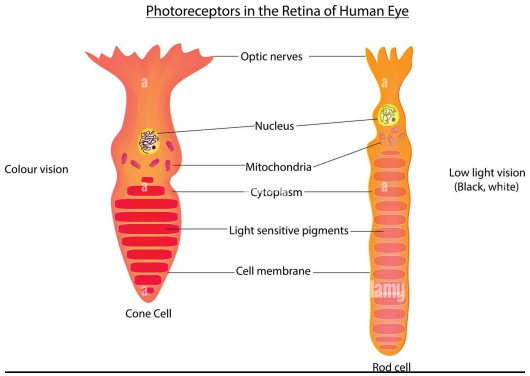
Brain

- **50-60%** of the brain's dry weight consists of **lipids** → mostly long-chain PUFAs
- 10-12% as arachidonic acid (ARA; n-6 long-chain PUFA)
- **10-20%** as **DHA**
  - From 30 wks gestational age to 18 months of age brain DHA content increases from approx. 90 mg to 3'300 mg → 35-fold increase
- **<1%** in the form of **ALA and EPA**



Eye

- **DHA** is a major structural lipid of retinal photoreceptor outer segment membranes (**60%** of total FA composition)



Umhau et al. (2013) *PLoS ONE*; Carver et al. (2001) *Brain Res Bul;* Sugasini *et al.* (2020) *Nutrients*

What are the potential consequences of n-3 PUFA deficiency?

Poor n-3 long-chain PUFA status during **pregnancy** has been associated with:

- Preterm birth
- Delayed neurocognitive development in offspring
- Poor visual acuity
- Allergy and asthma risk in offspring
- Maternal perinatal depression

Poor n-3 long-chain PUFA status during **infancy and childhood** has been associated with:

- Delayed neurocognitive development
- Poor immune development (↑ morbidities)
- Attention deficit hyperactivity disorder (ADHD)
- Depression

Preterm infants are at particular risk of n-3 PUFA deficiency and it's consequences as they had fewer crucial late-pregnancy weeks of DHA accumulation *in utero*.

Middleton et al. (2018) *Chochrane Database Syst Rev*. ; Bärebring et al. (2022) *Food Nutr Res*; Chang et al. (2018) *Neuropsychopharmacology;* Rodriguez et al. (2022) *Nutrients;* Smith & Rouse (2017) *Maternal Health Neonatol Perinatol*

N-3 PUFA intake recommendations

European Food Safety Authority (EFSA) recommendations:

- General population: 250 mg EPA+DHA per day
- Pregnant & lactating women: additional 200 mg DHA per day
- Children 7-24 months: 100 mg DHA per day
- Children >2 years: 250 mg EPA+ DHA per day

Recommendations by the BLV:

- General population: 500 mg EPA+DHA per day
- Pregnant & lactating women: min. 200 mg DHA

Dietary recommendations:

→ 1-2 servings of fatty fish/week, or

→ Fish oil/algal oil supplement

EFSA Panel on Dietetic Products, Nutrition and Allergies (2010). Available at: https://www.efsa.europa.eu/en/efsajournal/pub/1461
http://www.sge-ssn.ch/grundlagen/lebensmittel-und-naehrstoffe/naehrstoffempfehlungen/empfehlungen-blv/

