

Vitamin B12 – Why Vegans Need it

Vitamin B12 is essential for health because it helps make protein, helps red blood cells to carry oxygen, so vital for energy, and is essential for making DNA, building nerves and the brain. One of the most critical processes in the body, methylation, depends on B12. Without healthy methylation blood levels of homocysteine rise, which is associated with pregnancy problems, memory loss, poor mood, increased anxiety and ultimately nerve dysfunction experienced as loss of sensation in the extremities (peripheral neuropathy). Every few seconds there are a billion methylation reactions in your body and brain, all dependent on B12. It's also vital for gene expression - how genes are turned up or down.

Regardless of whether you're vegan B12 insufficiency is quite common, especially in pregnancy and young mothers, and those over 60, affecting at least one in five. Studies worldwide find that between 11 to 90 per cent of vegetarians have B12 deficiency. In countries like India, where lifelong vegetarians form a high proportion of the population, up to 71 per cent of pregnant women are B12 deficient.ⁱ A study in the US found low levels of B12 in the breast milk in 19 per cent of vegans, 18 per cent of vegetarians and 15 per cent of non-vegetarians. Those supplementing B12, however, had higher B12 levels in their breast milk.ⁱⁱ In another US study of vegetarian adults the use of B12 supplements or the use of B12 fortified milk substitutes were good predictors of sufficient blood B12 levels.ⁱⁱⁱ

Vitamin B12 in food has to combine with a stomach secretion called intrinsic factor to be absorbed. Some people don't make enough intrinsic factor and hence are prone to pernicious anaemia, which is one cause of B12 deficiency, and have to either supplement a lot more or have B12 injections. (The Pernicious Anaemia Society's website www.pernicious-anaemia-society.org has very useful information if you suspect you may have an issue.)

Unless you're one of these people you need a minimum of 2.5mcg (the RDA) but ideally should take in 10mcg a day. For those with malabsorption of B12, which is very common in older people and occurs in two in five people in the UK^{iv}. Often 500mcg is required to normalise blood levels and bring the critical marker,

homocysteine, down below 10mcmol/l. Homocysteine levels above this predict brain shrinkage leading to dementia.

Some foods contain 'false' B12 because it is in a form that is unable to bind to intrinsic factor. Hence, the list of nutritional ingredients of plant foods, unless fortified, may include B12 but whether or not this is functional B12 is debatable and should not be assumed.

Overall, it appears that when active B12 is present in plant foods it is largely due to bacterial 'contamination' which could be more positively described as the plant having a symbiotic relationship with bacteria. This can occur from the logs, for example, that shitake mushrooms are grown on, or in open cultivation of algae such as chlorella and spirulina. Since this B12 is not inherent in the plant, but dependent on the growing medium or its symbiotic relationship with bacteria, these foods are a rather hit and miss source of B12. If the food is grown in a sterile environment it may not contain B12. This has led to a more cautious view of the Vegan Society, to either supplement B12 or eat foods fortified with B12, rather than depend on plant foods that supposedly contain B12.

Before we look at the best plant foods for B12, given this caution, the evidence for their viability is largely derived from feeding people these foods and measuring their functional B12 status, and the ability of these foods to correct deficiency. (The best measure of B12 in the blood is called 'holo transcobalamin' or HoloTC, followed by Methyl Malonic Acid or MMA, which goes up if deficient. A raised homocysteine level, meaning poor methylation, is also a very useful indicator.) If you choose to rely on these foods for your B12 it is wise to check your B12 and homocysteine level, and essential to do so if you're contemplating getting pregnant. If your B12 level or HoloTC is low (below 300 pmol/l or 40pmol/l) or MMA above 270 nmol/L or if your homocysteine is above 10mcmol/l then you are endangering your health.

Vitamin B12 in Vegan Foods

The plants that have been found to contain some B12 are various mushrooms, notably shiitake, blue/green algae, nori seaweed and sea buckthorn, which is a plant that

grows close to the sea. In case you didn't know seaweed is algae that clings eg to rocks. Algae is divided into red algae, which grows in the sea, and blue/green algae which grows in freshwater eg lakes.

