

Vegetarianism during pregnancy: Risks and benefits

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ABSTRACT

Keywords:

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Background: During pregnancy, women face continuous nutritional challenges. Although it is a personal choice, the adoption of a vegetarian dietary pattern during pregnancy must be regarded as a situation that may be associated with some risks and benefits for the mother and the fetus.

Scope and Approach: In the present review, the most frequent nutritional deficits among pregnant vegetarians will be discussed, namely, those that refer to vitamin B12, zinc, iron, omega-3 fatty acids and vitamin D. If properly planned, vegetarian diets may also be associated with some important health benefits. The main potential outcomes of vegetarianism for pregnant women, fetal development and for the early and later life of the newborns will be also reviewed.

Key Findings and Conclusions: Taken together, despite some of the controversial published data, vegetarianism appears to be a safe dietary pattern during that period of time. So, the option for vegetarianism must be considered a personal choice that like any other feeding pattern may pose some nutritional risks but also bring some potential health outcomes both for the mother and for the children. In order to deal with the nutritional requirements during pregnancy, it is recommended that vegetarian mothers follow strict nutritional counseling.

1. Introduction

Diet during pregnancy is one of the most important factors that may be adjusted in order to deal with the continuous challenges that women face during gestation. It can have profound consequences not only for the mother, but also for the fetus, during the early life of the newborns, and even throughout all their life (Nyaradi, Li, Hickling, Foster, & Oddy, 2013; Zeisel, 2009). The main concerns of a pregnant diet must include high hygiene standards, avoid potentially toxic molecules, provide adequate amounts of energy and macronutrients and satisfy the needs (sometimes increased) of vitamins and minerals. Thus, following a healthy and balanced diet is of outmost importance during pregnancy (Agnoli et al., 2017; Melina, Craig, & Levin, 2016; Nyaradi et al., 2013).

Although there are no ideal diets, which are always beneficial and do not have any kind of limitations, the way people view eating has significantly changed in the last years. Indeed, food is now seen not only as a primary need to support the basic functions of human body, but also an important tool to promote a healthy life (Fung & Hu, 2003; Hu & Willett, 2002). In this context, growing attention has been paid to vegetarianism, since there are evidences that it can be linked to lower

weight, lower blood pressure and cholesterol serum levels and, consequently, it may protect against cardiovascular diseases (Calder, 2015; Calder & Yaqoob, 2009; Estruch et al., 2013; Yokoyama et al., 2014), metabolic syndrome (Ajala, English, & Pinkney, 2013; Zhang & Ning, 2011) and some types of cancer (Pistollato et al., 2015). Vegetarian diets are food patterns that avoid, restrict or abolish foods from animal origins. For example, lacto-ovo vegetarians are allowed to consume milk products and eggs, while vegans do not eat any food from animal sources (Snow, 2017). Besides that, it is also important to highlight that even among the different vegetarian patterns, there are important differences that rely on the restriction of specific kinds of plant foods (grains, legumes, vegetables, fruits, nuts and seeds), or even in the ways they are consumed (cooked vs. raw). Thus, assessing the impact of vegetarianism in different parameters is far of being a simple task, because it comprises a heterogeneous set of different feeding patterns. The reasons behind the adoption of a vegetarian diet may be diverse and include cultural, religious or personal preferences (including health-related and animal welfare issues) (Burdge, Tan, & Henry, 2017; Corrin & Papadopoulos, 2017). The amount of vegetarians is increasing and may account for up to 10% of total population (Penney & Miller,

2008). For example, in 2016, about 3.3% of American adults followed a vegetarian dietary pattern, and among them, about half were vegan (Melina et al., 2016). Moreover, vegetarianism seems to be more popular among young adults (~6%) than in older ones (~2%) (Melina et al., 2016). Regarding Europe, significant differences are found in different countries. Overall, it is estimated that about 5% of Europeans are vegetarians. Countries like Italy, Germany, Austria and France are those with the highest percentage (~9–13%). The more restrictive the vegetarian dietary pattern, the greater the risk of incurrance in some kind of nutritional deficit, so, accurate and nonjudgmental nutritional counseling may represent an indispensable step towards a healthy pregnancy and fetal development.

