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Role of Soyfoods in Plant-Based Diets

- Meeting Nutrition Needs of Vegetarians and Vegans
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ROLE OF SOYFOODS IN PLANT-BASED DIETS

By Virginia Messina, MPH, RD and Mark Messina, PhD, MS

Soyfoods can contribute valuable nutrition to plant-based diets, such as flexitarian, vegetarian, and vegan, while also providing important health benefits. They can be important sources of fiber, protein, essential fats, and minerals including calcium, iron, and potassium.[1-3] In addition to their rich nutrient profile, soyfoods provide dietary components, such as isoflavones, which are found in negligible amounts in other plant foods.[4]

Dietary Fiber in Soyfoods

High fiber intake is a hallmark of vegetarian and, especially, vegan diets. Intake among vegans is on average 50% higher than non-vegetarians.[5,6] The higher intake is an important advantage of plant-based eating patterns since fiber is 1 of 9 shortfall nutrients identified by the Dietary Guidelines panel. Fiber is also considered a nutrient of public health concern because underconsumption is linked to adverse health outcomes.[7]

While the fiber content of soyfoods varies markedly, foods made from the whole soybean, including tempeh, soynuts, miso, textured vegetable protein, and edamame, range in fiber content from about 5g–18g/100g serving (see table). In contrast, the fiber content of soymilk and tofu is less than 1g per serving, and foods made from soy protein isolate or concentrate provide little or no fiber.

Soyfoods as a Source of Protein in Plant-Based Diets

Although animal foods provide about 2/3 of the total protein intake of Americans,[8,9] findings from the Adventist Health Study-2, show that vegan protein intake is only slightly lower than that of non-vegetarians (13.6% vs 14.7% of total calories).[5]

However, there is considerable debate about protein requirements for certain population groups including concerns that current recommendations may be too low for some.[10-14] In particular, older people may need to consume 50% more protein than the Recommended Daily Allowance (RDA) to prevent or slow the loss of muscle mass that typically occurs with aging.[15] These issues are of particular concern in plant-based diets since vegans may have slightly higher protein needs than meat eaters, largely due to the lower digestibility of protein from plant foods.[16]

Many experts recommend that vegans consume approximately 10% more protein than meat eaters.[17] Because lysine is the limiting essential amino acid in vegan diets, it is important for vegans to consume at least 3 servings/day of legumes, a food group that includes beans, peanuts, and soyfoods. Traditional Asian soyfoods provide approximately 6g–19g protein/100g serving of cooked product (see table), making them among the best sources of protein in vegetarian diets. Furthermore, the quality of protein in soy protein isolate and soy protein concentrate, which is used in many plant-based meats, is similar to the quality of animal protein and greater than that of all other plant proteins.[16,18,19] Although vegans and vegetarians can meet protein needs without consuming soyfoods, their rich protein content and high protein quality make these foods valuable for those with higher protein needs such as older vegans, athletes, and those on weight reduction diets.

Iron and Zinc Content of Soyfoods

Meat is an important source of minerals iron and zinc in typical American diets. Dairy foods also provide zinc. Iron deficiency is a public health concern seen most often in young toddlers and, to a greater extent, in premenopausal and pregnant women. Most legumes are rich in iron, but like all plants, they contain only nonheme iron which has much poorer bioavailability than the heme iron found in meat.

Several dietary factors affect nonheme-iron absorption; of these, the presence of phytate in legumes, whole grains, nuts, and seeds is most important.[20] Because of less bioavailability of iron from plant-based diets, the Institute of Medicine (IOM), now called the Health and Medicine Division, established a RDA for vegetarians that is 1.8 times the RDA for the general population.[21] Although phytate also impacts absorption of zinc, the IOM has not established a separate RDA for zinc for vegetarians. In contrast, the European Food Safety Authority specifies zinc requirements that are based on 4 different phytate intakes: 300, 600, 900, and 1,200 mg/day.[22]

Despite the long-standing belief that phytate negatively impacts mineral nutrition, there is some debate about its practical impacts for mineral absorption. In comparison to long-term studies, the acute studies that have been used to ascertain bioavailability have been shown to exaggerate the impact of inhibitors such as phytate on the absorption of nonheme iron.[23] This observation also appears to be true for zinc.[24] Recent research suggests that[25] habitual consumption of a high-phytate diet can reduce the inhibitory effect of phytate on nonheme-iron absorption.[26]

Despite these findings, there remains considerable evidence that vegetarians have iron stores that are lower than those of meat eaters, albeit generally within recommended ranges.[27,28]

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The Soy Connection
P.O. Box 237
Jefferson City, MO 65102
sarah@qinc.co

UNITED SOYBEAN BOARD™

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This finding is true despite having comparable or greater iron intakes than the general meat-eating population. Dietitians who counsel vegetarian and vegan clients should help individuals identify iron-rich foods, and also provide education on the importance of consuming vitamin C-rich foods at meals to enhance absorption.

