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The Safety of a Vegan Diet During Pregnancy

Bezpieczeństwo diety wegańskiej podczas ciąży

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Summary

There is an increasing number of people who go vegetarian. Some young parents also switch to this diet. The safety of vegetarian diets, especially vegan diets, is very important, especially during pregnancy. Unfortunately, reference publications do not provide coherent data on the safety of vegetarian diets during pregnancy. On the one hand, the vegan diet has advantages because it reduces the risk of heart disease and gestational diabetes. On the other hand, vegetarians/vegans should be aware of potential deficiencies of some nutrients (iron, zinc, vitamin B12, vitamin D, omega-3 fatty acids, calcium, iodine) and the clinical consequences for the fetus. For example, iron deficiency may affect cognitive abilities, behavior, intelligence and increase the risk of preterm birth and low birth weight of infants. Plant food contains non-haem iron with variable absorption. Therefore, the vegan diet should include nutrients increasing the bioavailability of iron, e.g. ascorbic acid, carotene and retinol. Due to the fact that animal food is the main source of vitamin B12, vegans are at a very high risk of vitamin B12 deficiency, which will affect the infant's weight at birth. Low level of vitamin D, which is prevalent in animal food, is the most common deficiency among vegans and lacto-ovo vegetarians. This vitamin prevents gestational diabetes, reduces insulin resistance and guarantees normal function of the musculoskeletal system. Zinc deficiency during pregnancy may lead to preterm birth, neural tube defects or even miscarriage. In view of the clinical consequences of potential deficiencies of nutrients, the vegetarian/vegan diet should be well balanced.

Keywords: **vegan diet, pregnancy, advantages, disadvantages, vegetarian diet**

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INTRODUCTION

There is an increasing number of people who go vegetarian [2, 5]. It is estimated that about 5% of the population in Europe and 3.3% of the US population choose this lifestyle [5]. The percentage of young vegetarians amounts to 6–11% [59] and 29% in India due to religious reasons [18]. Many vegetarians are young parents. Therefore, it is essential to assess the safety of vegetarian diets, mainly vegan diet, during pregnancy [5]. Pregnancy requires increased consumption of macro- and micronutrients and a well-balanced diet. This is necessary for the health of the mother and the offspring. Plant-based diets contain less saturated fatty acids, animal protein and cholesterol,

Table 1. Diet models of vegetarian diet [5]

Diet model	Products excluded from the diet
Ovo-lacto-vegetarianism	• meat, fishes
Ovo-vegetarianism	• meat, fishes, milk
Lacto-vegetarianism	• meat, fishes, eggs
Veganism	• meat, fishes, eggs, milk, honey

Table 2. Extreme dietary patterns in the vegan diet [18]

Diet model	Approved food
Vitarianism	• unprocessed food or cooked at low temperatures
Fruitarianism	• fruits, nuts, seeds, bread, tofu
Macrobiotic diet	• grains, vegetables, legumes, fruits, dried fruits

but more folic acid, fiber, antioxidants, phytochemicals and carotenoids. However, they have low content of necessary nutrients such as iron, zinc, vitamin B12, vitamin D, omega-3 fatty acids, calcium and iodine. Therefore, refraining from eating food of animal origin may cause nutritional deficits [59]. Health care professionals should inform vegans about these consequences and suggest appropriate supplementation as a possible solution [18]. Vegetarian diets include various nutritional profiles, which depend on the degree of restriction or exclusion of one or more types of food (Table 1) [5]. Vegans may also adopt extreme dietary patterns (Table 2) [18].

Religious and ethical reasons, philosophical issues, healthy eating and environmental impact are the main reasons for following appropriate dietary patterns [18]. According to the American Dietetic Association and the Academy of Nutrition and Dietetics, balanced and well-planned vegetarian diets, including vegan diets, are safe during pregnancy [12, 39]. By contrast, the German Nutrition Society and the European Society for Paediatric Gastroenterology, Hepatology and Nutrition do not recommend vegan diets during pregnancy [39, 54]. Reference publications do not provide coherent data on the safety of vegetarian diets during pregnancy. Therefore, the aim of this review was to assess the safety of these diets during pregnancy [18].

