Review

Nutritional Considerations for Implementing a Vegan Diet for Perimenopausal and Post-Menopausal Women as a Form of Non-hormonal Therapy

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Nutritional Considerations for Implementing a Vegan Diet for Perimenopausal and Post-Menopausal Women as a Form of Non-Hormonal Therapy

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Abstract: The menopause is a natural transition that nearly all women experience around 52 years of age. This is caused by a decline in the hormone oestrogen, causing the menstrual cycle to eventually stop. This hormonal decline, typically lasting four to twelve years, can lead to menopausal symptoms such as poor sleep, mood changes, muscle & joint pain, brain fog and hot flushes. Menopausal symptoms can be alleviated and even eradicated through changes in diet. Over the past decade, veganism has risen in popularity for ethical, health, environmental and moral reasons. Following a vegan diet has been shown to reduce the risk of developing health issues that are common during the menopause, such as obesity, cognitive impairment, cardiovascular disease and type 2 diabetes. Vegan menopausal women typically report less bothersome symptoms than omnivores, consequently, more studies are now emerging trialling a vegan diet as a form of non-hormonal therapy to treat menopausal symptoms. As a result, the purpose of this review is to provide nutritional considerations for menopausal women who may be considering a vegan diet. Current evidence suggests that protein, essential nutrients vitamins B12 and D_3, omega 3 fatty acids and minerals calcium, iron, zinc, iodine and selenium should be prioritised. In addition, the risk of obesity is prevalent during the menopausal transition due to the decline in sex steroids reducing basal metabolism. Therefore, a focus on energy balance and appropriate and carefully monitored energy deficits are of utmost importance to meet individual needs to achieve a healthy weight.

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1. Introduction

It can be argued that the basis for a happy and long life is hormonal balance [1]. Hormones are substances that are released into the bloodstream from glands or organs, to then bind to a receptor to accelerate, slow down or alter cellular function [2]. A gradual decline in hormones is experienced by all humans as early as 30 years of age [3]. For women, around the age of 52 [4], a decline in the hormone oestrogen leads to irregular periods, to eventually the menstrual cycle stopping altogether [5]. This is known as the menopause, a natural transition over a third of the UK female population are experiencing currently [6,7]. The menopause only lasts for one day, marking the one-year anniversary of a woman's last period [8]. Induced menopause can be brought on after surgery to remove the ovaries (oophorectomy) or uterus (hysterectomy) [9]. Perimenopause occurs before the menopause and can be identified by the first onset of menstrual irregularity and/or experiencing menopausal symptoms despite still having periods [10]. Menopausal symptoms such as poor sleep, mood changes, muscle & joint pain, brain fog and hot flushes are highly prevalent, usually lasting for four years, sometimes up to twelve [11]. In 2023, a UK survey of over 6,500 menopausal women revealed that 73% experienced hot flushes at work, 63% felt drowsy and 47% struggled to concentrate

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and experienced low mood, all impacting the ability to do their jobs [12]. In another survey of 11,000 women, it was highlighted that 83% of Britain's workplaces had no formal menopause support [13]. Consequently, it comes as no surprise that depression and anxiety is more common in menopausal women [14], with longitudinal studies indicating that the likelihood of depressed mood can be up to three times greater compared to premenopausal women [15]. Furthermore, it is likely that the decline in mood of menopausal women contributes, at least in part, to the estimated £117.9 billion it costs the NHS to treat poor mental health annually [16].

To treat menopausal symptoms, hormone replacement therapy (HRT) is prescribed to supplement oestrogen and/or progesterone, mimicking hormones produced by the ovaries [17]. HRT is effective at relieving menopausal symptoms, in addition to preventing osteoporosis and CVD [18,19]. In 2002, a study was published indicating that HRT can increase the risk of breast cancer, strokes and heart attacks [20]. This resulted in high media coverage, causing UK HRT users to fall from 2 million to <1 million between the years 2003-2007 [21]. The study was later re-analysed after the discovery that most of the participants were more than a decade past their final menstrual period, suggesting the results should not be applied to younger women [22]. Since then, new findings show that the association between HRT use and diagnosed breast cancer is negligible [23]. In a 13-year longitudinal study intervention on over 27,000 women in the United States, it was concluded that there is little or no increased risk of developing breast cancer from HRT in comparison to a placebo [24]. The stigma around HRT remained prevalent until 2021, when the demand of HRT users began to increase from 1.48 million to nearly 2 million in under a year [25]. This was likely due to the air of Channel 4's documentary 'Sex, Myths and The Menopause' reaching 2 million viewers [26], and Maisie Hill's book 'Perimenopause Power' [27] selling 40,000 copies [28] both released in March 2021 dispelling the shame and fear around HRT and the menopause.

