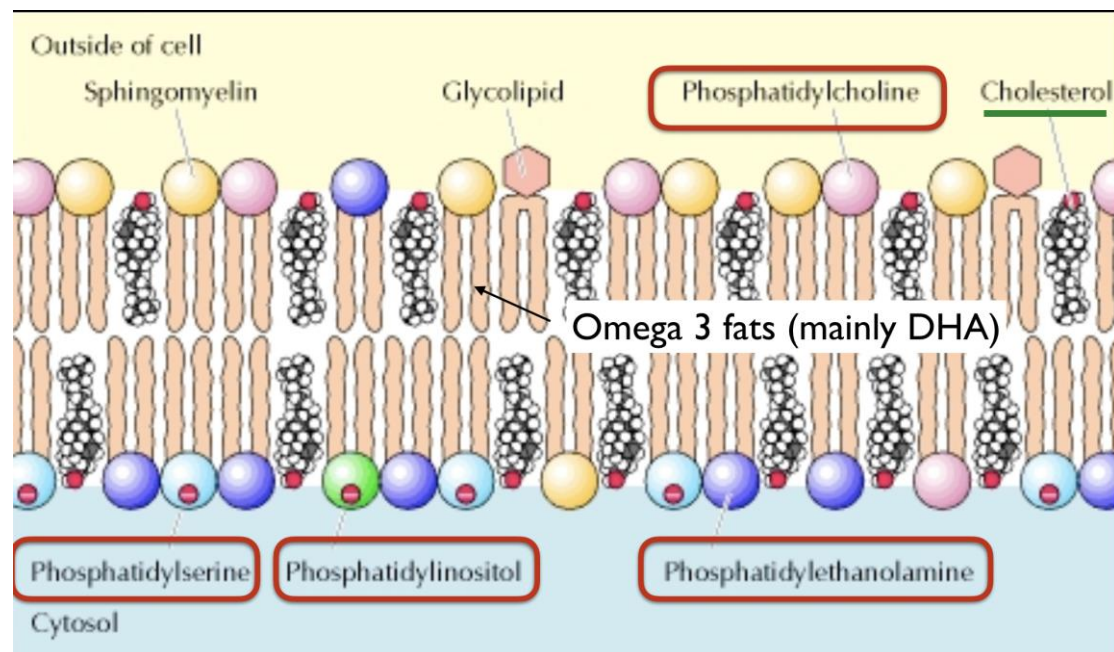


## Phospholipids –A Challenge on a Vegan Diet

Neurons, that is brain and nerve cells, are primarily made out of what's called 'phosphorylated DHA'. That means the omega-3 fat DHA that is bound to a kind of fat called a phospholipid, as shown in the figure below.

Seafood contains phosphorylated DHA but DHA supplements, whether derived from fish oil or algae, is not phosphorylated. Hence, it needs to be attached to phospholipids to work. This attachment is done by a B vitamin dependent process called methylation.

Figure



There are several different kinds of phospholipids with strange names all starting with 'phosphatidyl' such as phosphatidyl choline, phosphatidyl serine, phosphatidyl inositol and phosphatidyl ethanolamine. To a large extent these can be made from phosphatidyl choline. As a group of nutrients they are classified as 'semi-essential' because we can make some, but not enough for optimal health and especially optimal brain health.

As a consequence there are moves afoot to classify choline (which can be easily attached to the 'phosphatidyl' part) as an essential nutrient with a recommended intake. This has come about due to the growing evidence that insufficient choline in

pregnancy leads to cognitive impairment and developmental delay. This is particularly important for vegans because, like DHA, there's not so much choline in plant-based foods, but there is some in foods such as quinoa, soya, beans, nuts and broccoli – also important foods for protein.

Currently an adequate intake of choline is defined as between 400mg and 520mg a day, the latter for pregnant and breast-feeding women. This is based on how much choline you need for healthy fat metabolism, liver function and reducing homocysteine levels. You also need choline to do the right thing with cholesterol in the liver and brain. As you'll see in the figure above, cholesterol is a vital brain component. But these levels don't take into account what's being learnt about choline's role in brain development.<sup>1</sup> A good estimate of optimum daily choline intake would be at least 500mg and maybe double this in pregnancy.