IRON DEFICIENCY

Iron is necessary for normal function of all cells because it participates in supplying oxygen to them. It takes part in the transport of electrons and influences enzymatic activity. A high rate of cellular metabolism increases the demand for iron [21]. There is a higher demand for iron during pregnancy due to an increase in the volume of maternal blood and its transport to the fetus and placenta [59]. Iron is necessary for normal development of the fetus. Iron deficiency (ID) may affect cognitive abilities, behavior and intelligence due to permanent brain damage. Besides, ID increases the risk of preterm birth and low birth weight of infants [41]. The necessary amount of iron for normal pregnancy is 1,000-1,200 mg. A woman should have at least 500 mg of iron before conception in order to end pregnancy without iron supplementation and the risk of ID or iron deficiency anemia (IDA) [42]. Iron supplementation is necessary when the hemoglobin level drops below 110 g/l in the first trimester and below 150 g/l in the second and third trimester of pregnancy [2]. Women with anemia should be supplemented with iron compounds before planned pregnancy and then again after the eighth week of pregnancy (the risk of high levels of iron in the follicular fluid may increase the risk of malformations) [27]. In Germany the recommended dose of iron for pregnant women is 30 mg per day [28]. Because of its high bioavailability and safety, elemental iron is recommended by the Polish Neonatal Society [61]. Apart from that, ferrous or ferric salts, fumarate, sulfate and gluconate are recommended as oral supplements. Ferrous salts are better absorbed than ferric salts [17].

All pregnant women are at risk of ID. A well-balanced vegan diet can satisfy the demand for iron. Nevertheless, some authors think that vegans should increase the recommended daily iron intake up to 80%. Plant-based food contains non-haem iron, whose absorption may vary. The method of preparing a meal affects the bioavailability of iron. It is increased by vitamin C [2]. Ascorbic acid facilitates the transformation of Fe^{3+} into Fe^{2+}, which is an absorbable form. Apart from that, vitamin C counteracts absorption inhibitors, which form insoluble compounds. It chelates iron and thus makes it soluble [13]. Ascorbate also affects iron metabolism and cellular uptake. It increases ferritin synthesis, inhibits the degradation of lysosomal ferritin and reduces cellular iron outflow [29].

The absorption of iron is also enhanced by carotene and retinol [2]. The mechanism of action of vitamin A on iron absorption is not fully understood. Researchers believe that retinol forms chelates with iron and prevents binding to adverse compounds such as phytates. Vitamin A is an antioxidant and can also prevent the conversion

of Fe^{2+} into Fe^{3+} [20]. Piperine may also have a positive effect on iron absorption [17]. However, its absorption is reduced by phytates, calcium, coffee, and fiber [59]. Phytic acid forms insoluble compounds with iron due to chelation. The human body cannot digest and absorb these complexes [22]. Coffee, tea and wine contain polyphenols, which also inhibit absorption. It is believed that calcium inhibits the initial absorption of iron into erythrocytes [25].

