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THE IMPACT OF PLANT-BASED AND PLANT-RICH DIETS ON MACRONUTRIENT AND MICRONUTRIENT DEMAND AND FETAL HEALTH: A REVIEW

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ABSTRACT

Introduction and purpose: Vegetarian and vegan diets are increasingly adopted by women of reproductive age due to their potential health and environmental benefits. However, pregnancy places higher nutritional demands on the body, and plant-based diets may increase the risk of certain nutrient deficiencies if not properly managed. This review explores the impact of vegetarian diets on maternal and neonatal outcomes. Evidence suggests that strict vegetarian diets are associated with lower birthweights and a higher incidence of small for gestational age (SGA) infants, although results vary between studies. Vegetarian mothers generally gain less weight during pregnancy and may be more likely to initiate and maintain breastfeeding. No consistent differences were observed in the rates of gestational diabetes, preeclampsia, or preterm birth across dietary groups. Nutrients of concern include vitamin B12, iron, vitamin D, calcium, DHA, zinc, and iodine. With appropriate dietary planning and supplementation, vegetarian and vegan diets can support healthy pregnancies and positive maternal and infant outcomes.
Material and Methods: A comprehensive literature review was conducted using the PubMed and GoogleScholar databases, focusing on articles published since 2020. The search included the keywords: “vegetarian diet”, “pregnancy”, “pregnancy and diet” in various combination.
Results: Strict vegetarian diets in pregnancy are often linked to lower birthweights and a higher risk of small for gestational age (SGA) infants, though results varied across studies. Vegetarian mothers generally gained less weight during pregnancy, with some showing a risk of inadequate weight gain. Strict vegetarians also showed higher breastfeeding initiation and longer duration. Nutrient deficiencies, particularly in vitamin B12, iron, vitamin D, calcium, DHA, zinc, and iodine were more common in vegetarian women, underlining the need for proper supplementation.
Conclusions: Vegetarian and vegan diets can be safely followed during pregnancy, but they require careful nutritional planning and appropriate supplementation. While these diets may offer certain benefits such as healthier weight gain and better breastfeeding outcomes—they are also associated with potential risks, including lower birthweights and nutrient deficiencies. Key nutrients like vitamin B12, iron, vitamin D, calcium, DHA, and zinc must be closely monitored to support both maternal health and optimal fetal development.

KEYWORDS
Dietary Supplement, Nutritional Adequacy, Pregnant Females, Vegan Diet, Plant-Based Diet, Pregnancy, Veganism, Vegetarianism

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Introduction

Vegetarian and vegan diets have become much more popular in recent decades. These diets focus mainly on plant-based foods, with little to no intake of animal products. Typically, meat and fish are excluded. [1,2]

There are five main types of vegetarian diets, depending on which animal products are included:

- Vegan – includes only plant-based foods, with no animal products at all.
- Ovo-vegetarian – includes plant foods and eggs, but no dairy or meat.
- Lacto-vegetarian – includes plant foods and dairy products, but no eggs or meat.
- Lacto-ovo vegetarian – includes plant foods, dairy, and eggs, but no meat or fish.
- Pesco-vegetarian (also called pescatarian) – includes plant foods, dairy, eggs, and fish, but no other meats. [2]

Diets that are low in animal-based foods are gaining more recognition worldwide for their potential benefits to both human health and the environment. In fact, the 2015 U.S. Dietary Guidelines for Americans included a "healthy vegetarian" diet as one of three recommended eating patterns. [2,3]

Research has shown that vegetarian diets may be linked to a lower risk of being overweight, developing diabetes, and experiencing heart disease. In the U.S., the number of people identifying as vegetarian was estimated to be around 5% in 2012, with more women (7%) than men (4%) following this lifestyle. [3]

More and more women are following vegetarian diets, it's especially important to explore how these diets might affect pregnancy. Important time when nutrition plays a big role in both maternal and infant health. [3, 16]

Diet and pregnancy

In 2009, the Academy of Nutrition and Dietetics stated that vegetarian diets can provide adequate nutrition during pregnancy and may lead to positive health outcomes for both mother and baby. However, this statement was based on limited evidence.

