Nutritional concerns of lactating women consuming vegetarian diets\(^1\text{-}^3\)

Bonny L Specker

**ABSTRACT**

Nutritional inadequacies during lactation may affect the well-being of the mother, infant, or both. Vitamin D and calcium status in vegetarian women may be low, resulting in maternal bone demineralization. Vitamin B-12 deficiency resulting in neurologic damage has been reported in infants of vegetarian women. A review of several studies completed on women in the northeastern United States who were consuming a macrobiotic diet is presented. Supplemental vitamin D does not appear to be necessary given sufficient sun exposure. Calcium intake in vegetarian mothers was low and differences in magnesium-regulating hormones were apparent. However, it is not clear whether these hormonal changes resulted in adequate adaptation and prevented bone demineralization. The low calcium intake in the vegetarian women did not result in lower milk calcium concentrations. Elevated methylmalonic acid excretion, which is often seen in vitamin B-12 deficiency, was noted in the vegetarian mothers and their infants. Infants with high methylmalonic acid excretion were consuming milk low in vitamin B-12. *Am J Clin Nutr* 1994;59(suppl):1182S–6S.

**KEY WORDS**

Lactation, vegetarian, vitamin B-12, vitamin D, calcium, methylmalonic acid

**Introduction**

Pregnancy and lactation place nutritional demands on the mother because of requirements for fetal growth and for milk production. Nutrient intakes that often are of concern to individuals consuming vegetarian diets should be of special concern to pregnant or lactating vegetarian woman. This includes ensuring adequate intake of energy, iron, zinc, calcium, vitamin D, vitamin B-12, and riboflavin. Deficiencies of these nutrients can affect the well-being of the mother, infant, or both. This paper summarizes the results of several studies we completed in the early 1980s on the calcium, vitamin D, and vitamin B-12 status of lactating women consuming a vegetarian diet.

The vegetarian population studied was recruited from the Boston, MA and Middletown, CT areas and the nonvegetarian, or omnivorous, population was recruited from the Boston area. The vegetarian population was consuming a macrobiotic diet that typically consists of 50–60% whole cereal grains, 5% soups, 20–25% vegetables, and 5–10% beans and sea vegetables (1). Meat is avoided and little or no dairy foods or eggs are eaten. Occasionally, small quantities of seafood are eaten. Vitamin supplements are generally not taken.

**Vitamin D and calcium status**

Calcium requirements are thought to be increased during lactation and there is concern that vitamin D and calcium intakes in vegetarian women may be too low, theoretically resulting in demineralization of the mother’s bone.

A total of 51 women (36 women consuming a macrobiotic diet and 15 women consuming an omnivorous diet) participated in a study to determine the effect of the consumption of a vegetarian diet during lactation on biochemical indicators of vitamin D and calcium homeostasis (2). The vegetarian women reported having followed the diet for 4–180 mo, with a median of 47 mo. Blood samples were obtained by venipuncture for measurement of serum concentrations of 25-hydroxyvitamin D [25(OH)D], 1,25-(OH)\(_2\)D, and parathyroid hormone (PTH) concentrations. Calcium intakes were estimated from a modified food-frequency questionnaire. These estimates were correlated with calcium intakes obtained from 3-d diet diaries collected from a subset of participants.

Serum 25(OH)D concentrations were used as an indicator of vitamin D status, concentrations < 27.5 nmol/L indicated vitamin D deficiency. Two of the major hormones that regulate calcium and phosphorus homeostasis are 1,25(OH)\(_2\)D and PTH. The most biologically active metabolite of vitamin D is 1,25(OH)\(_2\)D. Decreased circulating concentrations of calcium and phosphorus and increased serum PTH concentrations increase the hydroxylation of 25(OH)D to 1,25(OH)\(_2\)D (3, 4). 1,25(OH)\(_2\)D increases active intestinal absorption of calcium and phosphorus and appears also to cause renal retention of these elements. Serum 1,25(OH)\(_2\)D concentrations were used to assess calcium status, high concentrations indicated increased calcium need. The combined action of 1,25(OH)\(_2\)D and PTH stimulates mobilization of calcium and phosphorus from bone, often leading to bone demineralization.

Vitamin D requirements are not thought to be increased during lactation. However, the necessity of vitamin D in maintaining adequate calcium status is important during lactation when the demand for calcium is increased. Because of decreased intake of...

---

1 From the University of Cincinnati Medical Center, Department of Pediatrics, Cincinnati.
2 Address reprint requests to BL Specker, University of Cincinnati Medical Center, Department of Pediatrics, ML #541, Cincinnati, OH 45267-0541.
3 Supported in part by Perinatal Research Institute, Children’s Hospital Medical Center, Cincinnati, and NIAMS-AR41366.
foods fortified with vitamin D, strict vegetarians are thought to be at an increased risk of vitamin D deficiency if sunlight exposure is limited. Therefore, it is not surprising that serum 25(OH)D concentrations were lower in vegetarian women compared with nonvegetarian women \( (P < 0.001) \) and that there was no difference between lactating and nonlactating women (Fig 1).