VITAMIN B12 DEFICIENCY

Vitamin B12 is a cofactor for methionine synthase and methylmalonyl-CoA mutase. It is involved in the conversion of homocysteine to methionine and the formation of succinyl-CoA from methylmalonyl-CoA. These reactions are part of the folic acid cycle and methionine cycle. Vitamin B12 is necessary for erythropoiesis, the production of neurotransmitters and synthesis of DNA and RNA [19]. In pregnancy the average daily demand for vitamin B12 is 2.2 μg [59]. According to Polish sources, the recommended daily intake of vitamin B12 for pregnant women is 2.6 μg [26]. Vegans are at very high risk of deficiency of this vitamin [59], because its main source is animal food. Vitamin B12 can also be found in plant-based foods, e.g. dried edible algae – green and purple lavers (nori) and mushrooms – black trumpet and golden chanterelle. Also, cooking methods such as frying, boiling, steaming, grilling and microwaving reduce the vitamin content in food [65]. The supplementation of 4 μg daily is recommended [59]. According to Baroni, many clinical trials have shown that high intravenous doses are recommended at the beginning of pregnancy and oral supplementation later [2]. Intrinsic factor (IF) is required for the absorption of vitamin B12 after oral administration. First, the IF- B12 complex is formed and then vitamin B12 is transported through the ileum. Only a small fraction of a high oral dose of vitamin B12 is absorbed. Sublingual administration is an alternative route. The results show that it is an effective method of increasing vitamin B12 levels [14]. Various forms of the vitamin B12 are available. Due to better bioavailability and safety, it is preferable to use methylcobalamin, adenosylocobalamin or hydroxycobalamin instead cyanocobalamin. Age, genetics and gastrointestinal pathologies may affect absorption [47]. Vitamin B12 deficiency may negatively affect fetal development. Vitamin B12 may be important for fetal brain development and it affects birth weight [48]. Vitamin B12 deficiency may cause neuropathy as a result of degeneration of nerve fibres and lead to brain damage [67]. As results from the systematic review and meta-analysis of data, a low level of vitamin B12 increases the risk of low birth weight. There is a linear association between the maternal plasma vitamin B12 concentration and preterm birth [55]. Vitamin B12 deficiency may increase the risk of type 2 diabetes [48]. Stewart et al. [62] proved the dependency between vitamin B12 levels and insulin resistance. Their study showed that low levels of vitamin B12 increased the risk of insulin resistance in children. A plant-based diet may result in high levels of folate in the blood, which corrects the hematological symptoms caused by vitamin B12 deficiency [59]. Folates are necessary for DNA synthesis and cell replication. Their deficiency may cause neural tube defects, e.g. spina bifida and anencephaly. There is also a higher risk of preeclampsia, miscarriage, prematurity, and low birth weight. Folates participate in the metabolism of one-carbon compounds and the methionine and S-adenosyl methionine (SAM) synthesis. When there are optimal levels of folates and too little vitamin B12 in the body, methionine synthesis is disturbed and SAM is not formed (vitamin B12 is a cofactor in methionine synthesis). SAM is necessary for the methylation of DNA, lipids and proteins [10]. The Polish Society of Gynecologists and Obstetricians recommends that pregnant women in I trimester (up to 12 weeks) be supplemented with 0.4-0.8 mg folic acid daily, after 12 weeks 0.6-0.8 mg [7, 27], whereas the recommended daily allowance of dietary folate equivalent is 0.6 mg. Nevertheless, additional supplementation is also recommended [26].

ZINC DEFICIENCY

Zinc is necessary for the normal function of metalloenzymes. It participates in the synthesis of nucleic acids and carbohydrate and protein metabolism. Besides, it has antioxidative properties. Zinc deficiency causes incorrect sexual and skeletal maturation, impaired growth and weakens the immune system. As new cells are formed very quickly during pregnancy, an adequate level of zinc in the mother's body is necessary for proper fetal development. It is believed that zinc deficiency may lead to preterm birth, neural tube defects or even miscarriage [11]. Anencephaly, encephalocele and spina bifida are some of the most severe congenital neural tube defects (NTD). According to Golalipour, NTD in infants are associated with maternal zinc deficiency [23]. Nossier et al. conducted a randomized double-blind study on zinc supplementation in pregnant women. The results showed that preterm birth, stillbirth and neonatal morbidity were less common with zinc supplementation [45]. Zinc deficiency was accounted for 20% of perinatal deaths in the world in 2011 [4]. The Institute of Medicine (now the National Academy of Medicine) recommends that adult pregnant women should take 11 mg of zinc daily [15]. Nuts, whole seeds, grains and legumes are products with high content of zinc [30]. Yeast is also a popular source of zinc [2]. Its absorption is limited by phytates and oxalates. Its bioavailability is increased by soaking, fermentation and milling. Zinc absorption can also be increased by fruit hydroxy acids, organic acids, amino acids containing sulphur or peptides containing cysteine [30]. Iron reduces the absorption of zinc. Zinc affects copper homeostasis and decreases its absorption [32]. Consumption of this mineral should be controlled due to the adverse effects of high doses. Long-term intake of high doses of zinc from supplements reduces the body's immune response and HDL-cholesterol levels. Chronic high consumption of zinc may cause copper deficiencies and serious neurological diseases. Zinc excess may significantly contribute to the development of Alzheimer's disease [26].

