

## **A Reminder About the importance of Vitamin B<sub>12</sub> for Individuals Choosing Plant-Based Diets**

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**Abstract**

Recent estimates suggest high rates of vitamin B<sub>12</sub> deficiency among the vegetarian and vegan populations, particularly in pregnant women or women of child-bearing age that, for ethical and health reasons, have been shifting towards a higher consumption of plant-based food. There is growing evidence that vitamin B<sub>12</sub> deficiency associated with increased risk of a myriad of diseases (neuro, vascular, immune, and inflammatory); and (2) important during pregnancy and in early development (first 1000 days of life). However, the current “recommendations”, “policy” and “guidelines” for those choosing a plant-based diet, including vegetarianism and in particular veganism, are piecemeal. We provide a robust cautionary note on the importance of vitamin B12 to those individuals seeking to adopt a plant-based diet and in particular a vegan diet, the latter being especially relevant to those choosing to partake in the Veganuary challenge.

**Key Recommendations for individuals choosing a plant-based diet:**

- Take a daily supplement containing 4-7 micrograms of vitamin B<sub>12</sub>, taken with other foods;
- Monitor your vitamin B<sub>12</sub> status particularly if no B<sub>12</sub>-containing supplements has been taken for a period of time;
- Seek expert advice to support planning of a plant-based diet - particularly if becoming vegan;
- Seek expert advice if you are already on a plant-based diet (e.g., vegetarian) and you are: (a) transitioning to a vegan diet, (b) Planning to become pregnant, or (c) Older than 60 years old.

A plant-based diet (PLANT-BASED DIET), in any form, is becoming increasingly common in Western society (Alae-Carew et al., 2021), whether motivated by climatic or animal welfare concerns or simple dietary preferences. Dietary trends should be considered in the broader context of overall nutrition, where both undernutrition and overnutrition have a growing impact on poor global health, termed “The Global Synergy” (Swinburn et al., 2019). Furthermore, given the steep population rise and inevitable strains on global food supply e.g., animal-based products are required to rise by 44% by 2050 to satisfy global consumption a plant-based diet offers a healthier and sustainable solution (*Plant-Based Foods in Europe*, 2020).

**Definitions of a PLANT-BASED DIET**

Various forms of plant-based diets exist, differing in the food groups that consumers exclude. One of the strictest forms of plant-based diet is a vegan diet, which eliminates all animal foods and their by-products, including gelatine and honey. Other plant-based diet categories include Lacto-ovo vegetarians, who eat dairy and eggs but exclude meat and fish, Ovo-vegetarians who include eggs but exclude all other animal products, Lacto-vegetarians who consume dairy products but exclude all other forms of animal products (including eggs), and Pescatarians who only eat fish and shellfish (BDA, 2021 <https://www.bda.uk.com/resource/vegetarian-vegan-plant-based-diet.html>). Finally, some may also “fluidly” label themselves Flexitarian, occasionally eating fish or animal products yet remaining primarily plant-based.

**Current PLANT-BASED DIET trends among UK-dwelling adults**

In the 2018 UK Food Standards Agency's 'Food and You' survey, ~1% of participants followed a vegetarian, partly vegetarian or vegan diet, with 3% identifying as vegetarian and 1% as vegan (Fuller et al., 2019). Importantly, a remarkably similar also seen in Western Europe and North America (Allès et al., 2017; Bakaloudi et al., 2021; Melina et al., 2016a).

### **Factors that underpin PLANT-BASED DIET as a food choice**

Exclusive of cultural influences, the main factors that govern intentions to follow a plant-based diet include ecological, ethical and health concerns (Allès et al., 2017; Leitzmann, 2014). There is also a growing influence of *perceived societal norms* as a factor underpinning plant-based diet as a food choice, adding to the pressure to preserve planetary and human health (Sharps et al., 2021). These trends affect the Western food industry, where the plant-based sector has seen a 49% increase in sales since 2018 (*Plant-Based Foods in Europe*, 2020). This upsurge in the visibility of plant-based alternatives (e.g., proteins), shifts in societal norms and lifestyle have contributed to a cultural shift towards a plant-based diet, as consuming fewer animal products is seen as more viable, healthier, sustainable, and supposedly more economical (Onwezen et al., 2021).