There is evidence that the iron in soybeans may not be impacted by phytate to the extent that would be expected. Much of the iron in soybeans is present as ferritin, a form of iron that may be resistant to inhibitors of iron absorption like phytate.[29-31] This may make soyfoods valuable for meeting iron needs in plant-based diets, but it is an area where more research is needed before reaching definitive conclusions.

Soyfoods are relatively low in zinc and it is unclear whether there is adaptation to the effect of phytate on zinc absorption. Zinc absorption from soy is about 25% lower than from animal foods.[32] Based on current observations, while soyfoods can make small contributions to zinc intake of plant-based diets, they are not an important source of this mineral.

Nutrients for Bone Health

Despite their relatively high content of phytate and oxalate, calcium bioavailability from calcium-set tofu[33] (tofu made by coagulating soymilk with a calcium salt) is similar to absorption from cow's milk. For soymilk, however, bioavailability varies according to the type of fortificant used. Calcium bioavailability is similar to cow's milk when calcium carbonate is used,[34] but is about 25% lower when the fortificant is tricalcium phosphate.[34,35] Some soymilk brands use a mixture of the 2. Others are fortified at levels exceeding the 300mg found in a serving of cow's milk. In this case, despite the lower fractional absorption that occurs with higher doses of calcium, the absolute amount of calcium absorbed is equivalent to or greater than that from cow's milk.[34]

Most soymilk is also fortified with vitamin D, typically ergocalciferol, or vitamin D2, which is vegan. Plant forms of vitamin D3 or cholecalciferol are now also available, but less commonly used. There has been a long running debate about the relative potency of these 2 forms of the vitamin.[36] A pharmacological dose of vitamin D3 is more potent than a similar dose of vitamin D2,[36] but the extent to which these forms of the vitamin differ at typical dietary intakes is less clear. The most recent findings show that[37] a daily supplement of 15mcg vitamin D (the current recommended intake), as either D2 or D3 significantly increased serum 25-hydroxyvitamin D levels compared to baseline, but vitamin D3 supplementation increased levels to a greater extent.

Potassium is another nutrient important for bone health. According to data from the National Health and Nutrition Examination Survey (NHANES) 2003–2006, cow's milk contributes approximately 10% of the total intake of Americans.[38,39] While legumes play a smaller role in American diets, they can contribute significant amounts of this mineral to plant-based diets. Most legumes, including soybeans, are good sources of potassium.[40,41] Soymilk derived from the whole soybean provides approximately 200–300 mg/cup, with the higher end of the range being similar to cow's milk. Other plant milks are much lower in potassium.[42,43] Little is known about potassium bioavailability[44] although 1 dose-response trial found that humans absorb about 94% of potassium gluconate in supplements, which was similar to the absorption rate of potassium from potatoes.[45]

Fatty Acids

Soybeans are very high in fat relative to other legumes and soyfoods[46] and provide both essential fatty acids; the omega-6 fatty acid linoleic acid and the omega-3 fatty acid alpha-linolenic acid (ALA).[47] In contrast to traditional Asian soyfoods, unless additional fat is added, soyfoods made with soy protein isolate or concentrate are very low in fat.

Approximately 60% of the fat in soybeans is polyunsaturated.[47] When replacing saturated fat, soybean oil has been shown to reduce blood cholesterol levels,[48] an attribute recently formally recognized by the U.S. Food and Drug Administration (FDA) in the form of a qualified health claim.[49]

The essential fatty acid ALA can be converted to the long chain omega-3 fatty acids, eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), but it's not clear that the conversion is sufficient to appreciably increase circulating and tissue levels of these fats.[50] Since these fats are found primarily in certain fish, it is probably more effective for vegetarians to take EPA and DHA supplements derived from microalgae rather than to rely upon ALA for this purpose.