VITAMIN D DEFICIENCY

Vitamin D is a lipid-soluble steroid hormone [46]. It occurs in the form of cholecalciferol (vitamin D3) and ergocalciferol (vitamin D2). Vitamin D3 can be found in animal food, e.g. fatty fish, egg yolk. It can also be produced in the skin from the 7-dehydrocholesterol precursor under the influence of UV-B radiation. Vitamin D2 is contained in mushrooms and yeast [50]. Its small amounts can also be found in broccoli, beans and green leafy vegetables. Vitamin D deficiency is the most common among vegans and lacto-ovo vegetarians [59]. Xie et al. found that the average vitamin D level in vegans was 15 ng/ml [68]. Vitamin D deficiency can be prevented by prolonged exposure to sunlight and consumption of fortified foods [59]. The supply of vitamin D is best reflected by the concentration of 25-hydroxyvitamin D (25(OH)D) in plasma [50]. The optimal level of 25(OH)D for pregnant women is more than 75 nmol/l (30 ng/ml). Sebastiani et al. recommend a dose of 1.000-2.000 IU. It is considered to be safe during pregnancy and helps to prevent vitamin D deficiency in newborns [59]. The Polish Society of Gynaecologists and Obstetricians recommends a daily dose of 1500-2000 IU of vitamin D3 in pregnancy [27]. Both forms of vitamin D (ergocalciferol and cholecalciferol) are absorbed to the same extent in the intestines. The bioavailability of vitamin D is greater when it is in an oily solution rather than in a solid form in combination with cellulose or starch. Accessibility can be enhanced by emulsification and encapsulation. The incorporation of vitamin D into nanoparticles is also beneficial. There is reduced absorption of vitamin D in people with pancreatic insufficiency, obstructive jaundice, cystic fibrosis, and gastric surgery. Studies show that vitamin D contained in mushrooms is highly bioavailable. The effectiveness of vitamin D supplementation can be increased through a diet rich in monounsaturated fatty acids. Vitamin E, phytosterols and fat substitute impair the intestinal absorption of this vitamin. However, the impact of fiber on its absorption is not fully understood [37]. Vitamin D modulates insulin receptor expression. This increases insulin response to glucose transport. Moreover, vitamin D prevents gestational diabetes and reduces insulin resistance. It regulates blood pressure and maintains an adequate volume of electrolytes and plasma [59]. It is necessary for the musculoskeletal system to function normally. Low levels of 25(OH)D are a risk factor for preeclampsia as well as asthma, allergic rhinitis, respiratory tract infections and eczema in children. Studies have shown that an insufficient intake of vitamin D increases the risk of preterm birth and low birth weight of the child [50]. Taneja et al. conducted a study on vitamin D deficiency and the effects of its supplementation in pregnancy. The results showed that the deficiency of this vitamin increased the incidence of gestational diabetes, preeclampsia and premature delivery [64].

OMEGA-3 FATTY ACIDS DEFICIENCY

Linoleic acid (LA, omega-6) and α-linolenic acid (ALA, omega-3) are polyunsaturated fatty acids. LA is converted into arachidonic acid (AA, omega-6) and ALA is converted into eicosapentaenoic acid (EPA, omega-3) and docosahexaenoic acid (DHA, omega-3). DHA is an important component of nerve membranes and the retina. It accumulates in the brain and retina at the end of pregnancy and in early postnatal life. An adequate DHA supply is necessary for optimal visual and neurological development in early life [59]. ALA consumption by vegetarians and vegans is similar to its consumption by non-vegetarians. The vegetarian diet is characterized by low EPA and DHA consumption, whereas these fatty acids are usually absent from the vegan diet [39]. The DHA levels in umbilical cord plasma phospholipids in vegetarians were 32% lower than in non-vegetarians. The consumption of EPA and DHA in lacto-ovo-vegetarians was almost undetectable, whereas in vegans it was not measurable. By contrast, the non-vegetarians in the study consumed about 80 mg EPA and 40-100 mg DHA daily. The results of these studies suggest that although women can convert ALA into EPA and DHA and they are capable of metabolic adaptations to increase maternal DHA levels during pregnancy, vegan and vegetarian women do not seem to be able to compensate for the low intake of EPA and DHA during pregnancy. Therefore, vegans might not provide enough DHA for proper fetal development [57]. ALA is poorly transformed into DHA and EPA in the body. 2–5% of ALA is converted into DHA in the human body [6]. Healthy people except pregnant women can maintain sufficient and stable levels for many years by EPA and DHA synthesis from ALA [39]. High LA intake inhibits DHA synthesis from ALA. Consequently, the most favorable balanced ratio of the intake of omega-6 and omega-3 fatty acids for vegetarians should be 1:2 or 1:3 to improve the conversion of ALA to more physiologically active fatty acids such as EPA and DHA [59]. Insufficient intake of energy, protein, pyridoxine, biotin, calcium, copper, magnesium, zinc and excessive consumption of trans fatty acids and alcohol also inhibit the synthesis EPA and DHA, whose plant sources are very limited (mainly some seaweeds) [1]. According to Koletzko et al., pregnant women who do not eat sea fish should take DHA supplements (at least 200 mg daily). By comparison, the Polish Gynaecological Society recommends min. 200 mg [27, 28]. In randomized controlled trials, supplementation with fish oil or omega-3 fatty acids, such as DHA, significantly reduced the risk of premature births to 34 weeks of pregnancy [28]. DHA supplements in the form of microalgae can be an alternative to vegans [2, 6]. It is noteworthy that products containing shark liver oil are not a source of omega-3 long-chain poly-unsaturated fatty acids (LC-PUFA). They contain almost exclusively alkylglycerols. Omega-3 LC-PUFA can be found in oils extracted from marine algae. It is very important to ensure a high quality source of DHA without the risk of contamination with heavy metals, dioxins and polychlorinated biphenyls, which can be harmful to the health. Dietary supplements obtained biotechnologically from Schizochytrium sp. algae are a safe source of DHA, because they are grown under controlled conditions to prevent the penetration of various impurities from sea water into their structure. This breeding technology guarantees the safety of the DHA obtained [53]. As DHA is beneficial to the length of pregnancy, life