### **Dietary planning and risk of vitamin B<sub>12</sub> deficiency in PLANT-BASED DIETS**

We present quotes from different global societies of Nutrition and Dietetics who have published their expert position statements on plant-based diet below.

**UK** - *"Carefully planned plant-based diets can support healthy living at every age and life stage. Plant-based diets can help to manage weight and may reduce the risk of type 2 diabetes and other chronic diseases. You can get all essential nutrients from plant foods but vegans need to ensure a reliable source of vitamin B12."* (BDA, 2021)

**US** - *"It is the position of the Academy of Nutrition and Dietetics that appropriately planned vegetarian, including vegan, diets are healthful, nutritionally adequate, and may provide health benefits in the prevention and treatment of certain diseases. These diets are appropriate for all stages of the life cycle, including pregnancy, lactation, infancy, childhood, adolescence, older adulthood, and for athletes. Plant-based diets are more environmentally sustainable than diets rich in animal products because they use fewer natural resources and*

*are associated with much less environmental damage". "Vegans need reliable sources of vitamin B-12, such as fortified foods or supplement"- (Melina et al., 2016)*

**Italy** - *"Well-planned vegetarian diets that include a wide variety of plant foods, and a reliable source of vitamin B12, provide adequate nutrient intake. Government agencies and health/nutrition organizations should provide more educational resources to help Italians consume nutritionally adequate vegetarian diets"- (Agnoli et al., 2017)*

**Germany** (childhood and adolescence) - *"Vitamin B12 should be supplemented in people of all age groups who follow a strict vegan diet without consuming animal products. A vegetarian diet in childhood and adolescence requires good information and supervision by a paediatrician, if necessary, in cooperation with an appropriately trained dietary specialist."(Rudloff et al., 2019)*

**Spain** (infants and children) - *"A vegetarian or a vegan diet, as in any other kind of diet, needs to be carefully designed. After reviewing current evidence, even though following a vegetarian diet at any age does not necessarily mean it is unsafe, it is advisable for infant and young children to follow an omnivorous diet or, at least, an ovo-lacto-vegetarian diet." "It also mentions the need to use B12 supplements at all ages, as well as other nutrients (iodine, iron, vitamin D3, poly-unsaturated fatty acid n-3), when required."*

All the statements emphasise vitamin B<sub>12</sub> deficiency as a serious risk to health and wellbeing in both vegetarian and vegan diets and clearly state that adopting such diets, especially vegan diet, requires adequate planning and continuous monitoring. Among the statements, Spain and Germany adopt the most conservative position, in particular warning against adherence to vegan diets in children. The UK statement is vague, which is in line with the general UK approach to recommendations for B<sub>12</sub> (see later). Thus, proper dietary planning and regular monitoring is a sensible point to emphasise. Indeed, we purport that one should not simply just "go vegan", but instead, seek expert support on how to carefully plan and implement a healthful vegan diet.

## **VEGAN DIET in health and disease**

We believe a cautionary note and further clarity are urgently warranted and needs to be added to the putative health benefits associated explicitly with a vegan diet. Consequently, this statement will predominantly review vegan diet.

