

Vegetarian Nutrition

a dietetic practice group of the Academy of Nutrition and Dietetics

Experts in Plant-Based Nutrition

RDN Resources for Consumers:

Choline

Introduction

Choline is indispensable for human health and well-being. It is utilized as a structural component of cell membranes, in transport of lipids, cell signal transmission, and formation of other compounds.

Function

Choline is essential in memory formation and its deficiency is associated with memory deficit. The American Academy of Pediatrics has identified choline as a critical nutrient for brain growth and neurodevelopment in the developing infant.

Intake

The US Institute of Medicine's (IOM) Adequate Intake (AI) of dietary choline is based on age, gender, and the stage of the life cycle (see Table 1). Data regarding choline intake among vegetarians are scarce. However, available findings suggest that intake is considerably below AI and that only a small percentage of vegetarians meet the recommendations. Data from the National Health and Nutrition Examination Survey (NHANES) 2007-2010 showed that, "Vegetarians have the lowest intakes among the US population, estimated at 192 ± 7 mg/d." Similarly, based on another NHANES cohort, reported mean intake among individuals who did not ingest meat on two days for which food intake was collected as 235 mg/day. In this sample, only 2.32% of meat avoiders met the IOM's AI for choline.

Available data lead to a conclusion that vegans and vegetarians are at a high risk of inadequate choline intake. Choline intake is associated with egg consumption, thus, vegans are at a higher risk of inadequate intake, compared to ovo-vegetarians. Although choline is found in many plant products, in the general population, grain products accounted for only about 20% of choline intake, while vegetables, including beans, just 7%.

Dietary sources

Moderate amounts of choline are found in many products of plant origin, especially legumes, nuts, and grains. Its highest content is found in wheat germs and soy flour. Choline content in most fruits is in a single digit per 3.5 oz. of a product. Table 2 includes significant plant sources of choline.

Lecithin, which is a common food additive derived either from animal or plant products, such as soybeans, used as emulsifying agent in such items as gravies, salad dressings, ice cream, and margarine, is a good source of choline, containing 3 to 4% of choline by weight. Some choline-containing supplements are derived of lecithin.

Choline supplements are available in various doses and forms. They include choline chloride and choline bitartrate. Doses include 250 mg, 300 mg, 310 mg, 350 mg, 500 mg, and higher.

Breastmilk is a source of choline and its content reflects intake. Choline is also added to baby formulas.

Choline synthesis

Although the body does synthesize some choline, available data show that this synthesis is not adequate to supply the required amount of choline for body function. In fact, feeding individuals with a choline free or low-choline diet resulted in adverse symptoms due to choline deficiency.

Symptoms of choline deficiency

One of the most common symptoms of choline deficiency is non-alcoholic fatty liver disease. As the name implies, it is characterized by accumulation of fat in the liver. This condition develops because choline is essential in the synthesis and release lipids into blood circulation. Thus, choline deficiency results in trapping lipids in the liver. Other symptoms include nonalcoholic steatohepatitis, liver damage, end-stage liver disease, muscle damage, and DNA damage. Treatments with choline sufficient diet have been shown to reverse many of the above-mentioned health conditions. Different individuals synthesize different amounts of choline. It is estimated that more than 50% of individuals with inadequate intake synthesis high enough amounts of this nutrient to avoid development of adverse symptoms. Since choline synthesis depends on estrogen concentration, postmenopausal women are at a higher risk of experiencing adverse symptoms.

Choline status in vegetarians

To date, choline concentration in vegetarians has been

assessed only in one study. Authors assessed choline content in breastmilk collected from vegan, vegetarian, and non-vegetarian nursing mothers. They found wide variation in total choline content (4–301 mg/L). The mean concentration of total choline was not significantly different in samples from participants adhering to different diet type. Most importantly, the majority (63%) of exclusively breastfed infants 0 to 6 months did not meet the AI, as choline concentration in all milk samples, regardless of diet type was low. Consistently, it should be concluded that inadequate choline intake by infants is common among offspring breastfed by vegan and vegetarian mothers. Any potential impact of suboptimal milk choline content remains to be determined.

Recommendations for vegetarians

Available data suggest that vegetarians, especially vegan, should pay close attention to making sure they include significant dietary choline sources. Consistently, it must be stressed that a variety of such foods as nuts, legumes, and whole grains be ingested daily. Choline supplements might be recommended in the most critical period of times, such as pregnancy or during lactation. However, choline supplements in adults have been shown to have prothrombotic affect. Thus, they may not be suitable for adults and elderly. Significant plant sources of choline are listed in table 2 in the appendix.

Table 1. Institute of Medicine's Adequate Intake of choline.[1]

Age/stage of life cycle	Adequate Intake (mg/day)
0-6 months	125
7-12 months	150
1-3 years	200
4-8 years	250
9-13 years	375
14-18 years	550 boys; 400 girls
≥ 19 years	550 men; 425 women
Pregnant	450
Breastfeeding	550

Table 2. Significant plant sources of choline*[9]

Food item	Amount (mg/100g of product)
Vegetables	
Broccoli, cooked	40
Brussels sprouts, cooked	41
Cauliflower, cooked	39
Tomato paste	39
Legumes/beans	
Soy flour, defatted	190
Soybeans, raw	120
Navy beans, raw	87
Soy protein powder	86
Pinto beans, raw	66
Peanut butter	61 – 95
Edamame, frozen	56
Peanuts, raw	53
Nuts and seeds	
Almonds	52
Cashews, roasted	61
Hazelnuts	46
Pecans	41
Pistachios, roasted	71
Walnuts	39
Flax seeds	79
Pumpkin seeds, roasted	63
Sunflower seeds, dried	55
Grains	
Amaranth	70
Quinoa	70
Buckwheat, dry	54
Whole wheat flour	31
Rye flour	30
Breakfast cereal	
Cereals ready-to-eat, wheat germ, toasted, plain	180
Cereals ready-to-eat, toasted wheat bran	81
Cereals, oat bran, dry	59
Cereals ready-to-eat, bran	49

- for comparison, a whole egg contains between 230 and 270 mg.

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References: References for this resource are available at www.VNDPG.org

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