



RD Resources for Professionals:

Choline in Vegetarian Diets

Choline is a micronutrient commonly grouped with the B-vitamins. It is often overlooked because it is found in a wide variety of foods, but because choline is found in large amounts primarily in animal foods there are concerns about whether vegans get enough.

Choline: Functions and Metabolites

Choline is used for the synthesis of phosphatidylcholine, the principle phospholipid in cell membranes.¹ It is also needed to synthesize very low density lipoproteins (VLDL) and the neurotransmitter, acetylcholine. Along with its metabolite, betaine, choline functions as a methyl donor.

Choline can appear in food in many forms: As free choline, phosphatidylcholine (also known as lecithin), sphingomyelin, glycerophosphocholine, and phosphocholine. The body can convert choline into betaine.

Food Sources of Choline

Choline is found in a wide range of foods. Although eggs and meat tend to be the richest sources, it is found in a wide range of plant foods in small amounts. Eating a well-balanced vegan diet with plenty of whole foods should ensure you are getting enough choline. Soymilk, tofu, quinoa, and broccoli are particularly rich sources.

Food Sources of Betaine

As pointed out above, betaine is not an essential nutrient, but it can spare choline.

Quinoa, spinach, sweet potatoes, beets, and wheat-based breads, crackers, breakfast cereals, and pasta appear to be much higher in betaine than other plant foods.

Special Conditions

Some people have genetic mutations that increase the need for choline. It is not clear how much choline such people need but the DRI is probably adequate for almost everyone.

Vegans concerned about liver dysfunction or any special dietary needs should consult with a registered dietitian for individual guidance based on nutritional assessment and health status.

Choline Requirements

The need for choline was discovered when it was found that people on total parenteral nutrition for long periods of time were developing fatty livers which resolved upon adding choline to the feeding regimen.^(2,3,4) The fatty livers were caused by an accumulation of triglycerides as a result of the liver's inability to synthesize and release very-low-density lipoprotein (VLDL) particles because of a reduced synthesis of phosphatidylcholine.¹

In 1998, for the first time, the Institute of Medicine (IOM) set an Adequate Intake (AI) for choline of 550 mg/day for men and 425 mg/day for women (both equivalent to 7 mg/day per kg body weight).⁵ The AI was based on the only study available at the time, a 1991 study that induced choline deficiency in humans.⁶

Since 1991, five more studies inducing choline deficiency have been conducted.^(7,8,9,10,11) They followed a similar pattern in which subjects were fed a diet with 50 mg or less of choline per day for six weeks or until they developed markers of dysfunction. A large proportion of

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subjects developed markers of dysfunction (increased liver enzymes, a fatty liver, or elevated creatine phosphokinase indicative of muscle deterioration) during the six weeks, indicating that most people cannot stay healthy on less than 50 mg/day of choline.

After inducing choline deficiency, the researchers then put the subjects on diets that met the DRI for choline and almost all the subjects' organ function returned to normal. In only one study, a choline amount between 50 mg/day and the DRI was administered.⁷ In this study, the four male subjects receiving 10 days of 138 mg/70 kg of body weight returned markers of muscle deterioration to normal, indicating that 138 mg per 70 kg of body weight per day might be enough choline. In another study, 825 mg per 70 kg of body weight per day was required to normalize liver function for some people.⁸

Neural Tube Defects

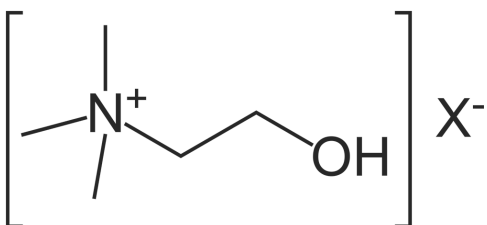
Since discovering that folate deficiency was a cause of neural tube defects (NTDs), other methyl donors involved in some of the same metabolic pathways, such as choline, have also been of interest in preventing NTDs and a case-control study of NTDs found an increased risk for those consuming less than 290 mg/day.¹²

Choline and Chronic Disease

The data on choline and chronic disease (cardiovascular disease, dementia, and cancer) are mixed. Ideal amounts appear to be about 300 mg per day. Most vegans probably get about that much from the foods they eat.