For example, the conclusion that vegetarian and non-vegetarian women have similar birth outcomes came from only four studies. Some of these studies had weaknesses like lacking proper comparison groups. [3]

Another challenge is the lack of a clear, consistent definition of what it means to follow a vegetarian diet. Some people who say they are vegetarian still eat meat, poultry, or fish occasionally, which can make research results less reliable.

Given all this, the goal of this study was to carefully investigate how vegetarian diets during pregnancy are linked to both newborn and maternal health outcomes. The researchers used both self-reported vegetarian status and actual dietary data, studying a diverse, modern group of pregnant women in the U.S. [3]

The Eunice Kennedy Shriver National Institute of Child Health and Human Development Fetal Growth Studies–Singletons was a prospective study focused on creating fetal growth standards. It included pregnant women carrying only one baby and enrolled an approximately equal number of participants who self-identified as non-Hispanic White, non-Hispanic Black, Hispanic, and Asian/Pacific Islander. These women were recruited between 8 and 13 weeks of pregnancy at 12 clinical sites across the United States. Participants attended up to five follow-up visits during their pregnancy. In total, 2802 women joined the study—2334 were not obese, and 468 were obese. A subgroup of 1948 women, who gave birth to live infants and were invited to take part in the study's nutrition component (introduced partway through recruitment), were also included.

Women in the non-obese group were excluded if they had chronic medical conditions (like asthma, diabetes, thyroid disorders, epilepsy, cancer, autoimmune diseases, or chronic high blood pressure) or certain lifestyle risk factors (such as smoking, illegal drug use, or drinking alcohol daily). [3]

Definition of Vegetarianism

Participants were asked whether they had followed a vegetarian diet for the entire past three months, answering either "yes" or "no." This was used to define self-reported vegetarianism. [3]

In addition, vegetarianism based on diet was assessed using a food-frequency questionnaire (FFQ) completed at the beginning of the study. This questionnaire asked how often participants ate meat, poultry, and fish over the previous three months. [3]

Neonatal Outcomes

The study looked at several newborn health outcomes, including body measurements (such as birthweight, length at birth, arm and thigh length, head and belly circumference, and total skinfold thickness). It also examined whether babies were small or large for their gestational age (SGA or LGA), had low birthweight (under 2500 grams), were classified as macrosomic (4000 grams or more), were born preterm (before 37 weeks), or experienced any health problems after birth. Birthweight data were collected from medical records, while trained research nurses measured the other body dimensions using standardized methods. Gestational age was calculated based on the mother's reported last menstrual period, confirmed by a first-trimester ultrasound. [3, 11]

SGA and LGA were defined using sex-specific standards from a U.S. reference (Duryea et al.). To better identify babies who were unusually small or large due to health issues (rather than just natural size differences), SGA and LGA infants were also assessed for associated health complications. [3]

These complications, noted in medical records, included conditions such as metabolic acidosis, extended stays in neonatal intensive care (over 3 days), pneumonia, breathing problems, seizures, serious jaundice needing treatment, inhalation of substances during birth, death, need for mechanical ventilation at term, intestinal disease (necrotizing enterocolitis), low blood sugar, brain injuries due to lack of oxygen, and other specific issues depending on whether the baby was SGA or LGA. [3]

Maternal Outcomes

The study also looked at several health outcomes for the mothers, including how much weight they gained during pregnancy, whether they developed gestational diabetes, high blood pressure-related conditions, or anemia. Each woman reported her weight before pregnancy when she first joined the study. Her weight was then measured at each follow-up visit using standard procedures, and also recorded from clinic records. Total weight gain was calculated up to the time of delivery, as well as weight gained during each trimester. These amounts were categorized based on the Institute of Medicine guidelines into three groups: inadequate, adequate, or excessive. [3]

Blood sugar levels were classified into three categories: gestational diabetes (diagnosed using results from an oral glucose tolerance test and whether the woman needed medication, based on medical records), impaired glucose tolerance, and normal blood sugar levels. [3]