functions of infants and neurological development, vegetarians and vegans should maintain adequate DHA levels during pregnancy and lactation. The differences in the lipid structure in which DHA and EPA are supplied may influence their bioavailability. However, most current formulations are limited by moderate solubility, increased dispersion, and poor lipid digestion. Supplements with high-fat meals may help to improve their bioavailability. However, this requires a high-fat diet and timely intake of supplements with the meal, which may affect patient compliance. Dietary supplements are available for consumers wishing to increase their intake of nutrients. However, many of them are in ethyl ester formulations, from which EPA and DHA are poorly absorbed when consumed without a meal containing dietary fat. Technologies have been developed to enhance EPA and DHA absorption through in-situ emulsification, which facilitates bioavailability even in the absence of a fat-containing meal. The results of randomized controlled trials on absorption enhancers incorporated into omega-3 fatty acid supplements show that they can markedly improve the bioavailability of EPA and DHA [31, 33, 34]. The absorption of fatty acids is reduced by calcium ions that form complexes with them [58].

CALCIUM DEFICIENCY

Calcium is very important for the health of both the mother and the foetus. Calcium deficiency causes low birth weight, intrauterine growth restriction, poor bone mineralization and preterm birth. Moreover, it increases the risk of preeclampsia and mother's hypertension [66]. The study by Egeland showed that calcium deficiency may lead to hypertension [16]. The daily calcium intake recommended to pregnant women by the WHO and FAO (The Food and Agriculture Organisation) is 1,200 mg [66]. According to the Polish Society of Gynaecologists and Obstetricians, the daily demand for calcium in pregnant women is about 1,200 mg. However, it is rarely balanced by diet and requires supplementation with oral preparations [52]. The average daily calcium intake in vegans is 483 mg [34]. However, according to Baroni, the demand for calcium can be satisfied by eating foods with high content of this element, e.g. sesame seeds, cruciferous vegetables, leafy vegetables with low content of oxalates, almonds, enriched plant milk, soy, tofu and dried figs. Tap and mineral water are also important sources of calcium [2]. The WHO recommends that pregnant women should be supplemented with calcium to reduce the risk of preeclampsia [66]. Calcium can be absorbed by active transport or passive diffusion. The intensity of active transport depends on the body's needs and food intake. Vitamin D and age do not affect passive diffusion. Calcium can only be absorbed if it is in a soluble form [24]. Calcium occurs in the form of various compounds, but carbonate and citrate are the most common supplements. Calcium carbonate should be taken while eating, whereas calcium citrate can be taken without a meal [63]. Calcium citrate reduces the bioavailability of non-haem iron when it is taken on an empty stomach [9].

The study published by Rzymski et al. shows that calcium citrate malate is most readily absorbed, compared to calcium pyruvate and calcium carbonate. But then, the urinary calcium loss is the highest. Rzymski et al. suggest that calcium carbonate and calcium pyruvate are the most efficient in supplementation [56]. In the case of a vegan diet, it is important to note that calcium absorption is impaired with meals high in oxalate and phytates [49].