According to the American Dietetic Association and the Canadian Dietary Association, vegetarianism may be adopted in all stages of life, including pregnancy (Craig & Mangels, 2009; "Position of the American Dietetic Association and Dietitians of Canada: vegetarian diets," 2003; Rizzo, Lagana, Rapisarda, La Ferrera, Buscema, Rossetti, et al., 2016). It poses some potential nutritional risks, but at the same time, it seems to have important health outcomes both for the mother and for the offspring (Pistollato et al., 2015). At the present, the search for healthy lifestyles, which include healthier feeding choices, combined with an increase concern about ecology and sustainability, is rising. Indeed, the reduction in the consumption of meat and meat-derived products, as well as the consumption of organic products is gaining supporters all over the world. These options are usually associated with healthier lifestyles and, thus, may be linked to several health benefits during pregnancy, not only for the mothers, but also for children (Simões-Wüst, Moltó-Puigmartí, van Dongen, Dagnelie, & Thijs, 2017; Torjusen, Brantsæter, Haugen, Lieblein, Stigum, Roos, Holmboe-Ottesen, Meltzer, 2010). In a study conducted in the Netherlands, it was reported that vegetarians were more prone to organic food consumption. Moreover, participants with a more often consumption of this type of products revealed a higher education level and a lower body mass index. Torjusen et al. (14) found in a large Norwegian cohort study that there was a relatively small proportion of organic food intake, and that the most frequent organic food choices involved eggs and vegetables. Those consumers included a higher percentage of vegetarians, as well as people with more active lifestyles and lower body mass index. Interestingly, no significant relationships were established between organic food consumption and education level, or with higher incomes. Taken together, it seems that the consumption of organic products is often related with specific cultural and socioeconomic characteristics, although with important apparent differences between different populations. Moreover, further studies are required to unravel the specific contribution of those changes in feeding patterns and in the related health outcomes. Only knowing the potential benefits and risks of this feeding pattern, the nutritional challenges that a pregnant woman faces can be overcome with a well-planned vegetarian diet. The present review aims to address the main nutritional benefits and risks of pregnant vegetarian women, as well as the main outcomes of vegetarianism to mother's and children's health.

2. Nutritional benefits

Although vegetarianism is a restrictive feeding pattern, and, consequently, may be linked to some nutritional potential deficits, it is also associated to some nutritional advantages, due to the high consumption of products from vegetal origin.

One of the main benefits is the high consumption of fiber, which usually increases with the restriction degree of vegetarian patterns (Ahola, Forsblom, & Groop, 2018; Li, 2014; Pistollato et al., 2015). Fiber consumption has been linked to many different positive health outcomes, namely, the decrease in the risk of different chronic diseases, some cancers (particularly those affecting gastrointestinal tract), and also a decreased incidence of a wide range of digestive disorders (Anderson, Baird, Davis Jr, Ferreri, Knudtson, Koraym, Waters &

Williams, 2009). Considering the cardiovascular health, it is also important to highlight that cholesterol has an exclusive animal origin, which means that vegetarianism is associated to a very low or even null intake of this nutrient (depending on the restrictive level of the adopted pattern) (Craig, 2009; Li, 2014; Pistollato et al., 2015). Consequently, this can decrease the risk of cardiovascular diseases, such as atherosclerosis or stroke. Another important benefit of vegetarianism is the high intake of folate (Craig, 2009; Li, 2014). Although this vitamin can also be obtained from animal sources, it is mainly found in plant-based products. The main outcomes of a proper folate intake are a healthy cardiovascular system, as well as a well-developed nervous system (Craig, 2009). This is particularly relevant during pregnancy since folate deficiency is usually associated to neural tube defects and/or increased risk of preeclampsia (Bullock, Lovell, Jordan, McCowan, Thompson & Wall, 2018; van Gool, Hirche, Lax, & Schaeppdrijver, 2018). Vitamin C status of vegetarians is also usually high (Craig, 2009), which may be particularly relevant for a proper tissue renovation (vitamin C plays a very important role on collagen biosynthesis), as well as to ensure a high functionality of immune system (Carr & Maggini, 2017). In addition to macro- and micronutrient intake, vegetarianism is also usually linked to a significantly higher consumption of antioxidants and other bioactive compounds (Ahola et al., 2018; Li, 2014; (Anderson, Baird, Davis Jr, Ferreri, Knudtson, Koraym, Waters & Williams, 2009), when compared to omnivores. Oxidative stress plays a key role on a wide range of disorders, especially in non-communicable diseases, such as cancer, chronic diseases or type 2 diabetes mellitus. A proper consumption of antioxidants may significantly decrease the risk of those diseases (Craig, 2009; Li, 2014; Pistollato et al., 2015).