Firstly, whilst a healthy vegan diet may be associated with better general health and lower risk of some non-communicable diseases, this does not translate to lower mortality rates among those on long-term vegan diets (Key et al., 1999, 2003; Norman & Klaus, 2020). Secondly, there is the risk of micronutrient deficiencies, particularly within a VEGAN DIET, potentially nullifying any putative health benefits (Bakaloudi et al., 2021; Pawlak, 2015; Rizzo et al., 2016; Waldmann et al., 2005; Woo et al., 2014). Furthermore, it is known that a VEGAN DIET lacks adequate amounts of specific micronutrients that are insufficiently found in “plants” or may have low(er) bioavailability. These include iron, calcium, and selenium (Bakaloudi et al., 2021), but the best example is offered by vitamin B<sub>12</sub>, also known as cobalamin, which is only found in animal products in substantial quantities. Vitamin B<sub>12</sub> is an integral cofactor for two vital cellular metabolic reactions (Lyon et al., 2020) and is essential for the synthesis of blood cells and brain nerve tissue (Hunt et al., 2014). Low vitamin B<sub>12</sub> status and overt of vitamin B<sub>12</sub> deficiency among vegans and vegetarians is commonly observed and reported, largely due to low dietary exposure (Bakaloudi et al., 2021; Pawlak et al., 2014; Rizzo et al., 2016). A vegan diet is associated with higher fracture risk, likely due to low BMI (Body Mass Index) and other nutrient deficiencies (Iguacel et al., 2019; Tong et al., 2020). Metabolic signs of vitamin B<sub>12</sub> deficiency may be associated with accelerated bone turnover in those following a plant-based diet, potentially causing adverse effects on bone health (Herrmann et al., 2009). In addition, there is growing evidence mentioning the negative relationship between mental health and a vegan diet, particularly depression (Dobersek et al., 2021; Iguacel et al., 2021). It is currently unclear whether the link between general health/disease and a vegan diet is causal, but current data does suggest that individuals following a vegan diet and have low vitamin B<sub>12</sub> status may be more vulnerable to developing neuropsychiatric and neurological disorders (Kapoor et al., 2017).

### **Vitamin B<sub>12</sub> Deficiency**

The main clinical features of vitamin B<sub>12</sub> deficiency may occur without serum levels being below the usual cut-off for ‘deficiency’ or without a diagnosis of megaloblastic anaemia (Smith et al., 2018). Signs and symptoms include cognitive changes and dyspnoea, whilst the

neurological complications may cause loss of sensation, postural hypotension, muscle weakness or loss of mental and physical drive (NICE, 2020). Low vitamin B<sub>12</sub> status among vegans warrants particular attention given its association with increased risk of a myriad of clinical consequences, including megaloblastic anaemia, pregnancy complications, including developmental anomalies, spontaneous abortions, preeclampsia, and low birth weight (<2500 g). Adequate vitamin B<sub>12</sub> status periconceptionally and during pregnancy plays a vital role in neural myelination, brain and cognitive development, and growth, which may be irreversible (Langan & Goodbred, 2017).

### **Current recommendations for vitamin B<sub>12</sub> in the UK and beyond**

The UK's recommended nutrient intake (RNI) for vitamin B<sub>12</sub> is currently set at 1.5micrograms for adults and is bizarrely unaltered for pregnancy (*Government Dietary Recommendations*, 2016). However, this differs in the USA, where RNI for adults is 2.4micrograms/day and modifies for pregnant and lactating women to 2.6 and 2.8 micrograms/day, respectively (Otten et al., 2006). Within the European Union, the estimated average requirement (EAR) is 4micrograms/day for adults and increases for pregnant and lactating women to 4.5 and 5 micrograms/day, respectively (EFSA Panel on Dietetic Products, Nutrition, and Allergies (NDA), 2015). Thus, the current UK recommendations for vitamin B<sub>12</sub> are piecemeal. Not only are they significantly lower than in other developed countries, but they are also unaltered for different *at-risk* population groups (e.g., women of childbearing age and pregnant women), which we know have substantially higher requirements.

### **Assessment markers**

There are several factors affecting vitamin B<sub>12</sub> status across the life course. Serum vitamin B<sub>12</sub> is the most common way to measure vitamin B<sub>12</sub> levels (Hunt et al., 2014). Other biomarkers such as low holotranscobalamin (holo-TC), and elevated methylmalonic acid (MMA) and homocysteine provide further ways to detect vitamin B<sub>12</sub> deficiency (Ströhle et al., 2019) and metabolic evidence of insufficiency is found at serum levels up to as high as 350pmol/L (Smith et al., 2018). Previous research has shown that Individuals following a vegan diet without consuming vitamin B<sub>12</sub> supplements are at a much higher risk of B<sub>12</sub> insufficiency, leading to low concentrations of holo-TC and serum vitamin B<sub>12</sub>, although this may not equate to cellular deficiency. Therefore, it has been suggested to use holo-TC



accompanied with MMA or homocysteine as appropriate biomarkers to identify a vitamin B<sub>12</sub> insufficiency in those following a vegan diet (Lederer et al., 2019).

