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## **The impact of a plant-based diet on the menstrual cycle and female fertility**

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## **Abstract**

**Introduction and objective:** A plant-based diet is being adopted by an increasing number of people worldwide. Its health benefits have been described in numerous scientific studies. Unfortunately, an improperly balanced diet that excludes animal-derived products can, through various mechanisms, lead to deficiencies and disruptions in the functioning of many systems in the body. This review paper aims to present and summarize the findings and current literature on the impact of a plant-based diet on the menstrual cycle and female fertility.

**Brief description of the state of knowledge:** There is insufficient research on how minerals and vitamins influence the biochemical processes of the menstrual cycle and related symptoms. While nutrient deficiencies in plant-based diets are widely discussed, most studies focus on general health rather than the reproductive system, which is crucial for hormonal balance and fertility. This highlights the need for more research to improve our understanding of the female reproductive and endocrine systems and ensure better care for women.

**Methods:** A literature review was conducted using PubMed and Google Scholar with search terms like "impact of plant-based diet", "menstrual cycle disorders", "causes of female infertility", "deficiencies in vegans and vegetarians" and related variations. Articles published within the last five years were prioritized.

**Conclusions:** A properly followed plant-based diet, supported by supplementation, has a positive effect on the female reproductive system, without causing menstrual cycle disorders or

infertility. Unfortunately, the more exclusions present in the diet, the more likely it is to cause deficiencies in minerals and vitamins. Inadequate levels of these nutrients can lead to abnormalities in the female reproductive system, both in laboratory tests and in symptoms experienced by women.

### **Keywords**

plant-based diet, vegan diet, vegetarian diet, menstrual cycle, women's infertility

### **Introduction**

There is an increase in the number of women around the world who declare that they follow a plant-based diet. There are several types of plant-based diets, but the main ones are: *vegan* (completely plant-based), *vegetarian* (plant-based eating pattern that excludes meat, poultry, and fish), *lacto-ovo vegetarian* (plant-based except for dairy products and/or eggs) and *pescatarian* (plant-based except for fish and seafood, with or without eggs and dairy)[1]. The benefits of a vegetarian diet include, among other things, lower blood pressure, reduced incidence of coronary heart disease and type 2 diabetes [2, 3, 4]. Additionally, studies have shown a reduced risk of cancer in people who do not eat meat or animal products [5]. Veganism and vegetarianism, despite their many health benefits, can lead to deficiencies in some nutrients that are mainly found in animal products. Based on available scientific sources, the most common deficiencies in vegans and vegetarians are: *vitamin B12, iron, calcium, zinc, vitamin D and omega-3 fatty acids* [6, 7, 8, 9]. Three main factors that could lead to menstrual cycle irregularities, which might vary between vegetarians and non-vegetarians, including energy imbalances linked to changes in body weight or physical activity, psychological and cognitive influences, and the components of the diet [10].

There is still a lack of sufficient scientific studies and research describing the impact of minerals and vitamins on the biochemical processes of the menstrual cycle and the symptoms experienced by women during its course. Much is discussed about nutrient deficiencies in individuals following a plant-based diet, but these studies mainly focus on overall health rather than the female reproductive system, which plays a crucial role in well-being, proper hormonal regulation, and women's fertility and reproduction.

A large number of research studies date back to the 1980s and 1990s, a time when public awareness of a balanced diet and the necessity of vitamin and mineral supplementation was lower, and the availability of plant-based products enriched with essential nutrients was significantly different from what it is today. This highlights the need for more extensive

research and observations to enhance our understanding of the female reproductive and endocrine systems, enabling more effective care for women.

### The menstrual cycle

The menstrual cycle lasts an average of 28 days. A normal cycle duration ranges from 21 to 35 days. During this time, changes occurring both in the female reproductive system and throughout the body depend on the levels of sex hormones - estrogen and progesterone. Estrogens are a group of steroids classified as C-18 compounds. Three main types of estrogens are: estrone (E1), 17 $\beta$ -estradiol (E2), and estriol (E3). These hormones are produced by the granulosa and theca cells of the ovary, the placenta, and also through the peripheral conversion of other hormones, such as androstenedione and testosterone. Progesterone, a C-21 steroid, is the natural gestagen in the female body. It is produced by the corpus luteum and the placenta.