Taken together, there are numerous and important benefits associated to vegetarianism. Those can have a profound effect in daily life of vegetarians. However, some of the highlighted potential advantages, may be particularly relevant during pregnancy, since nutritional requirements may be changed during that period, and also because some nutritional deficits may pose serious risks not only for the mother, but also for the development and health of the offspring (for example, folate deficiency).

3. Nutritional risks

Across the literature, there are many papers ascribing different nutritional risks for vegetarians, particularly in vegetarian pregnant women. One of the main potential outcomes of a vegetarian diet is protein deficiency, not only quantitatively, but also in some essential amino acids. In addition, there are several micronutrients whose ingestion may be insufficient in vegetarians (Koebrick et al., 2004; Piccoli et al., 2015; Sharma, Soni, Murthy, & Malhotra, 2003). In the following section, the main deficiencies of micronutrients that may be related with vegetarianism during pregnancy will be discussed.

3.1. Vitamin B12

Vitamin B12 is also known as cobalamin. It is a water-soluble vitamin whose needs are higher during pregnancy and even higher during lactation. It is essential for erythropoiesis, synthesis of nucleic acids and for the integrity of myelin sheaths (Pistollato et al., 2015). Vitamin B12 is only present in significant amounts in animal foods, though it can also be found in small quantities in vegetal products such as sauerkraut and in tea leaves, in some algae like chlorella and spirulina and in fungi such as shiitake and porcini mushrooms (Rizzo et al., 2016; Watanabe, Yabuta, Tanioka, & Bito, 2013). Regarding algae, it is important to highlight that some of them may also present vitamin B12 analogues that may decrease the efficiency of vitamin B12 (Watanabe et al., 2013).

Several reports have shown that vegetarianism during pregnancy may be associated with vitamin B12 deficiency, particularly in the case of vegan diets (Koebrick et al., 2004; Piccoli et al., 2015). The mean

plasma vitamin B12 values of vegetarians are usually 17–39% below the normal values (Pawlak, Lester, & Babatunde, 2014). This condition may contribute to a higher incidence of neural tube defects and impaired neurodevelopment, less lean mass and higher adiposity, insulin resistance, and increased risk of some cancers, namely, those from colon and breast tissues (Rush, Katre, & Yajnik, 2014). In addition, newborns breastfed by vegetarian mothers may also present low levels of vitamin B12 (Weiss, Fogelman, & Bennett, 2004). Those children may present lethargy, hypotonia, slow development and megaloblastic anemia, particularly during the second trimester of life (Chalouhi et al., 2008). Nevertheless, since folate and vitamin B12 are both required for erythropoiesis, and due to the fact that vegetarians usually present a high intake of the former, some of the symptoms associated to vitamin B12 deficiency may be somehow compensated (Agnoli et al., 2017).

In order to avoid the described deleterious consequences, supplements or fortified foods may represent a very important strategy to deal with those deficiencies (Snow, 2017, 2018), not only for the mother (Pepper & Black, 2011; Weiss et al., 2004), but also for the offspring (Chalouhi et al., 2008; Herrmann & Knapp, 2002). To this aim, the main Vegetarian Food Guides only consider a vegetarian diet “well-planned” if it includes a reliable source of vitamin B12 (Baroni, Goggi, & Battino, 2017; Messina, Melina, & Mangels, 2003).