Algae and Seaweed – A source of B12?

Chlorella and spirulina are blue/green algae, while nori seaweed is a red algae eaten in China as *zicai*, Korea as *kim*, New Zealand as *karengo* and Wales as a traditional *laver* bread. Of all the plant foods nori seems to be the best vegan food for B12.^v However, you do have to eat a lot. To put this into context an analysis of B12 in these different forms of nori found between 3mcg (in welsh nori) and around 60mcg in Chinese and Korean nori per 100 grams.^{vi} Now, a sheet of nori is 2.5 grams. So, to achieve the RDA of 2.5mcg of the most B12 rich untoasted dried nori would require eating two sheets, while to achieve 10mcg would require eating eight sheets a day. Is this functional B12? It appears to be having shown to correct B12 deficiency in animals. However, dried nori seems to be not as good as raw nori. In a study of female volunteers their B12 status got worse when given only dried nori (40 grams) but did not degenerate when given the equivalent amount of raw nori. On further analysis the researcher found that the B12 in the dried nori had converted the B12 into the 'false' form that cannot be efficiently absorbed.^{vii} So, it's hard to rely on nori for B12. If some active B12 is present it is a result of bacterial contamination rather than inherent in the food itself.

The most commonly reported vegan foods for vitamin B12 are supplements or powders of chlorella or spirulina, farmed in freshwater vats and lakes. This is another rather hit or miss source. One analysis of 19 dried chlorella supplements found B12 levels varied from an insignificant less than 0.1mcg to 415mcg per 100 grams. A teaspoon is about 5 grams so you'd have to be eating 20 teaspoons worth to get these levels.

Chlorella grown in open large culture tanks were more likely to have more B12, and it is likely to come from bacterial contamination or the intended addition of B12 into the growing medium.^{viii} Chlorella itself does not require B12 to grow. That having been said a study of seventeen vegan or vegetarian adults given 9 grams, roughly two

teaspoons, of chlorella powder for 60 days showed improvement in B12 status and a reduction in homocysteine, suggesting that the B12 in this chlorella was, at least, absorbable and functional.^{ix}

Spirulina suffers a worse fate, as one study found that 83 per cent of the B12 in the spirulina supplement they analysed was false B12.^x Again, it is likely that any B12 in spirulina comes from bacteria in the growing medium rather than the algae itself. However, the news is not all bad for spirulina. An animal study found that B12 deficient animals fed spirulina for ten weeks did restore their B12 status.^{xi} However, previous studies have identified the B12 in spirulina as false B12,^{xii} which not only doesn't work but inhibits real B12 from working.^{xiii} I would not rely on spirulina as a source of B12. Another algae, AFA Algae (*Aphanizomenon flos-aquae*), like spirulina is often claimed to provide B12 but it is also false B12.^{xiv}

Even so, I'd be very wary of relying on chlorella as your only source of B12. If you do choose to use algae as a source of B12, and not directly supplement it, then I strongly recommend you monitor your B12 level.

Despite its drawbacks in relation to vitamin B12 seaweed and algae are excellent sources of other nutrients that can be lacking in a plant-based, or rather land based diet, namely iodine and selenium. Iodine is essential for proper thyroid function, without which growth and brain development are stunted, while selenium is vital for healthy immunity. Both are rich in seafood, including seaweed, and can be deficient in plant-based food grown on deficient soil, which either means in landlocked regions and not grown organically. An easy way to up seaweed is to eat, for example, Clearspring's Seaweed Crispies as snack, and add to salads as a garnish. Seaweed, in the UK, is certainly a food group that has been largely ignored but features heavily in Japanese food.

Mushrooms are not a reliable source of B12

Various mushrooms are touted as good sources of B12 but, in reality, the amount they provide is very low and, once again, hit and miss both because B12 is not produced

by the mushroom but present from bacteria in the growing medium and you don't know how much is active B12.