The main source of vitamin D, other than dietary intake, is the endogenous synthesis of vitamin D in skin with exposure to sunshine. When serum 25(OH)D concentrations between the vegetarian and nonvegetarian women were compared by season of year when the sample was collected, significant differences were observed during the winter and spring months (December 22–June 21; \( P = 0.02 \), but not during the summer and fall months (June 22–December 21; \( P = 0.09 \)). The lack of difference in 25(OH)D concentrations during the summer and fall emphasizes the importance of sunlight exposure in maintaining vitamin D status in vegetarian women.

Calculated intakes were significantly lower in vegetarian women compared with nonvegetarian women \( (2) \). The estimated calcium intake in lactating vegetarian women was 486 mg/d (range 265–722 mg/d), compared with a mean of 1038 mg/d (range 346–2252 mg/d) in the lactating nonvegetarian women \( (P = 0.02) \). In nonlactating women the estimated mean calcium intakes were 340 mg/d (range 203–704 mg/d) and 681 mg/d (range 443–1160 mg/d) in the vegetarian and nonvegetarian groups \( (P = 0.004) \).

Differences in hormones that regulate calcium homeostasis were observed, indicating possible adaptations resulting from the low calcium intake. Vegetarian women had higher serum 1,25(OH)2D concentrations compared with nonvegetarian women \( (P < 0.001) \) and higher concentrations were observed in lactating women than in nonlactating women \( (P = 0.001) \; \text{Fig} \ 2 \). Serum PTH concentrations were not higher in the vegetarian women, regardless of lactation status. These data indicate that there is an hormonal response to a low-calcium diet and to lactation that theoretically may increase the efficiency of calcium absorption. Because it is generally thought that both 1,25(OH)2D and PTH are necessary for mobilization of calcium and phosphorus from bone, it is not clear whether the high 1,25(OH)2D concentrations indicate an adverse effect on bone \( (4) \). Further studies are required to determine whether increased calcium absorption occurs, and whether bone mass is maintained in vegetarian women consuming low-calcium diets to the same degree as in nonvegetarian women consuming a diet with higher amounts of calcium.

The mother’s diet also may affect the infant. Although it was not determined in this study whether maternal and infant vitamin D status were correlated, we previously found that milk concentrations of vitamin D are correlated with both maternal serum concentrations of 25(OH)D and maternal vitamin D intake \( (5) \). However, the vitamin D content of human milk is low, even at high maternal intakes, and is not related to the infant’s vitamin D status. The vitamin D status of an exclusively breast-fed infant is determined primarily by the infant’s exposure to sunshine \( (6, 7) \).

Whether differences in calcium intake between vegetarian and nonvegetarian women could affect the infants was determined by measuring milk calcium concentrations. Milk from 14 of the vegetarian women and 10 of the nonvegetarian women was determined to have mean calcium concentrations of 6.74 ± 1.07 mmol/L (27 ± 4.3 mg/dL) and 6.96 ± 1.35 mmol/L (27.9 ± 5.4 mg/dL), respectively. Thus, decreased calcium intake and changes in the calcitropic hormonal responses in lactating vegetarian women does not appear to influence the calcium content of human milk.

In summary, vegetarian mothers have decreased vitamin D status compared with nonvegetarian mothers. However, this difference was most apparent during winter and spring months when sun exposure is minimal. Differences in hormones that are responsible for maintaining calcium homeostasis were observed in lactating women consuming a vegetarian diet compared with lactating women consuming a nonvegetarian diet. Whether these hormonal responses provide sufficient adaptation to the calcium stress imposed by lactation and thus prevent bone demineralization needs to be determined. Although decreased maternal vitamin D status may influence the milk vitamin D content, the

![Fig 1](https://example.com/fig1.png)

**Fig 1.** Serum 25-hydroxyvitamin D [25(OH)D] concentrations in vegetarian (●) women compared with nonvegetarian (□) women \( (P < 0.001) \); there was no difference between lactating and nonlactating women. \( \bar{x} \pm \text{SEM}; n \) in parentheses. Adapted from reference 2.

![Fig 2](https://example.com/fig2.png)

**Fig 2.** Serum 1,25-dihydroxyvitamin D [1,25(OH)2D] concentrations in vegetarian (●) women compared with nonvegetarian (□) women \( (P < 0.001) \), and in lactating women compared with nonlactating women \( (P = 0.001) \). The increase in concentrations observed during lactation was similar by diet. \( \bar{x} \pm \text{SEM}; n \) in parenthesis. Adapted from reference 2.
obtained termination consuming the ten exposure. In our studies, milk calcium concentrations were unaffected by maternal calcium intake.

**Vitamin B-12 and methylmalonic acid excretion**

Another vitamin of concern in vegetarian mothers is vitamin B-12. There are many case reports of breast-fed infants of strict vegetarian mothers developing vitamin B-12 deficiency that often results in severe neurological damage (8–11). Vitamin B-12 functions as a cofactor for several enzymatic reactions in cellular metabolism and, in particular, is needed for the conversion of methylmalonyl-CoA to succinyl-CoA. Deficiency of vitamin B-12 inhibits this enzymatic conversion and results in a secondary increase in metabolites such as methylmalonic acid (MMA). Urinary excretion of MMA in elevated amounts is one indicator of vitamin B-12 deficiency.