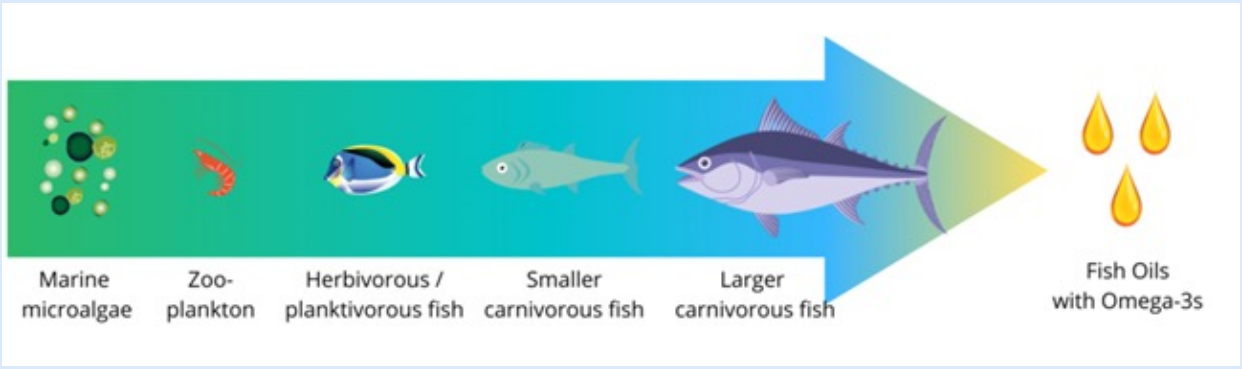
What are the dietary sources of n-3 PUFAs?

Sources of ALA

- Walnuts
- Seeds (flaxseed, linseed, rapeseed, chia seed, pumpkin seeds, hemp seeds)
- Soya and soya products
- Green leavy vegetable
- Margarines made from ALA-rich oils
- Meat and eggs (content depending on animal feed)

Sources of EPA and DHA

- Fish (especially cold-water fatty fish)
- Seafood
- Fish oil
- Algal oil
- DHA-fortified eggs & foods



- **Breast milk** (content dependent on maternal intake)
- Since 2020, all **infant and follow-on formula** in EU (and Switzerland) must contain 20-50 mg DHA/100 kcal

EFSA Panel on Dietetic Products, Nutrition and Allergies (2013). Available at: https://efsa.onlinelibrary.wiley.com/doi/abs/10.2903/j.efsa.2013.3408

EPA and DHA content of different fish species

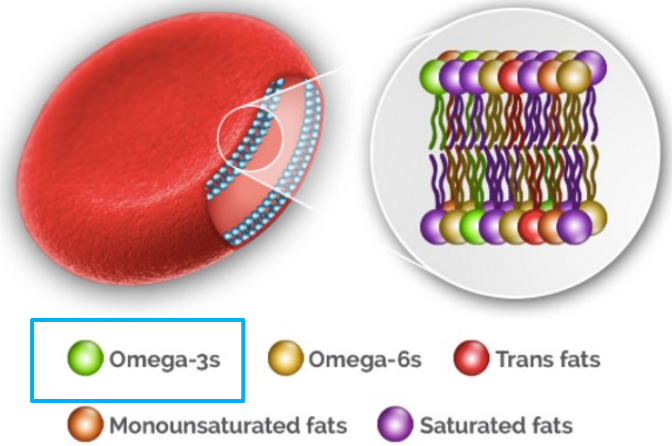
Type of fish	Amount (g) of EPA + DHA per 100 g portion	Number of times *per week* a 90 g portion should be consumed to provide ±500 mg EPA+DHA /day	Amount of fish (g) required per day to provide 500 mg EPA+DHA
Mackerel (salted)	4.584	1	11
Salmon, Atlantic	2.147	1.6	23
Herring, Atlantic	2.014	1.7	25
Bluefin tuna	1.504	2.3	33
Pilchards	1.480	2.6	34
Snoek	1.030	3.8	49
Sardines	0.982	4.0	51
Rainbow trout	0.988	4.0	51
Hake	0.518	7.5	97
Tuna, light	0.270	13	185

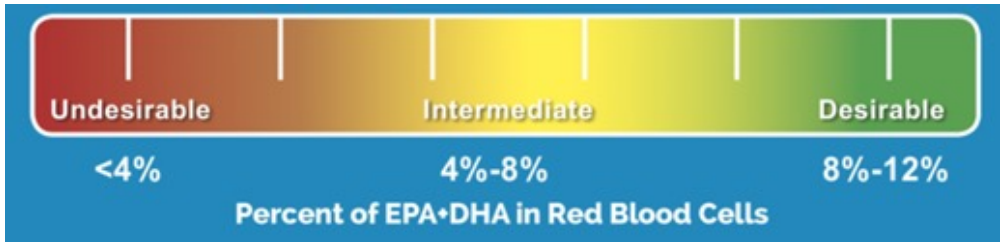
Smuts & Wolmarans (2013) *SAJCN*

How is the n-3 PUFA status assessed and deficiency defined?