### **Population groups adhering to a vegan diet at higher risk of vitamin B<sub>12</sub> deficiency**

Women of childbearing age, pregnant and lactating women, adhering to a vegan diet are at a much higher risk of vitamin B<sub>12</sub> deficiency and their offspring at elevated risk of low birth weight and preterm births (Ars et al., 2019; Rogne et al., 2017). Deficiency rates among vegan pregnant and lactating women are estimated to be as high as 62% (Pawlak et al., 2013), but we urgently need “current” and more representative data, particularly among UK dwelling adults. The current literature among individuals following a plant-based diet shows significantly higher rates of vitamin B<sub>12</sub> deficiency among vegan and vegetarian adults, ranging from 0-87% (Pawlak et al., 2014). As expected, the literature also shows a greater rate of vitamin B<sub>12</sub> deficiency among vegans than vegetarians, although rates among vegetarians are still substantial (up to 40%) and often the data presented pools vegans and vegetarians as one group! The most at-risk population are vegans who do not take any form of vitamin B<sub>12</sub> supplements (Pawlak et al., 2013). We would also like to state that there could be a much greater risk to vegetarian individuals, with already low vitamin B<sub>12</sub> status, who change to a vegan diet.

### **Ensuring adequate B<sub>12</sub> intake among those adhering to VEGAN DIETS**

The British Dietetic Association (BDA) advises those following a vegan diet to use supplements and consume B<sub>12</sub> fortified foods ([www.bda.uk.com/resource/vegetarian-vegan-plant-based-diet.html](http://www.bda.uk.com/resource/vegetarian-vegan-plant-based-diet.html)). However, data from the Quadram institute Food Databanks National Capability (FDNC, Zhang & Traka, 2021) whom have studied the macro/micronutrient composition of available vegan products in the UK supermarkets, have shown that most do not commonly or adequately fortify their products with vitamin B<sub>12</sub>. For example, milk substitutes were found to be far less likely to be fortified with vitamin B<sub>12</sub> than calcium. UK vegans consuming typical vegan diets were found to have significantly lower vitamin B<sub>12</sub> intake than the RNI consuming 0.5 +/- 0.08 micrograms/day, approximately 10% of usual omnivore intake. Overall, they found a general lack of vitamin B<sub>12</sub>, selenium and iodine within animal product substitute foods on the market, suggesting they are undependable for adequate vitamin B<sub>12</sub> intake. Using

supplements within a well-planned vegan diet or plant-based diet could be an acceptable and sustainable method to prevent overt vitamin B<sub>12</sub> deficiency (Weikert et al., 2020).

### **Conclusions**

Vitamin B<sub>12</sub> is an essential nutrient that is completely absent from plant-based foods. We have aimed to provide a robust cautionary note on the importance of vitamin B<sub>12</sub> to those individuals seeking to adopt a plant-based diet and in particular a vegan diet, the latter being especially relevant to those choosing to partake in the Veganuary challenge (see [veganuary.com](http://veganuary.com)). An appropriately planned vegan diet has the potential to uphold a healthy and sustainable life but consideration of a “complete diet” is essential to ensure adequate provision of the nutrient. Adverse health effects are associated with long-term inadequate vitamin B<sub>12</sub> status which is commonly observed among those adhering to a plant-based diets and particularly vegan diets. We specifically highlight women of child-bearing age, pregnant and lactating vegan women as well as those individuals whom are already on a plant-based diet (vegetarians) and who transition to a vegan diet, as a group who are most at risk. Prevention of vitamin B<sub>12</sub> insufficiency through supplementation is an economical, sustainable, and sensible way to avoid such situations. We therefore encourage people planning for a vegan diet to monitor their vitamin B<sub>12</sub> status, take a daily certified supplement of vitamin B<sub>12</sub> of at least 4-7 microgram at a mealtime and seek professional guidance as practical means to ensure long-term well-being.

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