High blood pressure and pre-eclampsia during pregnancy were diagnosed by a physician following standard clinic practices. Women were grouped as having no hypertension, mild or unspecified hypertension, or severe hypertension/pre-eclampsia. Records from prenatal care were used to determine whether a woman had gestational anemia. [3]

Results

The weighted prevalence of women who identified themselves as vegetarians was 6.2%. When using actual dietary intake to define vegetarianism, the prevalence was 2.0% for full vegetarians, 0.6% for pescatarians (who eat fish but not meat or poultry), and 17.6% for semi-vegetarians. Out of the 99 women who identified as vegetarians, only 22 were classified as full vegetarians based on their diet. [3]

Compared to non-vegetarians, both self-identified and diet-based full vegetarians tended to have higher levels of education, greater incomes, and were more likely to have private health insurance. They were also more likely to be Asian or Pacific Islander. Self-identified vegetarians had a lower average pre-pregnancy BMI than non-vegetarians. Among diet-based full vegetarians, the average pre-pregnancy BMI was even lower (23.4 kg/m^2), significantly different from non-vegetarians. Total calorie intake also differed by group: 1678

kcal/day for full vegetarians, 2020 kcal/day for pescatarians, 1649 kcal/day for semi-vegetarians, and 2304 kcal/day for non-vegetarians. [3]

Newborns of both self-defined and diet-based full vegetarians had lower average birthweights and birth lengths compared to those of non-vegetarians. For self-defined vegetarians, the adjusted difference in birthweight was –117.11 g and in birth length was –0.58 cm. Among diet-based full vegetarians, the differences were more pronounced: birthweight –202.02 g and birth length –1.01 cm. [3]

Their babies also had shorter upper-thigh lengthand were more likely to be small for gestational age or have low birthweight. Semi-vegetarians also had increased odds of SGA births. Only 1% of all newborns in the study were both SGA and had a health complication, so any link between this combination and vegetarianism was not precise. [3]

Diet-based full vegetarians had slightly higher odds of not gaining enough weight in the second trimester, but vegetarianism overall was not linked to other maternal outcomes like gestational diabetes, high blood pressure, or anemia. [3]

Diet and pregnancy

Another systematic review analyzed eight studies that included a total of 72,284 women from different countries like Denmark, Israel, Poland, and the United States, providing a broad, international view. [6]

The studies used various research methods, including both forward-looking (prospective) and backward-looking (retrospective) cohort studies, as well as cross-sectional designs. The number of participants in each study varied widely—from just 63 to over 66,000. [6]

The main goal of the research was to compare pregnancy outcomes in women following different types of diets: those who eat meat (omnivores), vegetarians, and strict vegetarians (vegans). The outcomes they looked at included birth weight, gestational diabetes (GDM), babies being small for their gestational age (SGA), preterm birth, preeclampsia, and how much weight women gained during pregnancy. [6]

The review found that women on strict vegetarian diets tended to have babies with lower birth weights and a higher risk of being born small for their age. However, there were no consistent differences between the diet groups when it came to gestational diabetes or blood pressure issues like preeclampsia. Strict vegetarians also tended to gain less weight during pregnancy, which might help prevent excessive weight gain. [6, 14]

Birthweight and Small for Gestational Age (SGA)

The review found that babies born to mothers who followed a strict vegetarian diet often had lower birthweights and were more likely to be classified as small for their gestational age (SGA). [6, 7]

For example, scientists reported that babies of strict vegetarians weighed about 240 grams less on average and had a much higher SGA rate (27.8%) compared to those born to mothers who ate meat (9.9%). Similar findings came from other studies which also showed higher rates of SGA among strict vegetarians. [6]

However, some studies had different results, for instance, found that babies of strict vegetarian mothers had the highest average birthweight (3.54 kg) and no cases of low birthweight. [6, 7]

This suggests that other factors might influence the outcomes. Even so, despite the lower birthweights in some cases, other measurements like head circumference and length at birth were still within normal ranges. [6]

Gestational Diabetes Mellitus (GDM)

Strict vegetarians generally had lower rates of gestational diabetes. Reported no GDM cases among strict vegetarians, compared to a 0.8% rate in omnivores. [6]