Despite the positive increase in HRT amongst women in the UK [29] there is a demand for non-hormonal therapy (NHT) to control menopausal symptoms due to the side-effects and risks from taking HRT [30]. Equally, if NHT intervention can be applied outside of healthcare, this provides independence and autonomy to women. Perhaps more importantly, the side-effects of HRT include acne, breast pain, nausea, hair loss or a mild rash/itchy skin, which may impact wellbeing. Equally, whilst current data now suggests that HRT is safe, there is still ambiguity and further research is required [31]. Additionally, during the very start of perimenopause, oestrogen can often surge higher than pre-menopause, meaning HRT may not be suitable during this time [32]. One method to explore NHT is via dietary intervention, which is essential in the primary prevention of chronic diseases and a healthy lifestyle [33]. Therefore, for women opting for NHT to alleviate menopausal symptoms, dietary therapy is advised as part of a lifestyle change. The diseases associated with the menopause, such as cardiovascular disease (CVD), tumours, type 2 diabetes mellitus (T2DM) and osteoporosis, can be drastically improved by eliminating or reducing dietary risk factors. As diet directly impacts cellular functions that are controlled by hormones [34], a higher consumption of processed foods, saturated fat, refined grains, fatty meats, sweets, and sugary beverages have been associated with an increased intensity of menopausal symptoms across a variety of demographics [35–38]. It is worth noting, however, women remain largely under-represented in medical literature [39] and studies investigating the relationship between diet and menopausal symptoms are scarce [40]. Longitudinal studies like The Women's Health Initiative launched in 1991, created the motivation for more robust and comprehensive studies on women's health and aging [41]. Furthermore, The Study of Women's Health Across the Nation, launched in 1994, was the first to highlight how women from different ethnicities characterise the menopausal experience [42].

New studies have started to emerge trialling a vegan diet specifically to lower symptoms in post-menopausal women [43]. Between 2023 and 2024, an estimated 1.1 million more UK adults adopted a vegan lifestyle. Around a quarter of UK Millennials and Generation Z follow the lifestyle, in comparison to an average of just 10% for the remaining older generations [44]. This is likely due to and increase in scientific literature (84% were published in the last 10 years [57]) and the links between processed/red meat intake and cancer as recent as the 1990s, with the World Health

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Organisation (WHO) classifying processed/red meat as carcinogenic in 2015 [45] the rise in influential vegan documentaries such as the 'Game Changers' and 'Seaspiracy' [46]. Veganism is characterised by the exclusion of any animal derived foods such as meat, eggs, dairy, and honey, with a diet consisting exclusively of plant derived foods [47]. The driving factor towards a vegan diet are the ethical values related to animal welfare [48] and environmental issues linked to the meat industry being recognized as one of the leading polluters [49], and potential health benefits [50]. Veganism has been shown to reduce the risk of all-cause mortality and cancer incidence, in addition to lower risk of blood disease and CVD. In addition, studies have shown implementing such a diet is effective to reduce body mass [51], adiposity [52], total cholesterol [53] and improving glycaemic control in comparison to an omnivorous diet [54]. Furthermore, concerns over the extensive use of antibiotics in animals in the meat and dairy industry leading to antibiotic resistance in humans has been highlighted [55]. An estimated 1.27 million human deaths attributed to antibiotic resistance in 2019 [56]. These factors suggest further investigation into the numerous benefits from a vegan diet are warranted.