Because of concerns among the macrobiotic population of vitamin B-12 deficiency in breast-fed infants of macrobiotic mothers, we investigated the relationship between infant and maternal vitamin B-12 status (12, 13). Two groups of mother-infant pairs were studied: of 23 lactating women, 17 were consuming a macrobiotic diet and 6 were consuming an omnivorous diet. The average age of the infants was 6 mo and the mothers reported consuming a vegetarian diet for 14 to 137 mo with a median of 72 mo. Blood samples were obtained from the mothers for determination of vitamin B-12 concentrations. Urine samples were obtained from the mothers and infants for measurement of MMA, which was expressed as μmol/mmol creatinine. Human milk samples were available for a subset of this group for determination of vitamin B-12 content (13).

An inverse relationship between maternal urinary MMA and maternal serum vitamin B-12 concentrations was found (Fig 3). This relationship was expected based on what is known about MMA metabolism. Whether women who were lactating had a higher prevalence of vitamin B-12 deficiency than nonlactating women was determined by using data obtained for nonlactating women from a larger study in a macrobiotic community (14). Thirteen women from this study were aged between 26 and 40 y, similar to the ages of the lactating women. Forty-six percent of the nonlactating vegetarian women were observed to have urinary MMA concentrations above the upper limit of the adult normal range (> 4.3 μmol/MMMA/mmol creatinine). Although 63% of the lactating women had elevated MMA excretion, this difference between the two groups was not significant by chi-square analysis (Fig 4). We were therefore unable to determine, with the group sizes in this study, whether the prevalence of vitamin B-12 deficiency differs between lactating and nonlactating vegetarian women. Although none of the mothers reported

![FIG 3](https://academic.oup.com/ajcn/article-abstract/59/5/1182S/4732583)

**FIG 3.** Maternal urinary methylmalonic acid (MMA) excretion and maternal serum vitamin B-12 concentrations. Urinary MMA and serum vitamin B-12 were inversely correlated ($r = -0.700, P = 0.003$). Adapted from reference 12.

![FIG 4](https://academic.oup.com/ajcn/article-abstract/59/5/1182S/4732583)

**FIG 4.** The prevalence of elevated methylmalonic acid (MMA) excretion (> 4.3 μmol MMA/mmol creatinine) between nonlactating and lactating women consuming a vegetarian diet. The prevalence was similar. $n$ in parentheses.

![FIG 5](https://academic.oup.com/ajcn/article-abstract/59/5/1182S/4732583)

**FIG 5.** Infant urinary methylmalonic acid (MMA) concentrations and maternal serum vitamin B-12 concentrations in vegetarians (●) and nonvegetarians (○). High infant urinary MMA was significantly associated with low maternal serum vitamin B-12 ($r = -0.681, P < 0.001$). Adapted from reference 12.
symptoms of vitamin B-12 deficiency, the long-term neurologic or subtle effects of decreased vitamin B-12 and elevated MMA excretion in the mother should not be dismissed.

Infant MMA excretion was correlated with maternal vitamin B-12 status (Fig 5) and infant MMA was significantly higher in infants of vegetarian mothers compared with infants of nonvegetarian mothers. Six of the 17 (35%) breast-fed infants of vegetarian mothers had urinary MMA concentrations that were greater than the upper 95% confidence limit (48 μmol/mmol creatinine) of MMA excretion for breast-fed infants of nonvegetarian mothers (15).

Because all of the mothers consumed a vegetarian diet during pregnancy, the finding of increased infant MMA excretion is consistent with the possibility that decreased fetal stores of vitamin B-12 were established in utero. In addition, decreased milk vitamin B-12 content could compound the problem of low vitamin B-12 status in the infants. Milk vitamin B-12 concentrations were correlated with maternal serum vitamin B-12 concentrations (Fig 6). In addition, infant MMA excretion was inversely correlated with milk vitamin B-12 concentrations, although this relationship existed, on average, at milk concentrations < 362 pmol/L. (Fig 7).

In summary, a significant percent of vegetarian women consuming a macrobiotic diet showed biochemical evidence of vitamin B-12 deficiency and the prevalence of vitamin B-12 deficiency did not appear to be higher in lactating women compared with nonlactating women. There was a relationship between maternal and infant vitamin B-12 status and a large proportion of infants had elevated MMA excretion, indicative of vitamin B-12 deficiency.

Conclusions

Although the following conclusions may be made concerning vitamin D, calcium, and vitamin B-12 status of lactating women consuming a macrobiotic diet, concerns are similar for lactating women consuming a vegetarian diet with little or no eggs or dairy products. First, vitamin D supplementation in lactating vegetarian women or their infants may not be necessary given sufficient sun exposure. Second, calcium intake in lactating mothers should be increased during lactation until it is determined whether low dietary calcium results in bone demineralization. The calcium intake of the infant appears to be unaffected by the mother’s diet. Last, vitamin B-12 supplements should be taken by women consuming a vegetarian diet. If the mother does not supplement herself with vitamin B-12, the infant should be supplemented.

References