- A clinical biomarker to identify individuals with an n-3 PUFA deficiency is not yet established.
- n-3 PUFA status can be assessed by measuring the **fatty acid composition (% of total fatty acids)** in **red blood cells**, plasma or whole blood using gas-chromatography (values related but not comparable!)
- The "**Omega-3 Index**" is the sum of EPA an DHA (as % of total fatty acids) in red blood cell membranes.

  → Omega-3 index testing now available in Swiss pharmacies and paid by some health insurance companies.

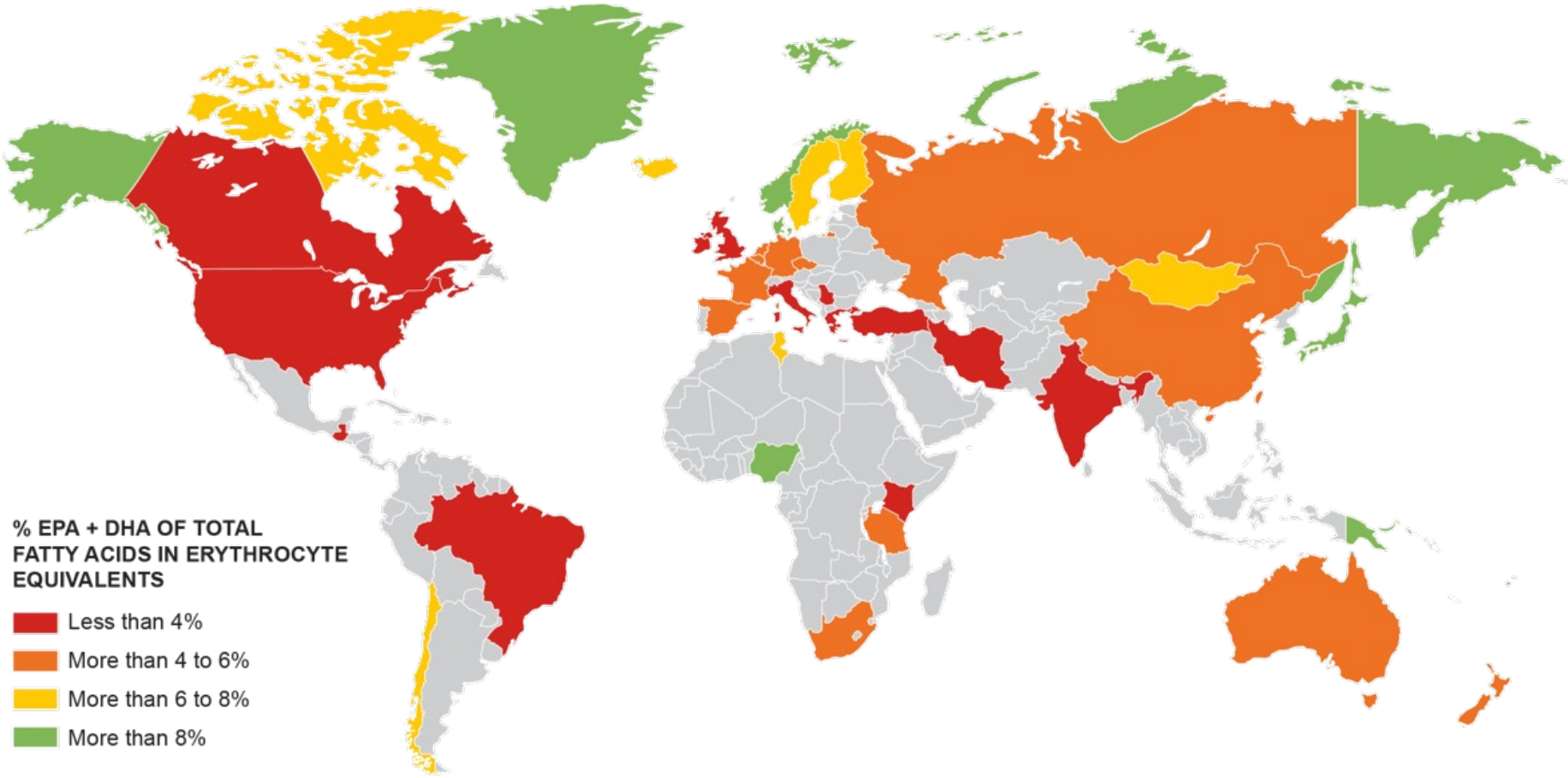


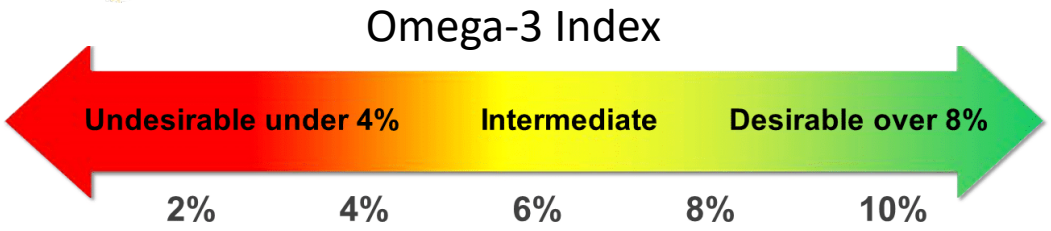


Reference ranges have been established based on cardio-vascular risk protection.

Harris & von Schacky, 2007

Global blood levels of n-3 long-chain PUFAs



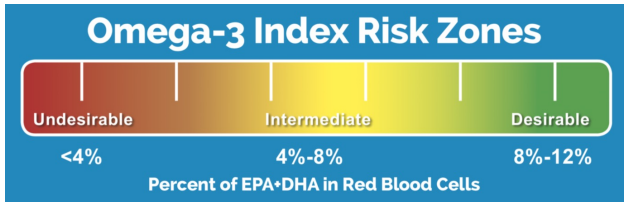


Stark *et al.* (2016)

n-3 PUFA intake and status in Swiss pregnant women

Omega-3 survey in a nationally representative sample of pregnant women (n = 508) taking part in the Swiss National Iodine Survey (Sep 2020 – Feb 2022)

- Mean n-3 index of **4.6 ± 1.1%** (min. 2.3% – max. 9.8%)
  - <6%: 91% (n = 461)
  - <4%: 33% (n = 169)
  - >8%: 0.98% (n = 5)



Frequency of consumption		N (%)	N-3 Index
Fish		428	
	<1x per month	147 (32)	4.35 ± 1.15[B]
	1-3x per month	185 (43)	4.70 ± 1.02[A]
	≥1x per week	96 (22)	4.95 ± 1.10[A]
	p-value	-	**<0.001**
N-3 supplements		466	
	Non-users	324 (70)	4.46 ± 0.99
	Users	142 (31)	4.93 ± 1.23
	p-value[2]	-	**<0.001**

N-3 supplements mostly delivered 200 mg/day DHA

Baumgartner et al. (*unpublished*)

n-3 PUFA intake and status in Swiss adolescents

Case-control study in Swiss adolescents diagnosed with paediatric major depressive disorder (n = 95) and health controls (n = 95) aged 13 to 17 years.