Other scientist found similar trends, with lower GDM rates in vegetarians. However, some studies found no meaningful differences in GDM between dietary groups. These mixed results indicate that while plant-based diets might help reduce GDM risk, more consistent evidence is needed. [6, 15]

Gestational Weight Gain and Excessive Weight Gain

Strict vegetarians tended to gain less weight during pregnancy and had a lower risk of gaining too much weight. Risk of excessive weight gain was 24.7% in strict vegetarians, compared to 35.6% in omnivores. [6]

However, Yisahak et al. found that vegetarians were more likely to gain too little weight, showing the importance of monitoring nutrition in these groups. [6]

Hypertensive Disorders and Preeclampsia

Findings related to high blood pressure and preeclampsia varied. One study reported a higher rate of preeclampsia among strict vegetarians (11.1%) compared to omnivores (2.6%). However, other studies found no significant difference in hypertensive complications between the diet groups. [6]

Preterm Birth

The connection between maternal diet and preterm birth showed mixed results. Some studies found that strict vegetarians had a slightly lower risk of giving birth prematurely: reported a preterm birth rate of 2.6% in strict vegetarians versus 4.4% in omnivores. However, Avnon et al. found no significant differences in preterm birth rates across different dietary groups. [6]

Anemia and Nutrient Deficiencies

Findings on anemia and nutrient deficiencies were inconsistent. One studies reported no major differences in anemia rates between plant-based eaters and omnivores. However, another one found that strict vegetarians who didn't take vitamin B12 supplements had much lower levels of both maternal and umbilical B12 compared to those who did supplement. This highlights the need for proper supplementation—especially of B12 and iron—when following a strict vegetarian diet during pregnancy. [6]

Breastfeeding Outcomes

Strict vegetarian mothers showed better breastfeeding results compared to non-vegetarians. They had the highest rate of starting breastfeeding (93.3%) and breastfed for the longest average duration—about 12.8 months. In contrast, non-vegetarian mothers had a lower initiation rate (72.4%) and shorter breastfeeding duration (6.6 months). These findings suggest that following a strict vegetarian diet during pregnancy might be linked to more positive breastfeeding habits and potentially better health outcomes for infants. [6]

Vitamin B12

A recent review has found that vitamin B12 deficiency or depletion is common among vegetarians. During pregnancy, the body increases its absorption of vitamin B12. This vitamin is better absorbed when consumed in small, frequent doses, as the fetus does not require large amounts. Vitamin B12 from the mother's body stores does not cross the placenta, but the vitamin absorbed from food does. Low levels of B12 in early pregnancy are linked to a higher risk of neural tube defects (NTDs) and complications like preeclampsia, anemia, and neurological issues. The recommended daily intake of vitamin B12 is 2.2 µg during pregnancy and 2.4 µg during breastfeeding. [9, 17, 19]

Vitamin B12 deficiency often shows up as clinical or mild anemia. However, macrocytic anemia may be hidden by other conditions such as iron deficiency, thalassemia, or high folate intake, which is common in vegetarian women. B12 deficiency is widespread in some developing countries like India, parts of Africa, China, and Central America.

In the PREFORM study from Toronto (368 participants), 35% of pregnant women had low B12 levels in mid-pregnancy, rising to 43% by delivery. Actual deficiency (serum B12 <148 pmol/L) was present in 17% at mid-pregnancy and 38% at delivery. B12 intake during pregnancy was only weakly linked to B12 blood levels. Another study found that even when women consumed more than the recommended amount of B12, deficiency increased from 8% to 35% between the second and third trimester. This drop is likely due to higher metabolism, B12 transfer to the fetus, and blood dilution during pregnancy. Therefore, it's important to determine whether low B12 is due to true deficiency or just normal pregnancy changes. [9, 19]

Koebnick and colleagues studied B12 levels in pregnant women with different diets: lacto-ovo vegetarian (LOV), low meat intake, and high meat intake (Western diet). B12 deficiency was seen in 39% of LOV women, 9% of low-meat consumers, and 3% of the control group. LOV women had nearly 4 times higher odds of having low B12 at some point during pregnancy. Deficiency was most common in the third trimester, suggesting that low B12 levels may reflect depleted stores rather than just blood volume changes. The researchers recommend that vegetarian pregnant women consume more than 3.0 µg/day of vitamin B12. [9]