3.2. Zinc

Zinc is a mineral that is required for numerous physiological processes, such as regulation of gene expression, functioning of immune system, cell signaling, enzyme action, among others (Foster & Samman, 2010). Due to its importance, zinc deficiency may have dramatic effects on growth, bone and sexual maturation, and may cause disturbances in immune response. Zinc is more abundant and bioavailable in food from animal origin (Hunt, 2003), so, vegetarian diet may be linked to some degree of zinc deficiency. The main animal sources of zinc are meat and milk (and their derivatives), while the main vegetable sources are whole grain cereals (Agnoli et al., 2017). Phytate, oxalate and dietary fiber, which are mainly found in plant-based products, have inhibitory effects on zinc intestinal absorption (Pistollato et al., 2015). On the other hand, cysteine and some hydroxyacids present in fruits can have an opposite effect (Wegmuller, Tay, Zeder, Brnic, & Hurrell, 2014). Summing all the factors, it is described that zinc absorption in vegetarians is about 15–26% while in omnivores it can reach 33–35% (R. S. Gibson, 1994; Hunt, Matthys, & Johnson, 1998). Besides that, pregnancy is also associated to higher zinc requirements, due to the importance of this mineral not only for the correct functioning of the body of the mother, but also for the fetal development (Swanson & King, 1987).

So, zinc deficiency may be another deleterious outcome related with vegetarianism during pregnancy (Abraham, 1982; Burdge et al., 2017), although there are also reports that demonstrate an absence of relationship between them (King, Stein, & Doyle, 1981). Recently, a meta-analysis about the zinc status on vegetarian mothers was conducted (Foster, Herulah, Prasad, Petocz, & Samman, 2015). It was not observed any significant difference between them and omnivore mothers, in the duration of gestation and in the birthweight of the children. In one study, significantly lower urinary zinc values were observed in vegetarians (Campbell-Brown et al., 1985). However, globally the ingestion of zinc by pregnant women was below the recommendations, in both groups (vegetarians and non-vegetarians), although in the former group mean ingestion was slightly lower. So, rather than a specific concern about vegetarian mothers, zinc deficiency appears to be a global concern affecting pregnancy in a transversal way (Foster et al., 2015). Since the relationship between modest zinc deficiency and pregnancy outcomes is scarcely documented (R. S. Gibson, 1994; Swanson & King, 1987), the real impact of the observed low zinc ingestion remains to be defined. It was proposed that if zinc intake during the pre- and post-delivery period is adequate, the nutritional status of their infants may

be considered normal (“Vegetarian weaning. Nutrition Standing Committee of the British Paediatric Association, 1988). Thus, it seems important to create strategies to increase zinc ingestion during pregnancy, particularly by women with a feeding pattern exclusively composed by plant-based foods. Increasing the ingestion of wheat, pumpkin seeds, nuts, pulses, some types of mushrooms, and, if necessary, zinc supplementation, may help to achieve proper zinc levels during pregnancy. In addition, the creation of strategies to improve zinc bioavailability may also represent an important attitude to avoid a zinc nutritional deficiency by pregnant vegetarian.

Regarding breast milk, zinc concentration appears to be somehow independent of maternal zinc intake (Krebs et al., 2012). This suggests that zinc amount in maternal milk may be maintained under homeostatic mechanisms. Its concentration is typically highest in colostrum and starts to gradually decrease during lactation (Foster & Samman, 2015). This means that special attention must be given to zinc intake, after the introduction of new foods in the feeding pattern of infants (Foster & Samman, 2015).

3.3. Iron

Besides zinc, iron may also be present in lower amounts in vegetarian mothers. This is due to the lower bioavailability of iron usually present in plant-based foods, when compared with those from animal origin (Craig, 2010; Hunt, 2003). This is mainly due to the fact that in plants iron is in the non-heme form. The consumption of food with high content of polyphenols or oxalate may also account for a decrease in iron bioavailability due to a decreased intestinal absorption, so special attention should be paid to tea, coffee, cocoa, spinach, among others.