IODINE DEFICIENCY

Iodine is an essential component of thyroid hormones. Iodine deficiency may cause various problems for both the mother and fetus. The severity depends on the degree of deficiency and the stage of fetal development. Serious deficiency in the mother may cause defects of the fetus's central nervous system or even its death. Iodine is necessary for proper brain development during infancy and childhood, and its deficiency causes mental retardation [60]. A vegan diet may cause low iodine intake, because meat, fish and dairy products are the main sources of iodine in the diet. However, iodine in salt may reduce the risk of deficiency. The safest way for pregnant vegan women to achieve the required iodine level is by consumption of iodized salt [59]. The content of iodine per gram of iodized salt is different in various countries [2]. The World Health Organization (WHO) suggests limiting the daily salt intake to 5 g to control blood pressure levels. Vegans are less likely to develop hypertension, so a slightly higher salt intake during pregnancy may be considered harmless [2]. According to SINU (Italian Società Italiana di Nutrizione Umana) and Polish recommendations, the estimated average daily demand for iodine in pregnant women is 150-200 µg [27, 59]. The adequate daily iodine intake for these women is 220 µg [26]. Women with thyroid disorders should consult a doctor before supplementation. A study on German non-vegan patients showed that the average daily iodine intake in women of childbearing age was 125 µg. Therefore, the median value did not reach the reference intake for adult women – 200 µg/day and the higher intake recommended by the German Dietary Society for pregnant women – 230 µg/day. According to Koletzko et al., pregnant women should take 100-150 µg of iodine every day in addition to a balanced diet. Many epidemiological studies indicate that even moderate iodine deficiencies, especially in early pregnancy, or thyroid hormone deficiency (hypothyroxinaemia) during this period may have adverse effects on the child's cognitive and psychomotor development. The iodine content in sea algae, especially dried algae and seaweed products, may vary significantly, and in some cases it may be very high. Therefore, even small amounts of algae/seaweed products, along with several iodized dietary supplements, may cause increased intake of iodine [28]. Excessive iodine intake may disturb fetal and postnatal thyroid function [2]. In addition, algae can be rich in arsenic and other impurities. Therefore, their consumption is not recommended [28]. Iodine from food products is usually well absorbed (between 70%–90%). However,

Table 3. Advantages and disadvantages of use vegan diet

Advantages	Disadvanteges
Lower risk of heart diseases	Iron deficiency
Lower blood pressure	Zinc deficiency
Lower cholesterol levels	Vitamin B12 deficiency
Rarely cesarean section, postpartum depression and preeclampsia	Vitamin D deficiency
Reduced risk of gestational diabetes	Omega-3 fatty acids deficiency
Reduced risk of eczema and wheezing in children	Calcium deficiency
Lower levels of glycated hemoglobin	Iodine deficiency
	Hypothyroidism

Table 4. Recommendations for the daily supplementation and for the daily dietary intake during pregnancy

Component	Polish recommendation [27]	WHO recommendation [13]	German recommendation [28]	The daily consumption requirement or sufficient intake* during pregnancy [26]
Iron	26-27 mg after a medically diagnosed deficiency	30-60 mg	after a medically diagnosed deficiency	27 mg
Witamin B12	-	-	-	2.6 µg*
Zinc	-	-	-	11 mg
Witamin D3	1500-2000 IU	200 IU (for pregnant women with documented vitamin D deficiency)	800 IU (in periods of low sunlight)	15 µg
DHA	min. 200 mg (1000 mg in conditions of significant deficiency)	-	200 mg (if oily sea fishes aren't included in diet)	100-200 mg
Calcium	-	1.5-2.0 g (in populations with low dietary calcium intake)	-	1000 mg
Iodine	150-200 µg	250 µg	100-150 µg	220 µg*

