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BRANCH RECOMMENDATION

Vegetarian Diets in Paediatrics. Nutrition Branch Recommendations

Dietas vegetarianas en Pediatría: Recomendaciones de la Rama de Nutrición

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What do we know about the subject matter of this study?

Several international societies support the implementation of vegetarian diets in the pediatric population. In contrast, others do not recommend it since there could be deficits of essential nutrients for growth and development. Therefore it must be strictly supervised by qualified professionals.

What does this study contribute to what is already known?

The objective of this publication is to describe potential nutritional deficiencies and to provide guidelines for the implementation of a balanced and safe vegetarian diet in the Chilean pediatric population.

Abstract

In recent decades, the vegetarian dietary option has been increasing in the general population, including the pediatric age group. This has led to numerous questions regarding the benefits and risks that may arise from its implementation. Food restriction implies the potential deficiency of several nutrients, establishing some of them as critical for this period of development and rapid growth, so the safety of vegetarian diets has not been fully established worldwide. The main critical nutrients are iron, zinc, calcium, vitamin B12, and omega-3 fatty acids. The groups most at risk of nutritional deficiencies are infants, adolescents, more restrictive vegetarian options, and those who do not have adequate professional nutritional counseling. Therefore, vegetarian diets should be strictly supervised. Scientific societies such as the American, Canadian, Italian, and British nutrition societies recognize vegetarian diets as healthy in the pediatric age as long as they are supervised by qualified health professionals. However, there are others that do not support it as the French one, while the Spanish one supports it with restrictions in the infant period. The objective of this publication is to describe potential nutritional deficiencies and to provide recommendations to follow a balanced and safe vegetarian diet in the pediatric population according to the available information, paying attention to the limitations that we may have in the implementation of this diet in our population, especially in critical stages such as infants and adolescents.

Keywords:
Vegetarian;
Vegan;
Nutritional Deficiencies;
Restrictive Diet

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Introduction

In recent years, the number of people following vegetarian diets has increased and has extended to pediatric ages[1]. In Chile, there are no population-based prevalence studies. In other countries, such as the USA, Spain, and France the prevalence in adults is 2-5%; around 10% in Germany, Sweden, and Italy, and up to 30% in India[2]. Some of the reasons for this increase are the pursuit of healthier lifestyle habits, ethical issues related to animal abuse, environmental reasons, religious beliefs, and health problems, among others[3].

In adults, these diets have shown benefits such as lower frequency of cardiovascular and cerebrovascular diseases, type 2 diabetes, hypertension, some cancers, and obesity[4,5], and in children and adolescents, a lower frequency of overweight and obesity[6]. However, due to food restrictions, people who follow vegetarian and especially vegan diets may be at risk of deficiencies in critical nutrients such as proteins, iron, zinc, calcium, vitamins D and B12, iodine, and omega-3 essential fatty acids. This safety concern about this type of diet is particularly important during the pediatric age, especially in periods of growth acceleration, such as infants and adolescents (Table 1). In this context, it remains unclear whether the health benefits outweigh the risks of nutritional deficiencies[1].

The American Academy of Pediatrics[7], the Canadian Pediatric Society[8], the Academy of Nutrition and Dietetics[3], the Italian Society of Human Nutrition (SINU)[9], the Spanish Pediatrics Association[10], and the Argentina Society of Pediatrics[11] point out that vegetarian and vegan diets are healthy if properly planned.

In contrast, the German Nutrition Society does not recommend a vegan diet in infants, children, and adolescents unless it is supplemented and the French-speaking Pediatric Hepatology, Gastroenterology, and Nutrition Group does not recommend it due to the risk of nutrient deficiencies, unavoidable without supplementation[12,13].

The objective of this publication is to describe the potential nutritional deficiencies and provide recommendations to follow a balanced and safe vegetarian diet in the pediatric population, according to the available information, focusing on the limitations that we may have in its implementation in our population, especially in critical stages such as infancy and adolescence.

Definition

The definition of vegetarian diets has become more specific over time and requires standardization for research purposes[12]. The usual classical way of classification implies excluded and accepted foods (Table 2).