The menstrual cycle consists of the follicular phase, the luteal phase, and ovulation occurring between them [11]. In the follicular

phase of the cycle, low levels of estrogen and progesterone stimulate the release of small amounts of follicle-stimulating hormone (FSH) and luteinizing hormone (LH). Several ovarian follicles begin to grow, secreting estrogen. Increased estrogen level leads to the thickening of the endometrium and the inhibition of FSH secretion. All developing follicles, except for the dominant one, undergo

atresia. The dominant follicle produces large amounts of estrogen, which triggers a peak in LH production. This leads to the release of the egg cell, and the ruptured follicle transforms into the corpus luteum, which produces estrogen and progesterone during the luteal phase. If fertilization does not occur, the corpus luteum degenerates, ovarian hormone levels decrease, and ultimately, the endometrium is shed, marking the start of a new menstrual cycle [10].

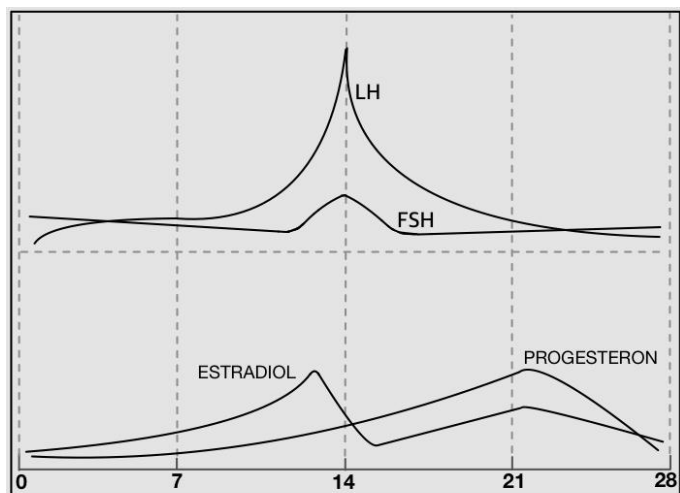


Figure 1. The levels of hormones regulating the menstrual cycle depending on the day of the cycle.

### Infertility and Menstrual Cycle Disorders

Infertility is the inability to conceive after 12 months of regular unprotected sexual intercourse. An article published in 2022 by Carson and Kallen reports that 12.7% of women of reproductive

age in the U.S. seek infertility treatment. The same article indicates that 85% of couples with an infertility diagnosis find its cause, while for 15% of couples, the cause remains unclear. Furthermore, ovulatory disorders, which will be discussed in the article below, have been identified by the authors as the cause of 25% of infertility cases [12].

Menstrual disorders include abnormalities such as irregular menstrual cycles, infrequent or frequent menstruation, heavy bleeding, absence of menstruation, prolonged menstruation, intermenstrual bleeding, amenorrhea, dysmenorrhea, and premenstrual syndrome (PMS). Dysmenorrhea has been described as the most common menstrual disorder (affecting approximately 90% of women studied). The high prevalence of this symptom in women highlights the scale of the issue and encourages the exploration of its underlying causes and potential ways to reduce its impact [13].

The hormones whose disorders will be frequently mentioned in this review are FSH and LH. Reduced levels of LH and FSH in women lead to ovulatory disorders, decreased production of estrogen and progesterone, and impaired gametogenesis. This results in reduced fertility and difficulties in conceiving. In assisted reproductive treatments, it can lead to resistance to gonadotropins and poor ovarian response to stimulation [14].

### **Weight loss**

Studies show that a plant-based diet has a positive impact on weight loss. A randomized, comparative study involved 62 obese middle-aged individuals who were assigned to consume various types of plant-based diets for six months. The greatest weight loss was observed in those following a vegan diet (7.5%) and a vegetarian diet (6.3%). In other groups, the weight loss was approximately 3.2% [15]. This indicates that a plant-based diet is an effective tool in combating obesity but can also pose a risk of excessive weight loss and nutrient deficiencies. Studies show that weight loss can affect the menstrual cycle, including its impact on the levels of sex hormones. Measurement of LH levels in women who lost 10% to 12% of their body weight during a 2-3 week fasting period revealed suppressed LH secretion [16]. Other studies indicate that 7 out of 8 women who experienced weight loss due to a vegetarian diet developed menstrual cycle disorders. LH levels decreased, while ovarian follicle development and FSH levels remained normal, suggesting proper peripheral signaling initiating LH secretion and a potential disruption in the hypothalamic-pituitary axis. The same study found no changes in sex hormone levels in subjects following a non-plant-based diet [17]. Another study showed that just a 4-day intense caloric restriction in meals leads to a decrease in LH levels in the women studied [18]. In studies involving women aged 19 to 27, divided into two groups (those

following a plant-based diet and those on a non-restrictive diet), it was observed that the cycle length shortened by an average of 5.2 days, measured from the peak estradiol level [14]. There are studies indicating that following a vegetarian or vegan diet may increase estrogen levels while simultaneously reducing their bioavailability [19]. Furthermore, Nieman D.C. describes that a plant-based diet, often characterized by low-fat content, may lead to a reduction in estrogen levels and menstrual irregularities [20]. He also mentions past studies [21, 22] in which female athletes were grouped based on their diets. It was found that a significant majority of athletes with menstrual irregularities were vegetarians.