food may contain substances that impede its absorption – goitrogens found in cruciferous plants (cabbage, Brussels sprouts, cauliflower, broccoli, spinach, kale, kohlrabi, swede, turnip). The amount of goitrogens can be significantly reduced by cooking. However, it is important to cook vegetables without a lid, because adverse compounds evaporate with steam. Peanuts are also an important source of goitrogens. The amount of goitrogens in peanuts can be reduced by soaking them before consumption. The goitrogenic effect of these products increases along with decreasing iodine supply [40, 44]. It is noteworthy that currently iodized salt is the most prevalent food supplement to control iodine deficiency disorders. However, inorganic iodine (KI or KIO3) from salt is less bioavailable than iodine from plant (or animal) sources [43]. Attention should be paid to hypothyroidism caused by the lack of iodine in the vegan diet. Shaikh et al. described a ten-day-old infant with a goiter, who had an elevated TSH level during screening. The vegan mother also had a goiter and her diet was low in iodine. The mother's thyroid function was normalized by the administration of Lugol's iodine. Thyroxine was prescribed to the child after an elevated TSH screening and withdrawn at two weeks when its plasma TSH level was normal. Thyroid function tests remained normal and the goiter disappeared at two months of age. Maternal diets should be determined at an early stage of antenatal care and supplemented if necessary to avoid maternal and fetal health risks. Although iodine deficiency is rarely diagnosed in clinical practice in the Western world, this report shows that it may still occur, especially in vegans [60]. In this case, attention should also be paid to the anti-thyroid effect of soy milk consumed by vegan mothers. Soy ingredients, isoflavones such as genistein and daidzein, inactivate thyroid peroxidase (TPO), thus inhibiting iodine organization. Genistein is a stronger TPO inhibitor than 6-propylthiouracil or methimazole. The anti-thyroid activity of soybeans is usually seen in the context of relative iodine deficiency, and studies show synergy between iodine deficiency and the soy intake. It is likely that the described case reflects the connection between relatively low iodine intake and soy milk consumption. Clinicians should be aware that soy-based diets significantly aggravate iodine deficiency and this is especially important for pregnant women and newborns [8].

Amiodarone is a benzofuran derivative and an iodine-rich drug administered to pregnant women to treat either maternal or fetal tachyarrhythmia. Amiodarone, its main metabolite (desethylamiodarone), and iodine are transferred, albeit incompletely, through the placenta, which results in a significant fetal exposure to the drug and iodine overload. Since the fetus acquires the capacity to escape the acute Wolff-Chaikoff effect only late in gestation, an iodine overload may cause fetal/neonatal hypothyroidism and goiter. Bartalena et al. studied 64 pregnancies in which amiodarone was given to the mother and noted 11 cases (17%) of hypothyroidism in the offspring. Hypothyroidism was transient in all cases. The assessment of the neurodevelopment of the hypothyroid infants showed some instances of mild abnormalities, most often resembling non-verbal learning disability syndrome. However, these features were also observed in some amiodarone-exposed euthyroid infants. This suggests that there might be a direct neurotoxic effect of amiodarone during fetal life. The authors concluded that the use of amiodarone in pregnancy should be limited to maternal/fetal tachyarrhythmia if it is resistant to other drugs or is life-threatening. It seems prudent to advise treating fetal/neonatal hypothyroidism as soon as it is diagnosed, even in utero, to avoid neurodevelopment abnormalities, although these may occur independently of hypothyroidism [3].

ADVANTAGES

A well-balanced plant-based diet seems to be beneficial at all stages of life. Vegans have lower blood pressure, lower cholesterol levels and are leaner than omnivores. They are at lower risk of heart disease. Caesarean section, postpartum depression and preeclampsia rarely occur in vegans. High fiber intake in the vegan diet helps to reduce the risk of gestational diabetes. The consumption of fruit and vegetables reduces the risk of eczema and wheezing [51]. It is believed that the vegan diet reduces exposure to genotoxic factors and prevents neural tube defects, diabetes, and orofacial clefts [2]. Studies show that vegans have lower levels of glycated haemoglobin (HbA1c), total and LDL cholesterol than omnivores [38]. Table 3 shows the advantages and disadvantages of the vegan diet.

CONCLUSION

According to the American Dietetic Association and the Academy of Nutrition and Dietetics, balanced and well-planned vegetarian diets, including vegan diets, are safe during pregnancy [12, 39].

However, there is high incidence of nutrient deficiency in pregnant vegans. The vegan diet may cause deficiency of iron, zinc, calcium, iodine, vitamin B12, vitamin D, and omega-3 fatty acids. Therefore, during pregnancy vegans should consult a specialist on their diet. A well-balanced vegan diet usually provides a good level of nutrients in pregnancy if it is combined with supplementation with folic acid, iron, zinc, calcium, iodine, vitamin D, vitamin B12 and omega-3 fatty acids [35, 36]. Despite the disadvantages, vegan diets also have many benefits.

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