- Mean n-3 index of **4.5 ± 1.1%** in cases and **5.2 ± 1.1%** in controls (p <0.001)
- Higher red blood cell n-3 PUFA status was associated with lower risk for pMDD
- Overall:
  - n-3 index <6%: 81%
  - n-3 index <4%: 20%
  - 16% of adolescents reported to consume fish ≥1 x per week (no difference between cases and controls)

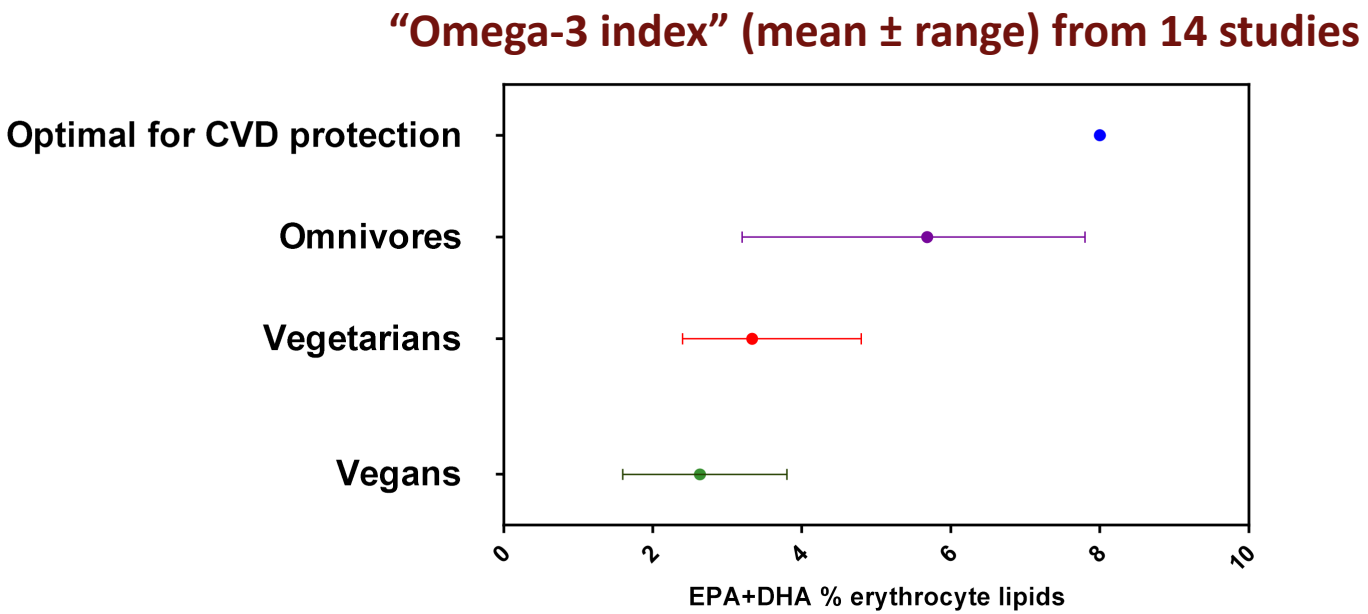
Osuna et al. (2023) *Journal of Affective Disorders*

Are people following plant-based diets at risk of n-3 PUFA deficiency?

Increasing evidence from cross-sectional studies in **adult populations** indicates that:

- ALA intake likely adequate or even higher…
- EPA and DHA intake and status consistently lower…

…in vegetarians (except pescetarians) and vegans compared to omnivores.



Lane et al. (2021) *Critical Reviews in Food Science and Nutrition*; Figure by Dr. Wendy Hall (King's College London)

Are children following plant-based diets at risk of n-3 PUFA deficiency?

Recent studies comparing n-3 intake and status between omnivorous, vegetarian and vegan children are scarce/non-existing.

The Vegetarian and Vegan Children (VeChi Diet) study compared dietary intake between 1-3-year-old omnivorous (n = 164), vegetarian (n = 139) and vegan (n = 127) children.