### Vitamin and nutrient deficiencies

As mentioned above, a plant-based diet is a risk factor for iron deficiency. Due to the suspected link between iron deficiency anemia and menstrual disorders, studies were conducted on mice fed a low-iron diet. The level of estradiol and the rate of ovarian follicle development were lower than in mice fed a non-restricted diet. This led to infertility in the mice. Returning to a diet containing the proper amount of iron resulted in the normalization of the study results and fertility after three weeks. Moreover, iron deficiency and the resulting anemia may affect ovarian blood supply, thereby reducing oocyte quality and causing ovulation disorders [23].

A plant-based diet and its associated deficiencies affect not only hormonal imbalances but also the symptoms experienced by women. In a study conducted by Naraoka and others, 321 healthy

women aged 20–39 were categorized into “heavy” and “light” groups based on the severity of menstrual pain. The group with more severe symptoms had lower average intakes of total protein, animal protein, vitamin D, vitamin B12, and fish. This may suggest that a plant-based diet is a risk factor for

Food products	Vitamin B12	Vitamin D	Iron	Omega-3 fatty acids	Protein
Chicken breast	0,3 µg	0,1 µg	0,6 mg	0,04 g	28 g
Beef	2,5 µg	0,8 µg	3,5 mg	0,068 g	18,7 g
Salmon	3,2 µg	7,4 µg	0,8 mg	1,723 g	19,8 g
Egg	0,89 µg	2 µg	1,8 mg	0,113 g	12,6 g
Chickpeas	0 µg	0 µg	2,9 mg	0,07 g	8,9 g
Tofu	0 µg	0 µg	1,1 mg	0,6 g	7,2 g

Figure 2. The content of vitamins and minerals in 100g of selected food products.

menstrual pain. Furthermore, the same study shows that in the “light” group, where participants consumed the aforementioned nutrients in sufficient amounts, PMS symptoms were less severe [24]. Studies show the impact of vitamin D and B12 deficiencies on the occurrence of severe

menstrual pain. Moreover, they highlight the importance of supplementing these vitamins in reducing menstruation-related symptoms [25, 26].

Moreover, literature data demonstrate that vitamin B12 has a positive effect on female fertility. Over half of the women seeking medical treatment for infertility are deficient in vitamin B12, whereas those with normal levels have a higher chance of achieving pregnancy [27, 28]. Additionally, Salvadea-Mateu et al. mention in their study that adequate vitamin B12 levels have a beneficial impact on maintaining pregnancy and achieving live births. In the same scientific article, the authors cite studies investigating the effect of vitamin D deficiency on female fertility. According to these studies, the impact of vitamin D is inconclusive, and once its minimum adequate level is reached, further increases do not result in additional health benefits [29]. These findings confirm that following a plant-based diet, particularly a vegan one, may not only be associated with an increased risk of menstrual disturbances but may also adversely affect female fertility.

There are reports on the impact of omega-3 and omega-6 fatty acids on symptoms experienced by women during the menstrual cycle. Omega-6 fatty acids are released during the luteal phase, leading to an increase in pro-inflammatory cytokines such as thromboxane A2 (TXA2), prostaglandin E2 (PGE2), and leukotriene B4 (LTB4). This exacerbates menstrual pain and causes systemic symptoms such as headaches and nausea [30]. Pia Saldeen and co-authors mention in their study a correlation between low levels of omega-3 fatty acids and a reduced omega-3 to omega-6 ratio with menstrual pain and discomfort [31].