Soybean is one of the main sources of iron for vegetarians (Hurrell & Egli, 2010). In order to increase the bioavailability of iron, vegetarians are recommended to have a high intake of vitamin C during the meals (Hunt & Roughead, 2000). In addition, the presence of organic acids such as citric, malic, lactic and tartaric acids, and carotenes and vitamin A also appear to contribute to higher intestinal absorption of iron (Collings et al., 2013; Craig, 1994). Since phytate decreases the bioavailability of iron, cereals and pulses may be soaked before consumption, in order to activate endogenous phytases (Agnoli et al., 2017).

On a general way, pregnant vegetarians are susceptible to present iron deficiencies (Agnoli et al., 2017; Pistollato et al., 2015). Nevertheless, in one published report, it was observed that vegetarians were more prone to ingest adequate amounts of iron and to take supplements during the first semester of pregnancy (Alwan et al., 2011). If proper iron levels are achieved, breast milk may present a mineral composition similar to that of omnivore mothers (Craig & Mangels, 2009; “Vegetarian weaning. Nutrition Standing Committee of the British Paediatric Association,” 1988). Iron deficiency may cause important handicaps in children, such as poor physical development and low productivity and cognitive performance (Alwan et al., 2011; Zimmermann & Hurrell, 2007). Iron supplementation during pregnancy and breastfeeding is thus recommended, either in vegetarian or non-vegetarian women, when hemoglobin levels drop under 105 g/L.

3.4. Omega-3 fatty acids

Omega-3 fatty acids are a heterogeneous class of lipids with many important health-promoting effects. Linolenic acid is the most abundant in plant foods, being mainly found in flaxseeds, hemp and chia seeds, walnuts and seaweeds (Davis & Kris-Etherton, 2003). Eicosapentaenoic and docosahexanoenoic acids (EPA and DHA, respectively) are other important omega-3 fatty acids, which are molecules with a very modest presence in plant-based products. The main dietary sources of these fatty acids are fatty fishes (such as tuna, sardines, herring, anchovies and mackerel), meat and dairy products (Tur, Bibiloni, Sureda, & Pons, 2012).

Omega-3 fatty acid deficiencies may occur in vegetarians, mainly in

EPA and DHA. This is more frequent in vegetarians following monotonous and poorly-planned diets (Burdge et al., 2017; Melina et al., 2016; Reddy, Sanders, & Obeid, 1994). These deficiencies can have an important impact not only during fetal development, but also in the content of DHA in breast milk (Michaelsen et al., 2011; Sanders & Reddy, 1992). Low levels of omega-3 fatty acids may be related to brain developmental defects, as well as to a variety of growth and metabolic disturbances (R. A. Gibson, Muhlhausler, & Makrides, 2011). One simple way to overcome this problem is by increasing the consumption of vegetable products such as flaxseeds, flaxseed oil, chia seeds and walnuts (Agnoli et al., 2017; Baroni et al., 2017). The intake of those fatty acids during the pregestational and perigestational periods also appears to be important for a successful supply of fatty acids to the fetus (Haggarty, 2004). So, an appropriate nutritional intervention may be performed as early as possible.

3.5. Vitamin D

Although vitamin D can be synthesized in the human body, a process that requires UV light exposure, this only occurs in relevant extent in places under significant sunlight exposure. Low levels of vitamin D can cause rickets in children and osteomalacia in adults (Pistollato et al., 2015). There are only few significant sources of vitamin D, mainly fat fishes and fortified foods (Pistollato et al., 2015). Globally, it is accepted that vitamin D deficiency is prevalent all over the world (Hovdenak & Haram, 2012; Kazemi, Sharifi, Jafari, & Mousavinasab, 2009), a situation that may be more frequent in pregnant vegetarians (Dasgupta, Saikia, & Sarma, 2012; Pistollato et al., 2015). Thus, supplementation appears to be an effective tool to ensure normal levels of vitamin D, particularly in regions that have poor sunlight exposure, or in low-income countries (Barger, 2010; Dasgupta et al., 2012; Hovdenak & Haram, 2012; Kazemi et al., 2009).