	Omnivorous	Vegetarian	Vegan	P-value
With supplements				
EPA intake (mg/day)	10.7 (4.3-46.6)	4.4 (1.0-9.3)	1.6 (0.4-5.4)	<0.001
DHA intake (mg/day)	35.4 (15.6-82.3)	19.1 (6.2-42.6)	19.5 (6.8-37.9)	<0.001
Without supplement				
EPA intake (mg/day)	10.7 (4.3-46.5)	3.8 (0.9-8.6)	1.4 (0.4-5.2)	<0.001
DHA intake (mg/day)	35.4 (15.6-82.2)	18.4 (6.0-38.3)	16.6 (6.0-30.9)	<0.001

Values are presented as median (25th–75th percentile)

EPA + DHA intakes low in all diet groups!

Weder et al. (2021) *European Journal of Nutrition*

Strategies to ensure adequate n-3 PUFA intake from plant-based diets

There is currently very little official guidance available for individuals consuming plant-based diets!

Individuals following plant-based diets should:

- Increase consumption of ALA-rich foods and oil, e.g.
  - 1-3 teaspoons of ALA-rich oil, such as rapeseed, flaxseed, or walnut oil
  - Use of rapeseed oil for cooking and shallow frying
  - Use of (high-quality) rapeseed, flaxseed, walnut oil, or hemp seed oil in salad dressings (check label in store-bought dressings)
- These oils should ideally replace fat/oil rich in saturated fatty acids (e.g. butter, peanut and coconut oil), and linoleic acid (e.g. sunflower oil) to increase conversion rate of ALA to EPA and DHA.
- Individual who are consuming fish, should consume at least 2 portions of (sustainably sourced) fish per week (at least one of them should be oily)
- Individuals who are not consuming fish, especially pregnant and lactating women, children and adolescents, should take a DHA (+EPA) supplement from microalgae.

Lane et al. (2021) *Critical Reviews in Food Science and Nutrition*

Dietary supplements available in Switzerland

- Various non-vegetarian/vegan DHA (+EPA) supplements are available in Switzerland of varying dose and form (capsules, oil, jellies)

- The EFSA has authorised DHA-rich oils from the microalgae *Schizochitrium* sp. as “novel foods” to be used in a number of foods, including nutrient supplements.

1 capsules provides 125 mg EPA and 250 mg DHA from *Schizochitrium* sp.

1 capsules provides ≥83 mg EPA and ≥250 mg DHA from *Schizochitrium* sp.

15-20 drops provides ≥63 mg EPA and ≥128 mg DHA from *Schizochitrium* sp.

EFSA Panel on Dietetic Products, Nutrition and Allergies (2013). Available at: https://efsa.onlinelibrary.wiley.com/doi/full/10.2903/j.efsa.2022.7083

Conclusions

- Very limited data comparing the n-3 PUFA status between children/adolescents consuming omnivorous, vegetarian and vegan diets.
- Recent data from Swiss pregnant women and adolescents indicate that the n-3 long-chain PUFA status in the Swiss population is concerningly low irrespective of diet type.
- Non-fish-eating individuals are highly likely at risk of having a poor n-3 PUFA status, which can have negative consequences for the development and functioning of the brain, eye and immune system.
- In these individuals, DHA (+EPA) supplements (e.g. alga-based) should be recommended and n-3 PUFA status may be assessed and monitored.

Thank you

Nutripaed Foundation

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Recommended reading

1. Rudloff S, Bührer C, Jochum F, Kauth T, Kersting M, Körner A, et al. Vegetarian diets in childhood and adolescence : Position paper of the nutrition committee, German Society for Paediatric and Adolescent Medicine (DGKJ). Mol Cell Pediatr. 2019;6(1):4.

1. Lane KE, Wilson M, Hellon TG, Davies IG. Bioavailability and conversion of plant based sources of omega-3 fatty acids - a scoping review to update supplementation options for vegetarians and vegans. Crit Rev Food Sci Nutr. 2022;62(18):4982-97.