Vitamin D and Calcium

Vitamin D levels during pregnancy are mainly influenced by sunlight exposure and the intake of vitamin D-rich foods, fortified products, or supplements. Although vitamin D needs do not increase during pregnancy, many people—including those with darker skin and vegetarians—are at risk of deficiency. [9, 12]

A study by Sachan et al. looked at 207 pregnant women from both urban and rural areas. They found that over 80% of the women in both groups had vitamin D levels below the normal cutoff (<22.5 ng/mL) and low calcium intake, especially in women who did not eat meat. About 14% of the women showed signs of biochemical osteomalacia, a condition where bones become soft due to vitamin D or calcium deficiency. Similar results were reported in a study of Iranian pregnant women at delivery. [9]

Calcium needs during pregnancy and breastfeeding are about 1000 mg per day, but vegetarians and vegans are advised to consume more—around 1200 to 1500 mg daily. They should aim for at least eight servings of calcium-rich foods each day. [9]

Despite general recommendations, pregnant vegetarians are still at high risk for vitamin D deficiency, which can lead to weakened bones, osteoporosis, and low calcium levels. [9, 12]

A study in Northwest China also found that pregnant women following vegetarian diets had low calcium intake. [9]

Iron

During pregnancy, a woman's daily iron requirement increases — from about 1 mg per day in the first trimester to approximately 7.5 mg per day in the third trimester. [4]

This rise in demand is due to several factors:

- The growing fetus needs iron for its development, especially to produce its own red blood cells.
- The placenta, umbilical cord, and fetal membranes (collectively called the afterbirth) also require iron as they grow.
- Additionally, the mother's uterus expands significantly, and her blood volume increases, which further raises the need for iron. [4]

Mild anemia during pregnancy is normal and mostly due to hemodilution, which is the natural increase in blood volume. In the second and third trimesters, the mother’s blood volume increases significantly, and more iron is needed to support the placenta and growing baby. Iron absorption—both from plant sources (non-heme) and animal sources (heme)—naturally improves during pregnancy and increases as pregnancy progresses. [5, 9]

However, some substances can block iron absorption, such as calcium, coffee, and dietary fiber. On the other hand, vitamin C helps increase iron absorption by counteracting the effects of phytates (found in plant foods). The actual amount of iron a pregnant woman needs depends on her iron stores before pregnancy. [5, 9]

A systematic review and meta-analysis found that vegetarians generally have lower iron stores than nonvegetarians. However, the evidence in pregnant vegetarian women is mixed. One British study of 1,274 pregnant women aged 18–45 showed that vegetarians had enough iron in their diets and were more likely than nonvegetarians to follow iron supplement guidelines during the first and second trimesters. [9]

Essential Fatty Acids

Linoleic acid (LA, omega-6) and alpha-linolenic acid (ALA, omega-3) are polyunsaturated fatty acids that must be obtained from the diet. LA can be converted into arachidonic acid (AA), and ALA is converted into EPA and DHA. DHA is especially important because it plays a key role in the development of the brain and eyes. It builds up in the baby's brain and retina during the final stages of pregnancy and early infancy. These fatty acids are transferred from the mother to the baby through the placenta. [8, 9, 18]

DHA is believed to be crucial for healthy vision and brain development in early life. However, women who do not eat fish or meat—such as vegetarians and especially those in countries like India—are at higher risk of having low DHA intake. Improved dietary assessments have shown that vegetarian women typically consume about 30 mg of DHA per day, which is much lower than women who eat fish or take fish oil supplements (who may get over 1000 mg/day). [9, 10]

DHA intake becomes especially important in late pregnancy, when the placenta prioritizes DHA transfer to the fetus. Although research on DHA during pregnancy is limited, studies have found that babies born to vegetarian mothers tend to have lower levels of DHA in their blood compared to babies of mothers who eat animal products. [9, 13]

Zinc

Zinc from plant-based foods is less easily absorbed by the body compared to zinc from animal sources. Vegetarians typically consume less zinc than omnivores, and while their blood zinc levels tend to be lower, they usually still fall within the normal range. [8, 9]