4. Impact on mother's health

The global effects that a vegetarian diet can have on pregnant women are diverse and, on a general way, poorly documented. It is described that it can contribute to lower blood pressure and, consequently, to decrease the risk of hypertensive disorders of pregnancy, such as pre-eclampsia or eclampsia (Carter, Furman, & Hutcheson, 1987; Piccoli et al., 2015). In another study, it was also reported a significant decrease on the prevalence of hypertension associated with proteinuria (Reddy et al., 1994). These observations reinforce the hypothesis that preeclampsia is associated with an increase in the consumption of saturated fat and sugar, and a decreased intake of fiber (Frederick et al., 2005). In line with this, it was proposed that the consumption of at least three daily servings of vegetables may decrease blood pressure during pregnancy (Carter et al., 1987).

Pregavid overweight has been associated with an increased risk of chronic diseases incidence by the offspring. An adequate intake of fruits and vegetables, as occur in vegetarianism, may help to control this variable (Laraia, Bodnar, & Siega-Riz, 2007). More recently, vegetarian diets were suggested to be involved in a better weight control in pregnant women, contributing to a lower or similar weight gain as compared with omnivores (Piccoli et al., 2015; Streuling, Beyerlein, Rosenfeld, Schukat, & von Kries, 2011). In one study it was observed that adopting a vegetarian dietary pattern in the first trimester of pregnancy may be linked to a lower gestational weight gain (Stuebe, Oken, & Gillman, 2009).

It is also believed that, due to the high amounts of fiber ingested by vegetarian mothers, the risk of developing gestational diabetes may be lower. In this context, it was suggested that an increment of 10g/day of ingested fiber may decrease up to 26% de risk of developing tat disease (Zhang, Liu, Solomon, & Hu, 2006).

Considering the gestational duration, some studies proposed that vegetarianism may be associated with a shorter time period, although

almost always within the expected duration (Piccoli et al., 2015). The only exception was reported in a study where the incidence of preterm delivery seemed to be increased in vegetarian mothers (Alwan et al., 2011). Regarding the type of delivery, there is conflicting data. Indeed, it was reported that this type of feeding pattern may also be associated with either an increase or a decrease in cesarean deliveries (Pistollato et al., 2015; Reddy et al., 1994).

Another potential benefit of vegetarian diets may comprise a decrease in the incidence of calf cramps during pregnancy (Koebnick et al., 2005), which may be at least partly explained by higher intakes of magnesium.

Lower maternal mortality and changes in the incidence of postpartum depression have also been linked to vegetarianism during pregnancy (Carter et al., 1987; Pistollato et al., 2015). Considering the latter, it is a frequent problem (13%) that usually starts during the first month after delivery. Vegetarianism has been associated with an increase in the incidence of postpartum depression, but the underlying mechanisms remain to be elucidated (Hogg-Kollars, Mortimore, & Snow, 2011).

Finally, a recent systematic review revealed that if a vegetarian diet is well-planned, balanced and varied, with no nutritional deficits, it is not associated with any relevant negative health outcome (Piccoli et al., 2015).

5. Impact on fetal development

The impact of vegetarian diets on fetal development is perhaps one of the most controversial aspects of vegetarianism. The available data is still scarce and further studies are required to have an integrated and more detailed perspective about it. There are reports that claim that vegetarianism during pregnancy is associated to a lower birthweight (~20–200 g), although in the majority of the cases it was not proved statistical significance of the results (Campbell-Brown et al., 1985; Pistollato et al., 2015; Reddy et al., 1994; Ward et al., 1988). In another set of published reports, it was described a higher birthweight (Fonnebo, 1994; Lakin et al., 1998). In line with this, two additional studies have shown that a high intake of vegetables and fruits may be linked to an increase not only in birthweight but also in fetal size (Mikkelsen, Osler, Orozova-Bekkevold, Knudsen, & Olsen, 2006; Rao et al., 2001). Both studies highlighted the putative role of green leafy vegetables on this outcome.