Choline Content of Selected Foods²³

	Serving Size	Choline (mg)
Legumes & Soy Products		
Soy milk	1 C	57
Tofu	1/2 C	35
Edamame	1/2 C, cooked	44
Peanut butter	2 T	20
Pinto beans	1/2 C, boiled	30
Green peas	1/2 C, boiled	22
Grains		
Oats	Instant 1 C, cooked	17
Bread (whole wheat)	1 slice	7
Quinoa	1 C, cooked	42
Nuts		
Almonds	1/4 C, dry roasted	18
Pistachios	1/4 C, dry roasted	22
Walnuts	1/4 C, halves	10
Vegetables		
Artichoke	1/2 med, cooked	21
Asparagus	1/2 C, boiled	23
Brussel sprouts	1/2 C, boiled	32
Cauliflower	1/2 C, boiled	24
Salsa	1/4 C	8
Broccoli (chopped)	1/2 C, boiled	31
Potatoes	1 C, boiled w/ skin	22
Carrots	1 med, raw	5
Fruit		
Banana	medium, raw	12
Orange	large, raw	15
Dates (Medjool)	5 pcs	12
Avocado	1/4 C, cubes	5
Apple	large, raw	8
Animal Products		
Yogurt	1/2 C	19
Swiss cheese	1/2 C	10
Milk (2% fat)	1 C	40
Egg	1 large, hard-boiled	113



Choline

Heart Disease

After 14 years of follow-up, the Atherosclerosis Risk in Communities study found no significant associations between choline intake and heart disease events.¹³ Intake categories ranged from about 300 to 500 mg/day. Three other studies found that choline intakes above 300 - 350 mg/day were associated with lower homocysteine levels^(8,14,15) than those eating about 250 mg or less, but the one study that compared choline intakes to cardiovascular disease rates found no association.¹⁵ One case-control study found a dose-dependent association with the presence of cardiovascular disease and elevated plasma levels of choline and its metabolites.¹⁶

Cancer

For breast cancer, one case-control study found that free choline intakes were associated with a lower risk,¹⁷ while a cohort study found no relation with choline intake.¹⁸ A 2007 report from the Nurses' Health Study II found no correlation between choline intake and breast cancer among 90,663 premenopausal women after 12 years of follow-up.¹⁸

For colon cancer, one cohort of women was found to have an increased risk with greater consumption (383 mg vs. 293 mg per day).¹⁹ In the same study, betaine was associated with a lower risk. In a cohort of men, no relation was found between choline or betaine intake.²⁰

For prostate cancer, one nested case-control study found that higher plasma choline levels were associated with an increased risk.²¹

Dementia

Lecithin has been studied thoroughly as a treatment for dementia. In 2004, The Cochrane Collaboration updated their literature review on lecithin supplementation and cognition and concluded the bulk of the evidence indicates that lecithin is not an effective treatment for dementia nor are lower levels of choline a cause of dementia.²²

DRI for Choline⁵

Age	Female (mg)	Male (mg)
0-6 months	125	
7-12 months	150	
1-3 years	200	
4-8 years	250	
9-13 years	375	
14-18 years	400	550
≥ 19 yrs	425	550
Pregnant	450	N/A
Breastfeeding	550	N/A

Conclusion

In summary, it appears that the AI for choline of 550 mg/day for men and 425 mg/day for women is more than adequate and, based on associations with chronic diseases, might even be higher than ideal. A range of 300 to 350 mg appears ideal for the long-term prevention of disease, whereas meeting the AI is recommended for women who might be considering pregnancy. Vegan women who are considering getting pregnant should make sure they are meeting the DRI for choline to reduce the risk of neural tube defects, and might consider a modest supplement.



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