During pregnancy, the body's need for zinc increases. Therefore, pregnant women—especially vegetarians—are encouraged to eat more zinc-rich foods and use cooking methods that improve zinc absorption. Techniques like soaking, fermenting, germinating, and using sourdough for bread help reduce phytates, which block zinc absorption. [9,10]

Although getting enough zinc during pregnancy is important, the specific effects of zinc deficiency are not clearly defined. It's believed that the body may adjust how much zinc it absorbs based on how much is consumed. The recommended daily intake of zinc for pregnant women aged 19–50 is 11 mg. [9, 20]

A meta-analysis comparing pregnant vegetarians and nonvegetarians found that vegetarians consumed significantly less zinc—about 1.4 to 1.5 mg/day less. However, neither group met the recommended intake. Despite lower intake, there were no major differences in zinc levels in the body (measured in blood, urine, or hair), or in pregnancy outcomes like birth weight or the length of pregnancy. [9]

Iodine, Magnesium

Vegetarian and vegan diets may lead to lower iodine intake, as the main sources of iodine are meat, fish, and dairy. However, using iodized salt can help prevent iodine deficiency. [9, 10]

Magnesium is essential for fetal development during pregnancy. However, magnesium levels in the blood naturally decrease during pregnancy due to increased demand, higher excretion through urine, and blood dilution. [9,10]

A study of 108 healthy pregnant women showed that those on plant-based diets (lacto-ovo vegetarian and low-meat diets) had significantly higher magnesium intake compared to women on a regular diet. The women on plant-based diets consumed around 508-714 mg/day of magnesium, while those on the control diet only consumed about 41 mg/day. Additionally, women on plant-based diets excreted more magnesium in their urine compared to the control group. This shows that vegetarian and vegan diets tend to result in higher magnesium levels. [9]

Proteins

During pregnancy and lactation, the body's protein needs increase significantly, rising to 71 g per day (about 1.1–1.2 g per kg of body weight) compared to 46 g per day (0.8 g/kg) for non-pregnant women. Protein is required for the growth and development of both maternal and fetal tissues, and this demand is highest during the third trimester. Protein synthesis increases, while the breakdown of amino acids and the production of urea decrease. The body also conserves more amino acids during pregnancy to retain protein during this time of increased need. [9, 10]

An additional 21 g of protein is needed during the second and third trimesters to support the fetus, placenta, and maternal tissue. Plant-based proteins are sufficient to meet these needs. Good sources of protein include legumes, nuts, tofu, and eggs. Soy protein is particularly effective in meeting protein needs, similar to animal-based protein. However, cereals are low in lysine, an essential amino acid. To meet lysine requirements, eating more beans and soy products is important. Increasing protein intake from various sources can help compensate for the lower lysine levels in cereals. [9, 10]

Pregnant women following a vegan diet may be at higher risk of protein deficiency, especially in the second and third trimesters. To ensure adequate protein intake, it's recommended to add 25 g of protein per day, which can be achieved by including 1.5 cups of lentils or 2.5 cups of soy milk in the diet. [9, 10]

Conclusions

Vegetarian and vegan diets are becoming more popular, especially among women of reproductive age. These diets can offer health benefits, but during pregnancy, they require careful planning due to increased nutritional needs.

Research shows that women on strict vegetarian diets often have babies with lower birthweights and a higher risk of being small for gestational age (SGA), though not all studies agree. Vegetarian mothers tend to gain less weight during pregnancy and may be more likely to breastfeed longer. No consistent differences were found in rates of gestational diabetes, preeclampsia, or preterm birth across diet types.

Nutrient deficiencies are a concern. Vitamin B12 is especially important and often lacking in vegetarian diets, leading to risks like anemia and birth defects if not supplemented. Vitamin D, calcium, iron, DHA (an omega-3 fatty acid), zinc, iodine, and protein also need attention. With proper supplementation and balanced intake of plant-based foods, a vegetarian or vegan diet can be safe and healthy during pregnancy.

Disclosures

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Formal analysis - Aleksandra Woskowska
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