A plant-based diet is a risk factor for insufficient protein intake. Studies have shown that reduced consumption of total protein and certain amino acids, such as tryptophan, a precursor to neurotransmitters, may contribute to the development of PMS (Premenstrual Syndrome) [32]. Premenstrual Syndrome is a condition characterized by physical, emotional, and behavioral symptoms that occur during the luteal phase of the menstrual cycle and resolve shortly after menstruation begins. These symptoms, which can include mood swings, irritability, bloating, and fatigue, affect up to 20% of reproductive-aged women and can vary in severity [33]. Not only insufficient intake of animal protein and total protein pose a risk factor for menstrual-related disorders, but also inadequate consumption of plant-based protein plays a significant role. A study conducted on 259 women aged 18–44 examined the relationship between plant protein intake and changes in hormone concentrations regulating the female reproductive system. According to the study's findings, insufficient plant protein intake is associated with lower luteal phase progesterone levels, higher follicle-stimulating hormone concentrations, and an increased risk of anovulatory cycles [34]. This suggests that failing to

meet the daily protein requirements—both animal and plant-based protein, especially in improperly managed plant-based diets—constitutes a significant risk factor for menstrual-related disorders. Another mineral whose deficiency may result from following a plant-based diet is zinc. Zinc is essential for the synthesis of testosterone, which is crucial for the maturation of ovarian follicles [35]. Abnormal zinc levels negatively affect the regulation of estrogen receptors. Studies have also described the direct impact of zinc levels on the development of ovarian follicles [36, 37] and ovulation [38]. Furthermore, research highlights the influence of zinc levels on the proper secretion of FSH and LH [39].

A 2022 analytical study, analyzing 7,356 vegans, 51,940 vegetarians, and 107,581 omnivorous participants showed that among those following a strict plant-based diet, without animal-derived products, calcium intake was lower compared to vegetarians and omnivores [40]. Proper calcium levels influence the maturation of ovarian follicles, oocyte growth, and their release [41]. Given these findings, a reduced calcium level can also be considered a risk factor for menstrual disorders. In a meta-analysis published in 2023, based on seven studies examining female sex hormone levels, it was reported that adherence to a vegetarian diet among women contributed to a reduction in plasma estrone levels [42].

In contrast to the deficiencies in vitamins and minerals that may arise from an improperly balanced plant-based diet, it is important to highlight the beneficial effects of this diet on the hormonal and metabolic profile in women. A study published in 2010, which included 41 women following an unrestricted diet and 21 vegetarians, described the effects of these diets on the participants' bodies. Among vegetarians, higher levels of SHBG and lower levels of free estradiol (E2), free testosterone, and DHEA-S were observed. The results indicated a beneficial impact of a vegetarian diet on the metabolic and hormonal profile. Interestingly, the same study found no significant differences in the positive effects of the plant-based diet on sex hormone levels between pre- and postmenopausal women, suggesting that this diet may have a protective effect against hormonal disorders and diseases characteristic of the postmenopausal period [43]. Skoracka et al. described in 2021 the impact of plant and animal protein consumption on women's fertility. Their work concludes that animal protein intake is associated with the risk of anovulatory cycles and an increase in testosterone levels, which disrupts the development and maturation of ovarian follicles [44]. In contrast, a 2022 review summarizing the effects of nutrients on ovulation in women highlights the positive effects of plant protein as opposed to the negative effects of animal protein. The findings indicate that adding one serving of meat to the daily diet increases the risk of ovulatory disorders by 32%. It was also demonstrated that consuming animal protein from red meat and poultry increases the risk of anovulatory cycles.



Based on these studies, it can be concluded that providing an appropriate amount of plant protein may positively affect ovulation and fertility in women compared to animal protein. This, in turn, places a well-balanced plant-based diet in a favorable light as a dietary option for women of reproductive age [45, 46].

It's not only plant-based protein that can positively affect the female reproductive system. Research studies highlight the beneficial effect of antioxidants in food on maintaining fertility [47]. Cinegaglia et al., in their 2020 article, reported that vegetarians exhibit higher levels of antioxidants compared to individuals on an unrestricted diet [48]. This statement is supported by findings from numerous studies, including one from 2020, which describes that by consuming large amounts of fresh vegetables and fruits, vegetarians and vegans provide significant levels of antioxidant vitamins (vitamin C, vitamin E, beta-carotene) in their diets. However, the authors of this study note the variability in the levels of trace antioxidant elements and emphasize the need for further research on the positive effects of plant-based diets in combating oxidative stress (OS) [49]. OS results from an imbalance between the actions of antioxidants and the presence of pro-oxidants, such as reactive oxygen and nitrogen species. The menstrual cycle is regulated by physiological concentrations of reactive oxygen and nitrogen species, and oxidative stress significantly influences the menstrual cycle, menstruation, fertilization, and embryo implantation in the uterus. Excessive oxidative stress can therefore lead to disorders in the female reproductive system and infertility [50].