The two varieties that appear to have the most are shiitake mushroom (*Lentinula edodes*) and truffles. The former due to contamination from the logs they're grown on and the latter because of where they grow, namely underground and close to tree roots. Studies have measured around 5mcg in shiitake and 11mcg in truffles in a 100 gram dried portion. A cup of mushrooms is about 70 grams, which is about 7 grams dry weight. That means that if you wanted to achieve even the RDA (2.5mcg) you'd have to be eating 50 grams of dried shiitake, or 500 grams of raw shiitake, roughly seven cups a day! Also, you don't know how much of this B12 is active. While shiitake mushrooms do seem to have active B12 a study of Lions Mane mushroom was found to have largely inactive B12.^{xv} The 'dirtier' the mushrooms the more likely they are to have B12 from bacteria from the soil.

An illustration of this was a study measuring blood levels of B12 and homocysteine in ten vegans eating Nori seaweed and wild mushrooms, and not taking supplements, versus supplementing vegans and vegetarians and meat eaters. The mushroom and seaweed eating vegans were borderline B12 status and low vitamin D levels. The supplementing vegans were sufficient in all nutrients.^{xvi}

Sea Buckthorn

Sea buckthorn (*Hippophae rhamnoides*) is a plant that grows by the sea. It's berries, ground in a powder, is available as a supplement and is reported to contain vitamin B12 as well as many other nutrients from vitamin C to omega-7. In one study it was found to contain 37mcg of B12 in 100 grams.^{xvii} That means that 10 grams, roughly two teaspoons, would provide 3.7mcg which is more than the RDA. But again, it is likely to be a result of symbiotic bacteria relating to where and how it grows than the plant itself. Sea buckthorn oil is not likely to contain B12.

B-12 Fortified Foods and Supplements

While the RDA is 2.5mcg an optimal level of B12, correlating with the healthiest levels of homocysteine, and consequently brain health as well as the level required for a healthy pregnancy, is around 10mcg a day. Many nutrition authorities have revised daily requirements to this level. B12 does store in the liver, which is why people who can't absorb it have monthly injections. This means it is not imperative that you get 10mcg every day, but rather average 70mcg a week.

Many vegan foods, especially those that replace a non-vegan source of B-12, are fortified. This can include non-dairy milks, yoghurts, cheeses, egg and meat substitutes. Some cereals do too. But do check. It's not a legal requirement for food producers. Nutritional or brewers yeast doesn't contain B12, unless it is specifically added. Unless a product states that b12 is added assume not. B12 is light sensitive so keep this yeast in a dark cupboard or fridge and buy a yeast product in a light proof container. Yoghurts using live bacteria such as Bifidobacteria, and some fermented food containing bacteria can also provide a little B12 but this is not declared on the label as it's variable. It's worth checking the foods you buy and adding up how much you're getting. Often, fortified foods will provide around 1mcg per serving. So, if in a day you eat three servings of fortified foods you'll be getting 3 mcg. Let's take an example of a typical day:

2 cups of soya/oat/almond/coconut milk (100ml x 2)	2mcg
1 tspn(5g) of nutritional yeast with B12	1mcg
Live coconut yoghurt or a fermented food	?0.5mcg

By far the easiest way to ensure you get enough B12 is to supplement 10mcg, or perhaps half this if you are consciously eating these fortified foods, plus nori and shiitake mushrooms or chlorella or spirulina. Still, since these are unreliable sources, the best is to supplement 10mcg a day so you know your needs are covered. An optimal level, not just the level to prevent deficiency, is probably 20mcg.

Vitamin B12 comes in different forms all ending with – cobalamine. (It's a molecule attached to the mineral cobalt.) The most common is cyanocobalamin, which is cheap, synthetic and stable, and converts into the natural forms of B12 which are hydroxycobalamin, methylcobalamin and adenosylcobalamin. B12, in all these forms,

is made from bacteria. There's an argument for having the natural forms, each of which does something slightly different in the body, but there's no strong evidence that one is vastly superior to another, except for those with inborn genetic abnormalities which may require one particular form of B12.