There are other options such as macrobiotic, fruit, and raw vegan diets. For any of these or other diets with no clear classification, a complete nutritional anamnesis should be obtained to determine the foods excluded, the intake of foods included in their option both in quantity per serving and frequency, and use of fortified foods and/or dietary supplements. This information will show the potential deficiencies in order to plan a balanced and sufficient diet.

1. Nutrient content of vegetarian diets

When comparing vegetarian and omnivorous diets, there is a higher intake of grains, legumes, vegetables, fruits, and seeds and, therefore, a higher intake of fiber, vitamin E, vitamin C, thiamine, folate, magnesium, copper, and omega-6 fatty acids. There is an equal or lower intake of energy, saturated fat, and cholesterol, with a potentially lower intake of protein, iron, zinc, calcium, iodine, omega-3 fatty acids, niacin, and vitamins D and B12[14]. These nutrients should be permanently evaluated, especially vitamin B12, due to the risk of irreversible neurological damage in infants[15].

Fortified foods are one option for achieving sufficiency, but fortifications vary and are not available to everyone. In Chile, there are food fortification programs, such as iron and folic acid in wheat flour, iodine in salt, and fluoride in water[16]. However, such programs were designed based on an omnivorous diet and may not be sufficient for vegetarian children, therefore, all this makes planning and advice necessary to achieve an adequate vegetarian diet[17]. Table 3 shows some recommendations for optimizing the bioavailability of nutrients in vegetarian diets.

2. Growth and development according to age

Numerous studies conclude that vegetarian children properly grow and develop on well-designed and supplemented diets[7,18].

In 2016, the Academy of Nutrition and Dietetics indicated that it is possible to cover nutritional contents in vegetarian children in fast growing stages by strictly and periodically monitoring growth velocity, a sensitive marker of nutrient adequacy[3].

The following studies were carried out in developed countries, in populations with a higher socioeconomic and education level. Thus, the extrapolation of results to our country requires careful consideration.

Infants and preschoolers: Since the 1980s, studies in vegetarian infants[19,20] and preschoolers show normal weight and height for these groups, concluding that a well-implemented vegetarian diet shows an adequate weight and height development. In 2019, Weder showed that well-supervised vegetarian and vegan diets in children aged 1-3 years (127 vegans, 139 vegetarians, and 164 omnivores) in the first years of life provide energy and macronutrients that ensure normal growth[21].

Children: A review of 24 studies of vegan and vegetarian diets in children and adolescents aged 0-18 years showed that their weight and height were within normal ranges[1]. Rosell compared in 16,083 vegetarians, height, body mass index (BMI), and age at menarche between those who had become vegetarians after the age of 20 and those who were vegetarians all their lives, reporting no differences between the two groups[22]. When comparing height, Sabaté found that the vegetarian children were even taller than the control group[23]. Finally, lower weight or fat mass, compared with omnivores, is consistent with assumptions that vegetarian diets may be beneficial for the prevention of obesity in childhood, but the underlying mechanisms are under discussion[6].

Adolescents: Growth in vegetarian adolescents is similar to that of omnivores, although generally when comparing their BMI, they are leaner (within normal ranges for their age) and with a lower prevalence of overweight and obesity [6,24].

If a patient presents a significant weight loss associated with a vegetarian diet, Eating Disorder should be suspected and ruled out.

Table 1. Risk factors for nutritional deficiencies in vegetarian diets in pediatrics.

Age: periods of rapid growth, infants and adolescents.
Lack of adequate counseling
More restrictive diet: vegan, macrobiotic, fruitarian and raw vegan diets
Reduced availability of alternative and/or fortified foods
Nutritional status: malnutrition
Major or severe illness with risk of nutritional deficiency
Lower educational level of parents and/or caregivers

Table 2. Types of vegetarian diet options[12]

Vegetarian option	Description
Vegans	Exclude dairy, eggs, and all types of meat
Lacto-vegetarians	Exclude eggs and all types of meat, but consume dairy products
Ovo-vegetarians	Exclude dairy and meats, but consume eggs
Lacto-ovo-vegetarians	Exclude all meats, but consume dairy and eggs
Semi-vegetarians or flexitarians	Consume dairy, eggs and occasionally some type of meat
Macrobiotics	Based on grains, legumes, vegetables, occasionally consume fish
Crudivores	Eat only foods cooked at less than 48°C.