Most important is choline's role in building, and maintaining, a healthy brain. A pregnant woman's intake defines the cognitive abilities of their child. Twenty years ago we knew that pregnant rats fed choline half way through their pregnancy have more connections between brain cells, plus improved learning ability and better memory recall.<sup>2</sup> Now we know it's true for babies with several recent trials showing similar results indicating that more choline in pregnancy enhances cognitive development.

An example of this is a study which gave women in their third trimester of pregnancy either 480mg of choline or almost double this – 930mg. They then tested the babies' information processing speed at 4,7,10 and 13 months. Not only were the babies of the mothers given the higher dose faster but also the longer the mother had been given even the lower dose the faster were the child's reactions. The authors concluded that “even modest increases in maternal choline intake during pregnancy may produce cognitive benefits for offspring<sup>3</sup>”. Seven years later, there will still memory advantages in the children whose mother had extra choline during pregnancy.<sup>4</sup>

Babies are born with blood choline levels three times higher than their mother, illustrating how vital this nutrient is for building neuronal connections, which newborn babies do at a rate of up to a million new connections a second! An optimal

intake for brain function is likely to be a lot higher than the 400 to 500mg recommended for adults, and higher still in pregnancy.

Since brain cells are made of a membrane containing choline (and other phospholipids) attached to the omega-3 fat DHA, without choline the omega-3 doesn't work. The attaching of the two depends on methylation, a process that is dependent on B vitamins, especially B12, folate and B6. Choline helps methylation and healthy methylation, indicated by a low blood level of homocysteine, helps synthesize choline. You need all three – DHA, choline and B vitamins especially B12. So, if you are lacking in DHA, or in vitamin B12, then you'll be doubly dependent on getting enough choline.

### **Choline rich foods - are vegans at risk of deficiency?**

While the richest dietary sources are fish, eggs and organ meats there is significant amounts of choline in plant-based foods, notably soya as in tofu and soya milk, quinoa, nuts and seeds including flax seeds, almonds and peanuts, and cruciferous vegetables including broccoli, cauliflower and Brussels sprouts.

While, on the face of it, it does appear that vegans, especially those planning pregnancy, need to become choline focused in relation to choosing the right daily foods, and possibly supplementing, there is not yet conclusive evidence showing that vegan mothers are at risk, although it is likely that they are. One of the learnings that has come out of studies on omega-3 DHA is that vegan mothers may convert more vegan omega-3 ALA into DHA as an evolutionary imperative – not that a top up with supplementation isn't still the recommendation. Could it be that vegan mothers make more choline if needed since it is so important for brain development? There are very few studies of vegans to know the answer to this question.

One recent study looked at choline levels in breast-milk of vegans, versus vegetarians and non-vegetarians. There was no significant difference with the author of the study concluding “This suggests that maternal plant-based diet by itself is not a risk factor for low breast-milk choline.”

The vegan community is certainly divided on this issue. Of course, the safe or cautious position, while the science unravels, is to supplement choline during pregnancy.

What intake of choline can you achieve from a vegan diet alone? Here's a list of the best plant-based food for choline, compared to egg and fish as a yardstick, listed in order of how much you could get in a reasonable serving\*:

FOOD	CHOLINE PER SERVING	PER 100g
An egg (all in the yolk) 50g	113mg	226mg
Fish eg salmon (100g/3oz)	90mg	90mg
Soya milk (cup – 250g)	57mg	23mg
Shiitake mushrooms (1 cup/145g)	54mg	37mg
Soya flour 12.5g (a cake slice)	24mg	192mg
Peas (1 cup -160g)	47mg	30mg
Quinoa, raw (1/3 cup 60g)	42mg	70mg
Beans, raw (1/3 cup – 60g)	40mg	67mg
black, white, pinto, kidney		
Broccoli, cauliflower		
or sprouts (1 cup/91g)	36mg	40mg
Tofu (half a cup-125g)	35mg	28mg
Hummus (1/2 cup)	34mg	28mg
Chickpeas (1/4 can)	33mg	33mg
Baked beans (1/4 can)	31mg	31mg
Flaxseeds (small handful)	22mg	78mg
Pistachio (small handful)	20mg	71mg
Pine nuts (small handful)	18mg	65mg
Cashews (small handful)	17mg	61mg
Wholegrain bread (2 slices – 50g)	17mg	34mg
Avocado (1/2)	14mg	28mg
Almonds 50g (small handful)	12mg	42mg
Peanuts (small handful)	12mg	42mg
Wheatgerm (tablespoon 7g)	12mg	178mg
Almonds or peanut butter (tbspn)	10mg	61mg

Source: USDA choline content database and <https://nutritiondata.self.com>

\*Many foods have not been analysed for choline, and measurements do vary, so this is a guide rather than a definitive list.