Despite the positive research associated with veganism, the vegan diet is also associated with reduced bone mineral density (BMD), resulting in an increase in bone fractures and osteoporosis [58,59]; a condition already prevalent in post-menopausal women [60]. Additionally, there is a misconception that protein is difficult to obtain in a vegan diet [61], furthermore, research shows vegans are more likely to be deficient in essential nutrients such as vitamins B12 and D_3, omega 3 fatty acids and minerals calcium, iron, zinc, iodine and selenium [62]. Therefore, the purpose of this review is to summarise the recommendations for a balanced vegan diet during the menopause, highlighting the key nutrients needed to avoid nutritional deficiencies and risk of osteoporosis.

2. Discussion

The Effects of a Vegan Diet During the Menopause

There are several health issues prevalent in menopausal women due to the reduction in hormones: obesity, cognitive impairment, CVD, T2DM, sarcopenia and osteoporosis are most common [63–66]. Adopting a vegan diet during the menopause can raise concerns about inadequate nutrient intake, however, a well-planned vegan diet that includes sufficient calories and nutrients can reduce the risk of developing the aforementioned health issues [67,68]. Studies assessing the impact of a vegan diet on menopausal symptoms is limited, however the studies that are available show promising results. In a survey of over 700 peri/post-menopausal women, vegans reported less bothersome vasomotor and physical menopausal symptoms than omnivores [30]. Furthermore, during a 12-week study, 84% of the post-menopausal participants of varying ethnicities following a vegan diet became free of moderate-to-severe hot flushes [69]. In another study of the same duration, the 42 participants following the diet saw an 88% decrease in moderate-to-severe hot flushes and greater reductions in menopausal symptoms compared to the control group who continued their usual diets. However, details of their usual diets were not mentioned, and no conflict of interest was stated [43]. As hot flushes occur in most menopausal women with HRT virtually eliminating them, oestrogens are evidently involved in their aetiology [70]. This could explain why phytoestrogen found in soybeans, which are plant compounds with oestrogen-like properties, have been shown to reduce menopausal symptoms [71,72]. In one clinical trial lasting 16 weeks, postmenopausal women supplementing dietary soy containing 90mg of isoflavones, a compound found in phytoestrogens, saw a 49% improvement in hot flushes in comparison to the women using HRT seeing a 45% improvement [73]. However, it should be mentioned that due to the lack of a placebo arm to the study, the placebo effect cannot be ruled out. Additionally, emerging evidence on the effects of nutrition on brain aging suggests that more favourable cognitive measures are associated with low plasma trans-fat levels, a dietary fat found naturally within certain meats [74] and abundant in baked goods specifically containing dairy [75]. Brain-supporting nutrition patterns are also associated with vitamin E [76], A [77] and C [78], several carotenes [79], and dietary fibres, all nutrients found only

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in plant foods [80]. As a result, considering the menopause impacts brain structure, connectivity and energy metabolism [81], it is no surprise that the vegan diet is effective at relieving menopausal symptoms.

Protein

Protein, made from a long chain of amino acids, is essential for the maintenance of every system and structure in the body, including skeletal muscle and hormone production [82]. It has been estimated that muscle mass starts to reduce from the age of 50 years by 0.5–1% annually [83]. During the menopause, dietary protein requirements increase, [84,85], this is due to the reduction in capacity of skeletal muscles activating protein synthesis, in response to anabolic stimuli, increasing the need for more protein [86]. Maintained skeletal muscle mass is associated with a higher dietary protein intake of ≥1.2 g·kg−1·d−1 amongst post-menopausal women, in comparison to those with low protein intake of ≤ 0.8 g·kg−1·d−1 [40,87]. Furthermore, in a 3-year study of over 24,000 women aged 65-79 years, the participants who consumed a higher protein intake were associated with a 32% lower risk of frailty [84]. Out of the twenty amino acids required by the body, nine cannot be synthesised and must be ingested via food. To fulfil protein requirements on a vegan diet, the consumption of complimentary legumes, nuts, seeds and grains are recommended to obtain a complete array of essential amino acids, as most plant foods alone do not contain all the essential amino acids, also known as a complete protein [88]. Furthermore, studies conclude that a high protein vegan diet is as efficacious in supporting muscle strength and protein synthesis as a protein content-matched omnivorous diet amongst healthy young adults between 21 and 30, and older adults aged 58-85 [89–92]. Currently, the recommended dietary allowance (RDA) for protein at any age is 0.8g per kg of body weight [93]. These recommendations are considered as the minimum amount to maintain nitrogen balance and does not include physical activity level (PAL), therefore, protein requirements vary on an individual basis [94]. However, in one study, mid-thigh muscle area decreased by −1.7 ± 0.6 cm^2 in participants aged 55 to 77 years after following protein intake at RDA levels for 14 weeks [95]. As a result, based on the evidence available, a diet should provide at least 1.2g-1.3g protein/kg body weight/day for healthy older adults, with a further increase for individuals with a higher PAL [40,96].