3. Essential nutrients by age group

a) Proteins

In vegetarian diets, the protein requirement is covered when the energy intake is adequate. In vegans, the main protein source is soy, which has 95% of digestibility[25]. Proteins from legumes, grains, nuts, seeds, and their butter are less digestible, so some recommend increasing their intake by 10-30%[3,13,18]. In addition, it is important the variety and frequency of consumption during the day, to reach a proper amino acid score[3].

Infants: The breast milk of well-supplemented vegetarian women is similar in composition to that of omnivorous women[26]. If breastfeeding is not possible, modified cow's milk formulas similar in composition to breast milk should be used, and in vegans, formulas based on vegetable protein fortified with micronutrients, essential fatty acids, and amino acids should be used for this age group[26]. In Chile, there are formulas based on soy and another based on rice protein, which are expensive and not widely available on the market. For the general population, homemade or store-bought vegetable drinks such as almond, coconut, oat, or from other vegetable sources are not nutritionally adequate as a substitute for breast milk at this critical stage of growth and development.

When starting complementary feeding, the intake of foods with vegetable protein should be increased by 10-15%[17,27]. Maintaining breast milk intake, at least 500 mL/day, improves the amino acid composition of the diet and protein utilization.

Preschoolers: in vegans increase protein intake by 20 to 30%[27].

Children and adolescents: in vegans, protein intake increase by 15 to 20%[3,8,18,26].

b) Vitamin B12

It is almost exclusively present in products of animal origin, with very limited content from some vegetables. The usual intake of eggs and dairy products does not cover the requirements during the pediatric age[26].

Vitamin B12 absorption depends on the saturation of intrinsic factor, which is essential for this process and occurs with intakes higher than 2.5ug. If supplements are consumed at higher doses, the percentage of absorption is lower. For this reason, smaller single daily doses or fractionated ones are recommended[28] (Table 4).

Vitamin B12 monitoring is still difficult since there is no agreed cut-off point to define deficiencies. Various publications show different values related to va-

Table 3. Recommendations to improve the nutritional intake of foods[8,17]

Nutrient(s)	Recommendation
Protein	- Consume different vegetable sources of protein throughout the day to provide all amino acid. - Mix legumes with cereals to achieve a better amino acid score.
Calcium	- Choose calcium-rich, low-oxalate vegetables such as broccoli, kale, brussels sprouts, collard greens, kale, walnuts, almonds, sesame seeds, soybeans, tempeh,legumes, calcium rich tofu and dried figs to promote calcium absorption
Iron and zinc	- Soak legumes and remove this water to decrease phytate content. - Ferment and/or sprout breads, grains and seeds to decrease phytates
Iron	- Avoid consumption of tea, coffee and cocoa with and after meals: their poliphenols inhibit iron absortion - Consume foods rich in vitamin C with meals (citrus fruits, strawberries, kiwi): favors iron absorption. - Decrease of calcium and phytate content with fermentation processes, prolonged soaking of legumes and roasting or soaking of nuts and dried fruits.
Omega 3	- Use of micro algae, nuts, canola and flaxseed oils, sesame and chia, peanut butter, soybeans and bean sprou

ried clinical manifestations (neurological or hematological). This suggests evaluating vitamin B12 together with other metabolites that are involved in its metabolic pathways and that may also reflect preclinical stages of deficiencies.

The cut-off points to define B12 deficiency vary between 211pg/ml (< 156pmol/L) and 488pg/mL (< 360pmol/L); although recommendations of scientific societies for vegetarian diet supplementation have defined 407pg/ml (< 300pmol/L) (Table 4)[9,11,29].

Complementary metabolites are homocysteine (normal < 10 mmol/L), holotranscobalamin II (normal > 45 pmol/L), and/or methylmalonic acid (normal < 271 nmol/L)[30,31].