Most RDA style multivitamins provide 2.5mcg, while optimum multivitamins usually provide 10mcg. Given that you'll also benefit from supplementing vitamin D it's best to choose a multivitamin that gives both 10mcg of B12 and 15mcg of vitamin D.

ⁱ Yajnik C, et al., Vitamin B12 deficiency and hyperhomocysteinemia in rural and urban Indians. *The Journal of the Association of Physicians of India* 2006,54; 775–782.

ⁱⁱ Pawlak R, et al., 'Vitamin B-12 content in breast milk of vegan, vegetarian, and nonvegetarian lactating women in the United States.' *Am J Clin Nutr.* 2018 Sep 1;108(3):525-531

ⁱⁱⁱ Damayanti D, et al., 'Foods and Supplements Associated with Vitamin B12 Biomarkers among Vegetarian and Non-Vegetarian Participants of the Adventist Health Study-2 (AHS-2) Calibration Study.' *Nutrients* 2018 Jun 4;10(6)

^{iv} Vogiatzoglou A, et al, 'Vitamin B12 status and rate of brain volume loss in community-dwelling elderly.' *Neurology* 2008;71:826–832

^v Watanabe F, et al., 'Vitamin B12-containing plantfood sources for vegetarians' *Nutrients* 2014;6:1861–73

^{vi} Watanabe F, Bito B., 'Vitamin B12 sources and microbial interaction' *Experimental Biology and Medicine* 2018; 243: 148–158. DOI: 10.1177/1535370217746612

^{vii} Yamada, K et al., 'Bioavailability of Dried Asakusanori (*Porphyra tenera*) as a Source of Cobalamin (Vitamin B12)' *International Journal for Vitamin and Nutrition Research* 1999 (69):412-418. <https://doi.org/10.1024/0300-9831.69.6.412>.

^{viii} Bito T, et al., 'Characterization and Quantitation of Vitamin B12 Compounds in Various Chlorella Supplements' *J Agric Food Chem.* 2016 Nov 16;64(45):8516-8524.

^{ix} Merchant R, et al., 'Nutritional Supplementation with *Chlorella pyrenoidosa* Lowers Serum Methylmalonic Acid in Vegans and Vegetarians with a Suspected

Vitamin B₁₂ Deficiency.' *J Med Food*. 2015 Dec;18(12):1357-62. doi:
10.1089/jmf.2015.0056

^x Watanabe F, et al., 'Pseudovitamin B(12) is the predominant cobamide of an algal health food, spirulina tablets.' *J Agric Food Chem*. 1999 Nov;47(11):4736-41

^{xi} Madhubalaji C, et al., 'Improvement of vitamin B12 status with Spirulina supplementation in Wistar rats validated through functional and circulatory markers.' *J Food Biochem*. 2019 Nov;43(11):e13038

^{xii} Dagnelie P, et al., 'Vitamin B-12 from algae appears not to be bioavailable.' *Am J Clin Nutr*. 1991;53:695-7

^{xiii} See <https://www.b12-vitamin.com/algae/>

^{xiv} Miyamoto, E, et al. 'Purification and characterization of a corrinoid-compound in an edible cyanobacterium *Aphanizomenon flos-aquae* as a nutritional supplementary food.' *Journal of agricultural and food chemistry*, 2006, 54. Jg., Nr. 25, S. 9604-9607

^{xv} Teng F, et al., 'Vitamin B12[c-lac-tone], a biologically inactive corrinoid compound, occurs in cultured and dried lion's mane mushroom (*Hericium erinaceus*) fruiting bodies' *J Agric Food Chem* 2014;62:1726–32

^{xvi} <https://www.ncbi.nlm.nih.gov/pubmed/25651739>

Schwarz J, et al., 'The influence of a whole food vegan diet with Nori algae and wild mushrooms on selected blood parameters.' *Clin Lab*. 2014;60(12):2039-50.

^{xvii} Nakos M, et al., 'Isolation and analysis of vitamin B12 from plant samples.' *Food Chem*. 2017 Feb 1;216:301-8. doi: 10.1016/j.foodchem.2016.08.037