Table 1. Protein food recommendations [97,98]. Protein - 1.2g-1.3g/kg body weight/day for healthy older adults, with a further increase for individuals with a higher PAL.

Food	Quantity	Protein (g)
pea protein (powdered)	30g	24
seitan (wheat gluten)	75g	18.7
calcium set tofu	100g	13
kidney beans, cooked	150g	12
chickpeas, cooked	100g	11
edamame beans, cooked	100g	11
red lentils, cooked	100g	8.1
wild rice, cooked	150g	8

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peanut butter	30g	6.8
quinoa, cooked	150g	7
soy milk	200ml	6.6

Essential Nutrients

The following nutrients are termed 'essential' as they cannot be synthesised by the body and must be ingested as food or supplementation with meals [99]. To optimise the absorption of essential nutrients, a diet rich in whole foods is optimal, as the fibre content slows down the digestion of food in the intestinal tract where the nutrients are extracted [100].

Vitamin B12

Cobalamin, a water-soluble vitamin also known as vitamin B12, is found in extensive quantities only in animal foods [101]. Due to its scarce presence in plant foods, it is essential that vegans consume either supplements or fortified foods to obtain this micronutrient [102]. B12 plays a vital role in the nervous system, and severe deficiency can cause symptoms such as loss of control of the bowel and bladder, memory loss, dementia, depression, general weakness and psychosis [103]. Additionally, there is emerging evidence that deficiencies in B12 could be connected to the development of sarcopenia, the age-related decline in muscle mass/function [104]. Adequate B12 intake significantly reduces the serum homocysteine level and, therefore, the risk of stroke [105]. A decline in cognitive function is common in menopausal women [106], therefore it is vital for menopausal women following a vegan diet to supplement B12. The RDA for vitamin B12 in the UK is 1.5 micrograms (μg)/d [104], however, research suggests that vegans may require a higher dose of this vitamin due to differences in the utilization and absorption of vitamin B12 from plant sources [102,107]. As a result, a high intake of 4-7 μg B12/day is recommended to secure an adequate B12 status comparable to that of healthy omnivores [108,109].

Table 2. Vitamin B12 food recommendations [110]. Vitamin B12 – 4-7 μg/day.

Food//supplement	Quantity	Vitamin B12 (μg)
supplement	1x tablet	4-7
fortified soy milk	100g	0.9
fortified cereals	40g	~6

Vitamin D_3

Vitamin D_3 is a fat-soluble micronutrient, integral to maintaining optimal bone health by promoting calcium absorption [111]. Several studies have highlighted the importance of adequate vitamin D_3 intake for maintaining BMD in menopausal and elderly women [112–114], as osteoporosis is very common during this period in women with low serum vitamin D_3 levels [115]. The body creates vitamin D_3 when exposed to sunlight, however, during the autumn and winter months in certain countries (e.g., UK), or for individuals who are not exposed to sunlight, vitamin D_3 should be ingested to avoid a deficiency [116]. The rate of hydroxylation of vitamin D_3 precursors in the body decreases with age, in addition to reduced skin synthesis of vitamin D_3 [117]. Consequently, postmenopausal women are significantly more at risk of musculoskeletal diseases related to vitamin D_3 deficiency, as well as dementia, than premenopausal women [118]. Plant sources of vitamin D_3 is

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limited to mushrooms that have been exposed to ultraviolet light, fortified cereals and non-dairy milk substitutes [119]. This is likely why vegans observed in literature typically exhibit lower vitamin D_3 intake and serum 25-hydroxyvitamin D (25(OH)D) levels, in comparison to omnivores who have more options such as oily fish or egg yolk [120,121]. The RDA for vitamin D_3 in the UK for anyone over the age of 1 year is 10 μg/day [122], however, studies suggest that this is too low to prevent fractures [123–125]. Therefore, a daily intake of a minimum 20μg (800 IU) vitamin D_3 supplement is recommended to prevent bone loss and reduce hip fractures in menopausal women [126–128]. Despite vitamin D_3 overdosing leading to hypercalcemia is rare [129], dosing should be monitored on a case-by-case basis, not exceeding the proposed upper limit of 100 μg/day [130]. Advantageous 25(OH)D serum levels are 30-48 ng/ml (75 nmol/L) in relation to maintained BMD [131,132].