Infants: Breastfed infants of non-supplemented vegetarian mothers are at risk of deficiency, with potential neurological damage that may be irreversible[15]. Adequate intake and absorption during pregnancy and breastfeeding have a greater influence on the infant than maternal deposits, and even short periods of intake restriction in the mother can alter them[15], therefore, vegetarian pregnant and lactating mothers should be evaluated and supplemented[17]. This supplementation of vitamin B12 should be exclusive since some components of multivitamins, such as vitamin C and copper, can degrade cobalamin[28].

From the beginning of complementary feeding, it is suggested to supplement with vitamin B12[32].

Children and adolescents: In all vegetarians, food and supplement intake should be evaluated in order to determine if they achieve vitamin B12 requirements. It is recommended that at least 3 daily servings of foods rich in B12 (milk, eggs, fortified foods) be consumed and monitoring with laboratory tests[1,3,18]. In our country, there are few fortified products, access to professional specialists to supervise diets is limited, and tests to monitor B12 are expensive, so if dietary control conditions are not optimal, it is recommended to supplement with vitamin B12, as in vegans (Table 4).

c) Vitamin D

Its concentration depends on sun exposure, fortified foods, or supplement intake[3]. There are few food sources, which are found in liver, fatty fish, and egg yolk, therefore, it may be lacking in vegetarian diets.

Infants: Breast milk and milk formulas do not prevent its deficiency, so they should be supplemented with 400 IU during the first year of life and 600 IU during the second year[33].

Children and adolescents: Its concentrations are on average twice lower than those that follow an omnivore diet. It has been described that exposure to sunlight on the face and hands, 20 to 30 minutes daily, three times a week, could be sufficient, but in situations such as wintertime, having dark skin coloration, excess weight, and living in latitudes over 35°, this exposure should be higher. However, it is not well defined yet, therefore it is recommended to evaluate 25OHD and, if there is a deficiency (< 20ng/ml), it should be supplemented, especially in vegans[33] (Table 5).

d) Calcium

If the intake of dairy products, formula, or fortified vegetable-based beverages is adequate, there should be no deficiencies[35]; and their calcium absorption is close to 30%. It is recommended to consume vegetables with higher calcium and lower oxalate content, but this alone is not sufficient to meet requirements (Table 3).

There is no consensus on the most appropriate method to measure calcium sufficiency, and it should be evaluated on a case-by-case basis, especially if there is deficient intake[26].

Infants: milk from vegan mothers has a good concentration of calcium. If there is no breastfeeding, a milk formula or fortified vegetable formula is recommended. When starting complementary feeding, it is necessary to add vegetables rich in calcium and low in oxalates (Table 3).

Children and adolescents: ovo-lacto or lacto-vegetarians meet the requirements if they comply with the intake of dairy products in the recommended quantity. In vegans, calcium intake is more than three times lower than that of omnivores[36], so they should be supplemented according to the estimated calcium intake in food.

e) Iron

Although vegetarian diets have the same amount of iron as omnivore diets, they require 1.8 times higher intake because of their lower bioavailability[37] (Table 3).

In Chile, *Purita* milk and wheat flour are fortified, but would not be sufficient sources to meet nutritional requirements[16].

Hemoglobin and ferritin should be measured in order to assess iron levels[38].

Infants and preschoolers: Iron is essential for growth, hematopoiesis, and neurological development. The prevalence of anemia in vegetarians is similar to that of non-vegetarians, but several studies show insufficient deposits[26,38]. Between 6 and 24 months of age, the iron requirement per kg of body weight is higher than at any other age and it has been shown that children can adapt iron absorption when requirements increase[26]. All breastfed children should receive supplementation from 4 months to one year of age. In the second year, it is suggested to maintain supplementation if they have a vegan or ovo-vegetarian diet, they do not consume enough fortified vegetable formula, and/or do not comply with a supervised and complete complementary feeding.

Children and adolescents: In vegetarians, adequate iron intake has been demonstrated and studies on anemia are inconclusive. Although this population showed lower ferritin concentrations than omnivores, the differences are small and rarely associated with anemia[39,40].

It is recommended to consider the intake of coffee and and tea , and do not recommend with meals as they decrease iron absorption[41].

f) Zinc

It is found in legumes, seeds, grains, and nuts, but its phytate and oxalate content decreases its bioavailability, so the same recommendations as for iron should be followed to improve its absorption (Table 3)[42].