### **The Impact of Soy Products on Women's Fertility**

Soy products are a common dietary substitute for meat among women following a plant-based diet. Soybeans contain large amounts of isoflavones, which are phytoestrogens, prompting research into their impact on women's health, reproductive system, and fertility. The review by Jacobsen et al. from 2014 presents conclusions about the effects of soy phytoestrogens on lowering levels of FSH and LH and extending the menstrual cycle [51]. Additionally, scientific studies referenced in this article describe the association between high soy isoflavone intake and the development of non-cancerous uterine pathologies or increased uterine bleeding [52, 53]. Research has also been conducted to examine the relationship between soy isoflavone consumption and difficulty in conceiving and maintaining pregnancy. It was observed that among vegans and vegetarians, their intake was higher compared to women following non-restricted diets. The results of the study suggest that consuming more than 40mg of soy isoflavones per day increases the risk of infertility by approximately 13%, while reducing the risk of live births by about 3% [51]. Unfortunately, this result only considers women who have

never been pregnant, rather than those with difficulties in conceiving or maintaining pregnancy, which expands the group of childless women to include those who did not want children or delayed pregnancy for social or economic reasons. In such cases, it would be beneficial to extend the study to include women actively trying to conceive and examine the impact of isoflavones in their diet on potential fertility issues or pregnancy maintenance.

In a descriptive paper from 2022, the authors evaluate the studies and analyses conducted so far on the impact of soy isoflavone consumption on fertility, menstrual cycle length, and hormonal balance in women. They point out that soy contains many other phytochemicals in varying concentrations, and it cannot be ruled out that these may also have an effect on women's bodies. Furthermore, the authors do not find reliable study results that definitively confirm a link between increased intake of phytoestrogens and the reproductive system and fertility. The lack of clear answers encourages further research, especially as the number of women following plant-based diets with high isoflavone content continues to rise [54].

## **Conclusions**

This review investigates the complex interplay between plant-based diets and female reproductive health, focusing on the menstrual cycle and fertility. While plant-based diets, particularly vegan and vegetarian patterns, offer significant health benefits such as reduced risks of cardiovascular disease, diabetes, and certain cancers, their improper implementation can result in nutrient deficiencies with direct implications for reproductive health. Key deficiencies identified include vitamin B12, iron, calcium, zinc, vitamin D, and omega-3 fatty acids. These deficiencies can disrupt hormonal balance, impair ovarian function, and lead to menstrual irregularities, ovulatory disorders, and reduced fertility.

The menstrual cycle, governed by the delicate regulation of estrogen and progesterone, is highly sensitive to dietary influences. Studies indicate that excessive caloric restriction and imbalanced plant-based diets may lower luteinizing hormone (LH) levels, disrupt ovulation, and shorten menstrual cycles. Furthermore, deficiencies in micronutrients such as vitamin B12 and iron have been associated with diminished oocyte quality, anovulation, and increased menstrual pain severity. Despite these risks, plant-based diets, when properly managed with adequate supplementation and protein intake, can have protective effects on metabolic and hormonal profiles. Higher levels of antioxidants, common in plant-based diets, have been linked to reduced oxidative stress, a factor crucial for maintaining reproductive health and fertility. Additionally, the inclusion of plant proteins has been shown to support ovulatory function and

may reduce the risk of hormonal disruptions commonly associated with animal protein consumption.

Further research is necessary to clarify these effects, particularly among populations with high soy consumption. In conclusion, this review underscores the importance of adopting a well-balanced and carefully planned plant-based diet for women of reproductive age. Nutritional education and appropriate supplementation are critical to ensuring that such diets support, rather than hinder, hormonal balance and fertility. While plant-based diets hold promise as a sustainable and health-promoting choice, they must be tailored to individual needs to mitigate risks and maximize benefits. Future research should focus on the long-term reproductive outcomes of plant-based dietary patterns to provide clearer guidance for healthcare professionals and individuals alike.

### **Disclosures**

**Author's contribution:** conceptualization, KG; methodology, KP, HS and AR; software, KG and MM; check, KP and MK; formal analysis, KG; investigation, ZC and NK; resources, ZC and NK; data curation, KG and NK; writing - rough preparation, HS, AR and WN; writing - review and editing, MK, MM and ZC; visualization, HS; supervision, HA; project administration, KG

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