Table 3. Vitamin D_3 food recommendations [119,133]. Vitamin D_3 - 20μg (800 IU)/day.

	Food/supplement	**Quantity**	**Vitamin D_3 (μg)**
	supplement	1x tablet	20
	fortified soy milk	100ml	56
	UV treated mushrooms	100g	~50 (depending on source)

Omega-3 Fatty Acids

Omega-3 fatty acids, also termed n-3, are a family of polyunsaturated fatty acids (PUFA). PUFA *α*-linolenic acid (ALA) is a precursor of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), the remaining two omega-3 oils found in seafood [134]. Due to the dietary restrictions, vegans can only consume ALA sources of omega-3s, these include flax, hemp, canola, soy, and walnut oils [135]. The human body converts ALA into EPA and DHA, as these more active longer-chain metabolites are more bioavailable and more easily absorbed. ALA converts to EPA and DHA at rates lower than 10% [136,137]. However, research shows that ALA is elongated and desaturated in a tissue-dependent manner, the carbons are then conserved and reused for synthesis of other products including cholesterol and fatty acids, deeming the low conversion rate redundant [138]. The adequate intake guidelines for ALA omega-3 suggest a daily intake of 1.1g for women. One tablespoon of the aforementioned oils or capsules rich in ALA derived from linseed, or marine algae, is recommended for maximum absorption on a vegan diet, rather than the whole seed [139]. This is because linseed, for example, can potentially pass through the gut unchanged due to the hard external shell, reducing the absorption of the PUFAs [140]. Adequate intake of ALA has been associated with a lower risk of health issues related to the menopause. Examples include a lower risk of total mortality related to a significantly lower risk of non-CVD deaths [141], an increase in BMD [142] and a potential mechanism for T2DM risk reduction from improving insulin sensitivity [143]. Additionally, regular consumption of linseed has been shown to significantly reduce low-density lipoprotein cholesterol by 12.5% in 3 weeks in postmenopausal women [144].

Table 4. Omega 3 fatty acid recommendations [139]. ALA Omega 3 fatty acids – 1.1g/day.

Food	**Quantity**	**Omega 3 ALA (g)**
walnuts	1x tbsp (28.4g)	2.57
flaxseeds	1x tbsp (28.4g)	2.35

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soybean oil	1x tbsp (13.6g)	1.23

Calcium

Calcium is a mineral needed by the body to increase and maintain BMD [145]. Low BMD has been associated with the vegan diet, potentially leading to osteoporosis [146], a degenerative skeletal condition common in the menopause [147]. Bone loss can accelerate to as much as 2-5%/year immediately before and up to 10 years post-menopause [148,149]. As a result, the reluctance to adopt a vegan diet during the menopause is understandable. However, lower BMD and increased fracture rates appear to be linked to a lower average calcium intake amongst vegan participants in studies [150]. Despite vegans exhibiting lower calcium intake, in comparison to a diet that incorporates dairy, a well-planned vegan diet can successfully maintain a healthy calcium status [151]. Furthermore, BMD loss can be controlled just as effectively as HRT with adequate calcium intake [152]. Calcium-rich plant foods include green leafy vegetables, tofu, tahini, in addition to fortified products such as cereals or milk alternatives. Vegetables with low-oxalate levels have an optimal absorption rate, such as broccoli, Chinese cabbage, pak choi and kale [98,153]. To reduce fracture risk in menopausal women, 700-1200mg/day of calcium is recommended and should not be exceeded. Calcium intake above the recommended amount does not reduce fracture risk [154] and high intake could reduce zinc absorption [155].

Table 5. Calcium food recommendations [98,156,157]. Calcium – 700-1200mg/day.