Globally, the interpretation of these data is far from being a simple task, since age, sex, ethnics and culture are variables that may influence the global effects of vegetarian diets on birthweight. One study also revealed that vegetarian mothers had an increased probability to have children with congenital malformations, namely, hypospadias (North & Golding, 2000), but the details about this association remain to be unraveled.

6. Impact on children development

Vegetarian diets are often associated to a lower exposure to toxic molecules. Moreover, it is also characterized by higher intakes of antioxidants and other bioactive molecules that may confer additional protection against external agents. Consequently, this feeding pattern may have a profound impact on offspring not only during fetal development, but also in the development of the newborns, and later in life.

Nitrate, nitrite and N-nitroso compounds are known to increase the incidence of neural tube defects and pediatric brain tumors (Pistollato et al., 2015). The main dietary sources of these molecules are cured meat and smoked fish (Lijinsky, 1999), which are absent in vegetarian diet patterns, although pickled vegetables may also contain relevant amounts of them. Globally, the risk of developing diseases associated to nitrate, nitrite and N-nitroso compounds is lower in children from vegetarian mothers (Brender et al., 2012; Pogoda et al., 2009).

The incidence of some immune dysfunction, particularly

Table 1
Main potential outcomes of vegetarianism during pregnancy.

		All cases (n vegetarians)
Nutritional deficiencies	Vitamin B12	109 (27) [Koebnick, Hoffmann, Dagnelie, Heins, Wickramasinghe, Ratnayaka, Gruendel, Lindemans & Leitzmann, 2004]
	Zinc	60 (20) [Abraham, 1982]; 23 (17) [King et al., 1981]; 45 (25) [Haddad, Berk, Kettering, Hubbard, & Peters, 1999]
	Iron	32 (14) [Thomas & Ellis, 1977]; 46 (21) [Sharma, Kiran, Ramnath, Khushiani, & Singh, 1994]
	Omega-3 fatty acids	19 (4) [Lakin, Haggarty, Abramovich, Ashton, Moffat, McNeill, Danielian & Grubb, 1998]
	Vitamin D	71752 (27493) [Rizzo, Jaceldo-Siegl, Sabate, & Fraser, 2013]
Maternal outcomes	Lower blood pressure	775 (775) [Carter et al., 1987]; 144 (48) [Reddy et al., 1994]
	Better weight control	1388 (50) [Stuebe et al., 2009]
	Lower risk of gestational diabetes	13110 (ND) [Zhang et al., 2006]
	Lower incidence of calf cramps	108 (27) [Koebnick, Leitzmann, Garcia, Heins, Heuer, Golf, Katz, Hoffmann & Leitzmann, 2005]
	Shorter gestational duration	144 (48) [Reddy et al., 1994]
	Increased incidence of postpartum depression	100 (19) [Hogg-Kollars et al., 2011]
Fetal outcomes	Lower-to-normal birthweight?	144 (48) [Reddy et al., 1994]; 144 (59) [Campbell-Brown, Ward, Haines, North, Abraham, McFadyen, Turnlund & King, 1985]; 32 (14) [Thomas & Ellis, 1977]; 165 (112) [Ward, Abraham, McFadyen, Haines, North, Patel & Bhatt, 1988]
	Normal-to-high birthweight?	19 (4) [Lakin, Haggarty, Abramovich, Ashton, Moffat, McNeill, Danielian & Grubb, 1998]; 7285 (ND) [Fonnebo, 1994]
	Increased risk of hypospadias	7928 (3211) [North & Golding, 2000]
Children outcomes	Lower risk of neural tube defects	201 (120) [Koebnick, Heins, Hoffmann, Dagnelie, & Leitzmann, 2001]
	Lower risk of brain tumors	3441 (ND) [Pogoda, Preston-Martin, Howe, Lubin, Mueller, Holly, Filippini, Peris-Bonet, McCredie, Cordier & Choi, 2009]
	Lower risk of immune system dysfunction	763 (ND) [Miyake et al., 2010]
	Lower risk of orofacial clefts	355 (50) [Krapels, van Rooij, Ocke, West, van der Horst & Steegers-Theunissen, 2004]