Infants: Zinc levels in breastfed infants of vegetarian mothers are equal to that of infants of omnivorous mothers. There is no consensus recommendation for zinc supplementation at this age, but in those infants that show less height growth, use non-fortified vegetable formulas, or do not follow an adequate complementary diet, it is suggested to supplement from 6 months to 2 years of age[38]. No marker adequately reflects zinc levels, but clinical history, decreased plasma zinc concentrations, and lower linear growth may be indicative[38].

Children and adolescents: The few existing studies find similar zinc concentrations in vegetarians as in omnivores[42]. In very restrictive vegans, supplementation may be necessary[38].

g) Omega-3

In vegetarians, lower levels of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) have been observed[43]. Vegetarians tend to consume more omega-6 and minimal amounts of omega-3. Regular consumption of foods rich in omega-3 is recommended to restore their balance (Table 3).

Infants: Vegetarians' breast milk has lower levels of DHA, but the parameters in newborns are the same[44].

Table 4. Vitamin B12 supplementation dosage, according to age

Age	Dietary intake requirements (ug/day)	Supplementation maintenance (ug/day)	Vitamin B12 deficiency treatment (ug/day)*
Suckling	2.8	50	1000 ug/day
0-6months	0.4	5	-
6-12months	0.5		250ucg/day or 10ucg 3 times/day
1-3 years	0.9		
4-8 years	1.2	25	500ug 4 times/week (4 to 6 years) 500ug 6 times a week (7 to 10 years)

If vitamin B12 < 102pg/ml (75pmol/L) indicate for 4 months, vitamin B12 between 102 and 203pg/ml (75 and 150pmol/L) indicate for 3 months, if vitamin B12 between 203 and 298pg/ml(150 and 220pmol/L) indicate for 2 months and if vitamin B12 between 298 and 407pg/ml(220 and 300pmol/L) indicate for 1 month. (references 9,13,17,28,29).

Table 5. Vitamin D supplementation dose, according to age (13,34).

Age	Maintenance	Deficiency	UL*
Neonates	400UI/day	1000UI/day for 6-8 weeks	1000UI/day
1 month to 10 years	400-1000UI/day	1000-3000UI/day for 6-8 weeks or 50000UI/ weekly for 6 weeks	2000UI/day
> 10 years	400-1000UI/day	1000-3000UI/day for 6-8 weeks or 50000UI/weekly for 6 weeks	4000UI/day

*Upper limit, maximum doses for chronic treatment.

However, it is recommended that pregnant and breastfeeding vegan women to supplement with DHA 100-200 mg/day.

When starting complementary feeding, add omega-3 rich oils (flaxseed, canola). Intake of DHA 100 mg/day is recommended from 6 months to preschool age[17].

Children and adolescents: They should have an adequate intake of foods rich in omega 3 (Table 3) and an appropriate balance of omega 6/omega 3 in the diet by reducing the intake of omega 6 (marigold oil, corn) and favoring the consumption of oils rich in omega 3 (flaxseed, canola) and other vegetable oils such as olive oil. However, if we want to ensure a minimum intake of DHA and/or EPA, the use of a DHA supplement is recommended[13], which in vegetarians and vegans can be from commercially available algae.

h) Iodine

Thyroid hormones are essential for neurological development and depend on optimal levels of iodine[45]. In Chile, salt is iodine-fortified, but if it is not used, it may be deficient, which again makes nutritional anamnesis an important element for detecting patients with insufficient intake[26].

4. Special Considerations

a) Pregnant women and wet nurses:

Although there is evidence that when the diet of vegetarian mothers is adequate, variables such as duration of pregnancy and newborn weight are similar to those of pregnancies in omnivorous mothers, pregnant women should have appropriate guidance on the requirements of essential nutrients[46] and their supplementation should be evaluated on a case-by-case basis, especially iron, vitamin B12, and DHA. Pregnant vegetarians are at risk of iron deficiency , as are omnivores, so they should receive supplementation.