Protein and Fiber Content of Selected Soyfoods

Source: USDA Nutrient Database (unless otherwise indicated)

SOYFOOD	DATABASE NUMBER	WEIGHT (g)	PROTEIN (g)	FIBER (g)
Tofu, firm (Vitasoy, Azumaya)	16277	100	9.1	0.6
Tofu, extra firm, prepared with nigari	16159	100	10.0	1.0
Tofu, firm, prepared with calcium sulfate and magnesium chloride (nigari)	16126	100	9.0	0.9
Soybeans, mature seeds, dry roasted	16111	100	43.3	8.1
Soybeans, mature seeds, roasted, no salt added	16410	100	38.6	17.7
Edamame, frozen, prepared	11212	100	11.9	5.2
Soybeans, mature cooked, boiled, without salt	16109	100	18.2	6.0
Soynuts	41410010	100	38.6	17.7
Soy burger (Impossible Foods)*	-----	113	19.0	3.0
Tempeh (Lightlife Foods, Inc.)	365644	100	19.1	8.3
Miso	16112	100	12.8	5.4
Soymilk (WhiteWave)**	445888	100 ml	2.5	0.4
Soy flour	16117	100	51.5	17.5
Soy protein isolate	16122	100	88.3	0
Soy protein concentrate acid wash	16420	100	63.6	5.5

*https://faq.impossiblefoods.com/hc/en-us/articles/360018939274-What-are-the-nutrition-facts-

**WhiteWave is now Danone North America

Beyond Nutrients: Soyfoods and Health

Soyfoods are uniquely rich sources of isoflavones which are largely lacking in diets that don't include these foods. Isoflavone intake of people in Japan is approximately 40mg/day[51] compared to just 3mg/day in the United States.[52]

Isoflavones have been posited to reduce risk of both breast[53,54] and prostate[55] cancer, although most data come from case-control rather than cohort studies. Also, evidence suggests that for protection against breast cancer, soy consumption must occur during childhood and/or adolescence.[56-58] Among postmenopausal women, isoflavones may alleviate hot flashes[59] and improve bone health.[60]

Soy protein has been shown to lower circulating low-density-lipoprotein cholesterol (LDL-C) levels. The FDA set 25g/day as the threshold intake required for cholesterol reduction. Meta-analyses suggest that the reduction is approximately 4%,[61-63] which in theory can over time reduce risk of developing coronary heart disease by 4–8%.[64,66] Furthermore, when soyfoods are added to the diet, because the polyunsaturated fat content increases, there will likely be a significant drop in LDL-cholesterol levels.[65,66]

Soyfoods in Plant-Based Diets

In conclusion, soyfoods possess many nutritional and health attributes that make them particularly valuable to consumers who wish to consume more plant protein. Because of the wide range of soyfoods available, they are relatively easy to incorporate into diets.

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MEETING NUTRITION NEEDS ON A VEGETARIAN OR VEGAN DIET

By Taylor Wolfram, MS, RDN, LDN

Many people are embracing the consumption of plant-based foods,[1] chiefly plant protein alternatives, and approximately 3% of Americans are vegetarian or vegan.[2] While it is possible to attain all essential nutrients on a vegetarian or vegan diet, some planning and supplementation are likely required.

Most vegetarians and vegans have no trouble meeting macronutrient needs. Many plant foods, such as grains, potatoes, and fruit, are rich in carbohydrates. Protein is plentiful in legumes including soy, peanuts, lentils, and beans, and fat can be found in avocados, olives, nuts, and seeds.

While many micronutrients are abundant in plant foods, there are a handful that vegetarians and vegans need to be extra diligent about consuming. Nevertheless, vegetarians and vegans can meet all nutrient intake recommendations through a balanced eating pattern that includes fortified foods and dietary supplements.

The Plate Method

The United States Department of Agriculture's MyPlate can be adapted to fit a vegetarian or vegan diet. MyPlate outlines a balanced meal and depicts a plate consisting of approximately ½ fruits and vegetables, ¼ grains, and ¼ protein foods, as well as 1 serving of dairy.[3] Vegetarians and vegans can select plant-based options for protein foods and vegans may choose calcium-fortified soymilk in place of dairy.