Food	Quantity	Calcium (mg)
calcium pressed tofu	100g	400
fortified ready oat cereal	30g	402
fortified soy milk	200ml	240
fortified soy yoghurt	150g	180
kale, cooked	80g	120
tahini	15g	102
almonds	30g	81
dried figs	30g (2x figs)	75
pak choi, steamed	80g	58
Chinese cabbage, raw	80g	37
Broccoli, steamed	80g	35

Iron

Typically, 3-4g of the mineral iron is found in the body, 80% of this is predominantly combined with haemoglobin in red blood cells. This iron-protein compound increases the oxygen-carrying

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capacity of blood [158]. The remaining 20% of the body's iron is stored in liver, spleen and bone marrow as a reserve for when dietary intake is insufficient [159]. Iron deficiency (ID) typically causes fatigue, a symptom prevalent during the menopause [160]. ID can lead to anaemia, a condition that occurs when the body has deficient blood cells, which if left untreated can lead to heart failure [161,162]. Iron plays an important role in collagen synthesis and vitamin D_3 metabolism, consequently, it has been hypothesised that iron deficiency negatively affects bone through different mechanisms [163,164]. In a questionnaire survey of over 14,000 women ranging from 45-50 years of age, women with a recent or past iron deficiency reported that their physical and mental wellbeing was significantly lower compared to women with a history of iron sufficiency [165]. Blood ferritin, a protein that stores iron, and iron levels in vegans are typically lower than non-vegans, even when consuming an equal iron intake to omnivores [166,167]. This is mainly due to the less effective absorption rate of non-haeme iron, only found in plant-derived foods, in comparison to haeme-iron in animal sources [168]. The RDA for menopausal women is 8.7mg/day [169]. Iron sources for vegans include spinach, soy, dried figs, beans, and cocoa products such as dark chocolate [2,170]. Including foods rich in vitamin C helps to increase iron absorption, due to the ascorbic acid increasing the solubility of the non-haeme iron. Foods containing phytates or tannins, such as tea or coffee, reduces iron absorption [171]. As haem-iron is only found in animal foods, vegans are not at risk of the risks associated with haem-iron overdosing [172]. Risks associated with non-haem iron overdosing does not appear in literature, however overdosing using supplements is rare but can occur [173]. As a result, for women opting for iron supplements in addition to food, doses should not exceed the RDA.

Table 6. Iron food recommendations [98,157,170]. Iron – 8.7mg/day.

Food	Quantity	Iron (mg)
bran flakes	48g	6.5
dark chocolate	2x tbsp	5.4
porridge oats	40g	3.6
pumpkin seeds	50g	2.5
soybeans	80g	2.4
spinach, raw	80g	1.6
dried figs	30g (2x figs)	1.2

Zinc

The mineral zinc is a critical component in the communication between neurons, with roles in practically every cell and tissue type [174]. Research suggests that adequate zinc intake, which is 7mg for women >19 years of age [121] can reduce age-related macular degeneration, which is the primary cause of vision loss in older people, as the human retina has high zinc concentrations [175]. Zinc and calcium, along with trace elements magnesium, and potentially copper, are essential cofactors involved in the synthesis of various bone matrix constituents [176,177]. As a result, zinc deficiency is thought to play a key role in bone loss experienced during the menopause [178], as zinc and magnesium serum samples from post-menopausal women with osteoporosis are typically lower compared to women with normal bone health [177,179]. Zinc also aids in iron metabolism, therefore, decreased plasma zinc levels can result in iron deficiency anaemia [180]. Plant-food sources of zinc include whole grains such as oats or barley, in addition to peas, nuts, soybeans and legumes [181].

 doi:10.20944/preprints202502.1953.v1

Zinc absorption rates in plant-derived sources are limited due to the phytic acid present [47], the inhibitory effects of phytate can be minimised by methods such as soaking, heating, sprouting, fermenting and leavening [182]. For example, soaking chickpeas for 12h decreases phytic acid content by 55%, thus increasing the bioavailability of zinc [181].

Table 7. Zinc food recommendations [157]. Zinc – 7mg/day.