ND = not defined.

hypersensitivity reactions, appears to be decreased with the adoption of a vegetarian diet during pregnancy (Pistollato et al., 2015). More precisely, the increased maternal intake of antioxidants, particularly vitamin A, C and E, may reduce the risk of eczema, wheeze, asthma and atopic dermatitis (Miyake, Sasaki, Tanaka, & Hirota, 2010; Nurmatov, Devereux, & Sheikh, 2011). In the case of diabetes, it was proposed that plant-based diets during pregnancy may be protective for children, although there is a lack of evidence to support this hypothesis (Pistollato et al., 2015).

Orofacial clefts are congenital defects that are strongly associated to a low intake of folic acid. Not surprisingly, an increased intake of vegetables and other plant-derived foods, appear to confer some protection against those defects (Krapels, van Rooij, Ocke, West, van der Horst, & Steegers-Theunissen, 2004; Pistollato et al., 2015).

The present evidence points to a very significant influence of maternal dietary habits on the incidence of the majority of pediatric tumors (Mosby, Cosgrove, Sarkardei, Platt, & Kaina, 2012). The potentially protective foods include green leafy vegetables, fruit and other plant-derived products. The beneficial effects appear to be linked to their high vitamin and mineral content, as well as the presence of important antioxidants and other bioactive components. These molecules may cause a significant decrease in the risk of pediatric acute lymphoblastic leukemia, Wilms tumor, primitive neuroectodermal tumors and anaplastic astrocytomas (Jensen et al., 2004; Linabery, Johnson, & Ross, 2012; Pistollato et al., 2015; Pogoda et al., 2009; Spector et al., 2005).

7. Conclusions

The feeding pattern is one of the most important exogenous factors that may influence the continuous changes that occur during pregnancy. Maternal under- or overnutrition are considered risk factors for the development of several chronic diseases, that may compromise the life of either the mother or the children. Not surprisingly, vegetarianism may have a profound impact on mother's health, fetal development and in the development of the newborns. From an obstetric point of view, it is important to stress out that the global outcomes of vegetarianism may

be considerably more complex and intricate than the sum of all the individual effects on both mother's and child's health. Also, some of the potential benefits attributable to vegetarianism may be an indirect consequence of it, rather than a specific effect of this feeding pattern. For example, the better weight control and the decrease in the blood pressure may be linked to improvements in several health markers in both the mother and the offspring. Also, the adoption of vegetarianism is frequently related to healthier habits which may also contribute to better health outcomes. Table 1 summarizes the main potential health outcomes of vegetarianism during pregnancy. Some of the effects were directly proven and are now well-documented (for example, vitamin B12 deficiency or effects on blood pressure), while others are mainly assumed indirectly (for example, lower incidence of gestational diabetes). The analysis of the available information regarding this issue is a very difficult task, due to the high heterogeneity of data, experimental protocols, variability among the characteristics of the study groups and the intricate and very complex relationship between diet and lifestyle.

Taken together, it is important to highlight that vegetarianism may be associated to an increased risk of some nutritional deficits only if the diet is not well-planned. This may have serious clinical outcomes and, due to that, pregnant vegetarians should seek a strict follow-up by nutritionists with expertise in vegetarian nutrition. Well-planned vegetarian diets appear to be safe during pregnancy, since they provide all the required nutrients. Properly planned vegetarian diets are not only perfectly compatible with a normal pregnancy, but may also present additional benefits in some cases, even in pre-pregnancy. Thus nutritional counselling must be considered a very important strategy for women in childbearing age, in order to help them to become healthier and, consequently, to have healthier pregnancies. Although pre-pregnancy counselling is far from being a generalized practice, this situation might have a profound impact from a public health perspective. The choice for a vegetarian feeding pattern during pregnancy is a personal choice that must take into account the potential risks and benefits of it. Pregnant vegetarians, like pregnant omnivores, should be able to take the better decisions regarding what they eat, when they eat and how many they eat. Only considering feeding as a whole it is possible to achieve a healthy pregnancy.

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