What does this mean for your daily diet? Here's a typical vegan daily menu aimed to maximise choline intake and how much it would give you (I'm not including all foods and recipes, just those ingredients that deliver significant amount of choline):

FOOD	CHOLINE
<b>BREAKFAST</b>	
A cup of soya milk	57mg
Small handful of nuts or seeds (Flax, chia, almonds etc)	20mg
<b>LUNCH</b>	
A cup of cooked quinoa (1/3 cup raw)	43mg
A serving (100g) of either broccoli, cauliflower or Brussels sprouts	36mg
Avocado (1/2)	14mg
<b>SNACKS</b>	
A tablespoon of almond or peanut butter	10mg
Hummus (1/2 cup)	34mg
Two slices of wholegrain bread	17mg
<b>DINNER</b>	
A serving of tofu (125g) or beans	35-40mg
Half a cup of shiitake mushrooms	27mg
A serving (100g) of either broccoli, cauliflower or Brussels sprouts	36mg
<b>TOTAL</b>	<b>332mg</b>

In reality you are unlikely to achieve this every day, and it would be quite limiting on your food choices, so a realistic target would be to achieve 300mg of choline from food. If you are aiming to achieve 500mg, which is the low end of optimal – more than this may be optimal in pregnancy – that leaves a shortfall of around 200mg of choline, suggesting the need for supplementation.

The most direct source of choline is from soya-derived lecithin granules and capsules. A flat tablespoon of lecithin granules (7.5g), which has a neutral and pleasant taste and can be sprinkled on cereals, in shakes and soups or eaten as is, provides 1,500 mg of *phosphatidylcholine* and around 200mg (13 per cent) of choline. Some ‘high phosphatidyl choline’ lecithin, sometimes called ‘high PC lecithin’ is 18 per cent choline, thus you need less – approximately a flat dessertspoon.

One tablespoon of lecithin granules equals three 1,200mg lecithin capsules (if ‘high PC’ two capsules would suffice). We suggest that this is a sensible addition to a completely vegan diet. (If you aspire to be plant-based most, but not all of the time the addition of two eggs, or an egg and a fish serving, would achieve 500mg a day of choline.)

You can also find ‘brain food’ supplements providing a combination of different kinds of phospholipids, not just choline, but its hard to get enough choline from these if your only other food sources are plant-based foods.

In summary, we need both omega-6 and omega-3 fats, as well as phospholipids.

- Have one or two servings a day of dark green, leafy veg – especially those that grow in colder climates such a kale, broccoli, brussels sprouts, or a serving of seaweed as sources of both choline and omega-3.
- Have a serving of quinoa, beans or tofu every day, if not two, for choline.
- Have a dessertspoon of high PC lecithin, or two capsules of high PC lecithin granules every day. These guidelines are especially important if you are planning a pregnancy, pregnant or breast-feeding.

If you are not completely vegan the best food source for phospholipids and choline are eggs. Eat six eggs a week. The choline is in the yolk. The advice re omega-3 – eat three servings of fish a week, is good for choline too but it is present in all fish, not just oily fish high in omega-3 fats.

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<sup>1</sup> Derbyshire E. ‘Could we be overlooking a potential choline crisis in the United Kingdom?’ *BMJ Nutrition, Prevention and Health*, 2019; 0:1–4

<sup>2</sup> Pyapali G, et al., ‘Prenatal dietary choline supplementation decreases the threshold for induction of long-term potentiation in young adult rats.’ *J Neurophysiol.* 1998 Apr;79(4):1790-6.

<sup>3</sup> Caudill, M, et al, ‘Maternal choline supplementation during the third trimester of pregnancy improves infant information processing speed: a randomized, double-blind, controlled feeding study’ *FASEB J.* 2018 Apr;32(4):2172-2180. doi: 10.1096/fj.201700692RR.

<sup>4</sup> Bahnfleth C, et al., ‘Prenatal Choline Supplementation Improves Child Color-location Memory Task Performance at 7 Y of Age (FS05-01-19).’ *Curr. Dev. Nutr.* 2019, 3 (Suppl. 1) doi: 10.1093/cdn/nzz052.FS05-01-19