Given the importance of vitamin B12 and DHA in the neurodevelopment of children and the increase in their requirements during pregnancy and breastfeeding, vegetarian mothers should receive supplementation. During breastfeeding, vitamin B12 levels in breast milk correlate with those of the mother, which are maintained at adequate levels only with supplementation[10,17,47] (Table 4).

b) Child and Adolescent Athletes:

There is not enough research regarding the adequacy of vegetarian diets in sports performance, especially in children and adolescents, however, as in all vegetarians, it is important to make good food planning, ensuring an adequate intake of energy, protein, vitamin B12, calcium, iron, and zinc, since the requirements are increased in competitive athletes and may be deficient, especially vegans[8].

Regarding proteins, the requirements can be met with an adequate vegetarian diet, with no need for supplements, but the intake should be adjusted when doing sports where the requirements are increased, such as endurance training (1.2g/kg to 1.4g/kg) and strength training (1.6g/kg to 1.7g/kg)[48].

It is important to pay special attention to adolescent girls who participate in endurance sports, as they may be at greater risk of developing iron deficiency, due to the lower bioavailability of iron from vegetables, the increased sport-related losses (in sweat, stool, and urine), and menstruation, so it is recommended to monitor their levels periodically[49]. All adolescents who engage in the competitive sporting activity require nutritional counseling, especially vegetarians.

c) Eating disorders (ED):

When an adolescent becomes a vegetarian, it should be evaluated whether there is an intention to restrict foods in order to lose weight and whether there are other "forbidden" foods in her/his diet that may indicate the presence of an ED. However, it is more common for the eating disorder to be present before starting a vegetarian diet[50].

5. Recommendations by age

In summary, we can provide the following general recommendations and the critical nutrients analyzed according to age group.

Infants and preschoolers:

- This is a particularly critical stage of life due to rapid growth and development, which requires frequent follow-up with an evaluation of dietary intake, anthropometry, and, eventually, laboratory tests if there is suspicion of deficiency.
- Encourage breastfeeding and, if breastfeeding is not available, use fortified milk or plant-based formulas.
- Supplement vitamin B12 and omega 3 (DHA 100-200 mg/day) in vegetarian breastfeeding mothers.
- Supplement iron and vitamin D equal to omnivore population. Nutritional requirements must be met according to the vegetarian option.
- Start complementary feeding at 6 months of age, under the advice of a nutrition professional to achieve a balanced and complete diet as much as possible, according to the vegetarian option. Control the intake of dietary fiber to avoid early satiety and lower intake.
- Supplement with vitamin B12 and Zinc from the beginning of complementary feeding, given the potential risk of deficiency and the difficulty of its biochemical study.

Children and adolescents:

- Ask why they became vegetarian and assess concerns about weight and body image.
- Discuss the risks of a vegan diet; if they have already decided, make a rigorous plan, with the use of supplements and regular check-ups.
- Provide education on healthy vegetarian eating and sources of information (recipes and food guides).
- Ensure intake of essential nutrients, especially vitamin B12 and calcium.
- Control with laboratory tests at the time of consultation (if no previous tests) and at one year (advance to 6 months if there are deficiencies).
- Perform laboratory tests blood count, serum ferritin, 25 OH vitamin D, homocysteine, Vitamin B12, and zinc.

Conclusions

There is a growing interest in following vegetarian diets in all age groups and, although they are healthy and protect against several chronic diseases, if they are not adequately planned and supplemented, nutritional deficiencies can be generated with the consequent risk of altered growth and development, and even neurological damage, sometimes irreversible, especially in stages of life with higher nutrient requirements such as pregnancy, infancy, and adolescence.

Considering that in our country access to specialized nutritional counseling, fortified foods, and supplements is still limited, the recommendation for the pediatric population is a balanced omnivorous diet, as it allows, with greater safety, to meet the nutritional requirements of growing children. However, we must be prepared to support parents and children who, properly informed, decide to implement any vegetarian diet. Therefore, health professionals should have adequate knowledge of these types of diets, periodically evaluate growth and development, monitor laboratory tests, and, when possible, refer to a nutrition specialist for proper dietary planning and supplementation.

Conflicts of Interest

Authors declare no conflict of interest regarding the present study.

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