Food	Quantity	Zinc (mg)
bran flakes	48g	5
cashew nuts	30g	1.7
Brazil nuts	2x tbsp	1.3
tahini (sesame butter)	2x tbsp	1.3
peanut butter	2x tbsp	1
pearl barley, boiled	150g	1
porridge oats	40g	0.9
soybeans	80g	0.7
peas, boiled	80g	0.6

Iodine

The mineral iodine is required by the thyroid gland to synthesize thyroxine and triiodothyronine, two hormones that accelerate resting metabolism [183]. Vegans have a higher prevalence of iodine deficiency due to the exclusion of iodine-rich foods such as dairy, eggs or fish in their diet [184,185]. Iodine deficiency can cause hypothyroidism [186] resulting in a reduction of metabolism and weight gain [187]. As the incidence of metabolic syndrome in postmenopausal women is 2–3 times higher than before menopause, meeting the recommended 140 μg/day is essential for women choosing to go vegan during the menopause transition [169]. Menopausal women are recommended to consume an iodine supplement of 140 μg/day to meet dietary requirements [188], as vegan dietary sources such as iodised table salt [189] and seaweed [190] contain a negligible amount, and limited plant-based alternatives to milk are fortified with iodine in the UK and worldwide [191].

Table 8. Iodine food recommendations [98,191]. Iodine - 140 μg/day.

Food/supplement	Quantity	Iodine (μg)
supplement	1x tablet	140
peanuts	30g	6
cashew nuts	30g	3.3
walnuts	30g	2.7

 doi:10.20944/preprints202502.1953.v1

red lentils, cooked	100g	2

Selenium

The mineral selenium, as well as iodine, is required for thyroid health [192]. It is also an antioxidant [193], helping to prevent cell damage, in addition to preventing mental health decline, and potentially reducing the risk of heart disease and certain cancers [194,195]. Reports show that, in the UK, 51% of adult women were below the lower reference nutrient intake of 40µg/day [196]. Selenium-rich plant foods include grains such as wheat and rice as well as sunflower seeds and asparagus [197]. Vegans typically have a lower intake of selenium [198], however, just one Brazil nut per day typically contains enough selenium to more than meet the recommended 60µg/day [199]. Alternatively, if a supplement is preferred, the recommended intake should not be exceeded due to risks of selenium toxicity [200].

Table 9. Selenium food recommendations [199,201]. Selenium - 40µg/day.

	Food/supplement	**Quantity**	**Selenium (µg)**
Brazil nuts		1x nut	288
supplement		1x tablet	60
white rice, cooked		80g	50
green lentils, cooked		100g	18
sunflower seeds		30g	14.7
wholemeal bread		100g	11
white pasta, cooked		100g	10
asparagus, steamed		80g	7.2

Other Areas of Importance

There are other important nutrients that should be mentioned for menopausal women, these are vitamins B1 (thiamine), B2 (riboflavin), B3 (niacin), B6 (pyridoxin), B9 (folate), and minerals magnesium and copper [179, 202, 203). Vegans have been shown to have lower levels of vitamin B2, but higher concentrations of folate compared to omnivores [146]. Furthermore, by adhering to a diverse whole food vegan diet, a deficiency in these nutrients is unlikely.

Table 10. Food recommendations for vitamin B1, B2, B3, B6, B9 and minerals magnesium and copper [98,122,204].

	Nutrient	**RDA**	**Food**	**Quantity**
	B2 (riboflavin)	1.1mg/day	1 tsp yeast extract (e.g. marmite)	1mg
			170g buckwheat	1mg

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		184g hulled barley	1mg
		48g bran flakes	0.67mg
		30g almonds	0.28mg
		80g mushrooms	0.37mg
		100g fortified bread	0.24mg
B6	1.2mg/day	48g bran flakes	0.67mg
		100g baked potatoes with skin	0.61mg
		30g pistachio nuts	0.51mg
		100g firm tofu	0.5mg
		100g chickpeas, cooked	0.47mg
		100g peeled banana	0.37mg
		80g red pepper, raw	0.29mg
		100ml fortified soy milk	0.23mg
B9 (folate)	200µg/day		0.2mg
		150g wild rice, cooked	128.8µg
		80g spinach, raw	116µg
		80g pinto beans, cooked	64µg
			57.6µg
			15.9µg
B1 (thiamine)	0.8mg/day	2x Weetabix biscuits	0.48mg
		80g broccoli, steamed	0.42mg
		30g peanut butter	0.38mg
		30g sunflower seeds	0.23mg
		40g porridge oats	0.20mg
B3 (niacin)	13.2mg/day	30g multigrain hoops	6.6mg
			5.3mg
		100g pinto beans, cooked	2.7mg

 doi:10.20944/preprints202502.1953.v1

		5g yeast extract (e.g. marmite)	3.2mg
		80g green beans, steamed	3.1mg
		2x Weetabix biscuits	1.5mg
			1.5mg
magnesium	270mg/day	185g brown rice, cooked	81mg
		5g yeast extract (e.g. marmite)	81mg
		170g wholewheat pasta, cooked	81mg
		30g tahini	52mg
		80g bulgur wheat, cooked	38-58mg
			23mg
copper	1.2mg/day	30g ground almonds	0.68mg
		30g cashew nuts	0.63mg
		30g pumpkin seeds	0.47mg
		30 pine nuts	0.44mg
		80g edamame beans	0.40mg
		70%-90% dark chocolate	0.21mg
		100g tofu	0.16mg
		30g sunflower seeds	
		30g cashew nuts	
		30g pumpkin seeds	
		30g tahini	
		30g walnuts	
		100g cooked green lentils	
		1x tsp cocoa powder	

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Energy Intake

During the menopause, the basal metabolism decreases due to the lack of sex steroids, therefore increasing the risk of obesity during the transition [205]. Consequently, energy requirements should be calculated on an individual basis to meet specific needs. For example, to reduce fat mass while maintaining skeletal muscle mass, a ~500 kcal lower energy intake per day than the current total energy requirement, whilst meeting the previously mentioned protein recommendations, is generally recommended to achieve a negative energy balance [206,207]. However, slower and more conservative negative energy balance may also be a practical option to ease the burden of reduced energy intake. It is also worth noting that determining energy expenditure accurately is also extremely difficult in the real world, and therefore to ensure an appropriate energy balance is present, regular body mass checks are the best indicator. Reductions of approximately 1-2lb (0.5 – 1kg) per week is sustainable and recommended [207], however, regular follow-ups are also recommended to monitor if weight cycling occurs (i.e., repeated loss and regain of body weight). Severe energy restriction (i.e., >500 calories per day) is not recommended as this may then either lower than the basal metabolic rate, lead to micronutrient deficiency or gallstones, or does not lead to weight loss in the long term [208]. Furthermore, calorie restriction can reduce oestrogen levels further, resulting in reduced bone formation, and resultantly, weaker bones [209]. The largest barrier to appropriate energy balance is adherence, and to promote this the use of behaviour change strategies are generally recommended, including exploring the capability, opportunity, motivations for behaviour change (COM-B). Finally, a downstream benefit of optimal body composition is that these changes will support the treatment of co-morbidities, such as cardiovascular disorders and metabolic complications [207].

5. Conclusions

Evidence suggests a balanced vegan diet can be achieved in peri/post-menopausal women to aid the alleviation of menopausal symptoms, all whilst meeting nutritional requirements. This review plays a crucial role in highlighting the potential nutritional deficiencies that may arise in veganism and the menopause, providing effective strategies to address them. Although the mechanisms underlying why the vegan diet can lessen symptoms have not yet been confirmed, research suggests this may be due to positive effects on brain health, hormonal function and nutrition patterns consistent with that of a vegan diet. A well-planned vegan diet has also been shown to reduce the risk of health issues prevalent during the menopause transition. Vegan menopausal women should supplement vitamins B12 and D_3 and mineral iodine due to the lack of plant-food sources, in addition to consuming plant-foods rich in omega 3 fatty acids, and minerals calcium, zinc and selenium. However, before supplementation is considered a blood test should always be carried out to confirm deficiency. If deficient, supplementation, especially for B12, Iodine, D3, will plausibly be required. Additional studies are needed to determine the mechanisms behind vegan nutrition patterns in connection with the alleviation of menopausal symptoms, especially during perimenopause. This will allow more informed decisions for menopausal women choosing to seek treatment in the form of NHT.

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