There are a few iterations of vegetarian or vegan versions of MyPlate, including The Plant Plate by Virginia Messina, MPH, RD, and The Vegan Plate by Brenda Davis, RD, and Vesanto Melina, MS, RD.[4,5]

Protein and Amino Acids

While all plant foods contain some amount of protein, legumes are particularly rich in this nutrient. It is important to consume adequate essential amino acids to meet dietary requirements. Soy contains all 9 essential amino acids in amounts that meet human needs and is a high quality, staple protein for vegetarians and vegans.[6]

A good rule of thumb for vegans is to consume 3–4 servings of legumes each day to ensure adequate intake of protein and the amino acid lysine, which is lacking in most other plant foods.[7] One serving of legumes is equivalent to ½ cup cooked beans, peas and lentils, ½ cup tofu and tempeh, ¼ cup peanuts, or 2 tablespoons peanut butter.[7] Additional sources of plant-based protein include quinoa, seitan, whole grains, nuts, and seeds.[7]

Omega-3 Fatty Acids

Vegetarians and vegans need to be diligent about eating adequate alpha-linolenic acid (ALA).[8] The body is capable of converting ALA to longer omega-3s eicosapentanoic acid (EPA) and docosahexanoic acid (DHA), although conversion rates can be quite low.

ALA-rich foods include soybean oil, walnuts, and ground flax, chia, and hemp seeds.[9] To be prudent, vegetarians and vegans may take an algae-based DHA supplement in addition to eating a few daily servings of ALA-rich foods to meet omega-3 needs.[10]

Calcium and Vitamin D

While some dark leafy greens, such as collards and kale, contain calcium, most non-dairy vegetarians and vegans may need to consume calcium-fortified beverages and/or a calcium supplement to meet calcium needs. One cup cooked kale or collard, mustard or turnip greens provides approximately 200mg of calcium, about 20% of daily needs for adults.[11] One cup cooked edamame, ½ cup soynuts, ½ cup cooked tempeh, 2 tablespoons almond butter, and 1 cup cooked bok choy each deliver about 100mg of calcium.[11]

Vitamin D needs may be met through fortified foods, dietary supplements, and sun exposure. Some UV-exposed mushrooms may contain vitamin D, but only if it is indicated on the label. It is a good idea for non-dairy vegetarians and vegans to consume calcium and vitamin D-fortified non-dairy plant milks.

Iron and Zinc

Menstruating individuals and endurance athletes have higher iron needs; thus, it is important to incorporate iron-rich foods into the diet daily.[12,13] Eating iron-rich plant foods with a source of vitamin C increases iron absorption. Plant foods that deliver iron include white beans, kidney beans, chickpeas, tofu, spinach, and Swiss chard.[12,13] Vitamin C-rich foods include citrus fruits, strawberries, kiwi, tomatoes, and bell peppers.[14]

Good plant sources of zinc include oatmeal, wheat germ, pumpkin seeds, and cashews.[15]

Iodine

Iodine content of plant foods depends on the soil in which they're grown. Non-dairy vegetarians and vegans can ensure adequate iodine intake by getting most of their sodium from iodized salt via home cooking and seasoning or by taking a supplement. Salt in processed foods is rarely, if ever, iodized.

Vitamin B12

Fortified foods and dietary supplements are the only reliable plant sources of vitamin B12.[16] Recommendations in the book *Vegan for Life* by Jack Norris, RD, and Virginia Messina, MPH, RD, state vegans should do 1 of the following: consume 2 servings/day of fortified foods providing 1.5–2.5mcg of vitamin B12 each, take a daily vitamin B12 supplement of at least 25mcg, or take a supplement of 1,000mcg 2 times/week.[16]

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ABOUT THE AUTHORS

Virginia Messina, MPH, RD, writes and speaks on plant-based nutrition for health professionals and the public. She has written books on vegan nutrition for consumers and co-authored the first vegetarian textbook for health professionals, *The Dietitians' Guide to Vegetarian Diets.* Her website is theveganrd.com and she is @TheVeganRD on Twitter.

Mark Messina, PhD, MS, is the co-owner of Nutrition Matters, Inc., a nutrition consulting company, and is an adjunct professor at Loma Linda University. His research focuses on the health effects of soyfoods and soybean components. He is chairman of *The Soy Connection* Editorial Board and executive director of the Soy Nutrition Institute.

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Soy Leghemoglobin

BONUS ARTICLE

Access this "Healthy Handout" at soyconnection.com/healthprofessionals/newsletter.

ABOUT THE AUTHOR

Taylor Wolfram, MS, RDN, LDN, is a private practice dietitian, health writer, and consultant based in Chicago, Ill. She has expertise in vegan nutrition, uses a Health At Every Size® approach, and believes everyone has a right to body autonomy and respect.

SOY LEGHEMOGLOBIN

By Sue Klapholz, MD, PhD

Food companies utilize soy protein as an ingredient to increase the plant protein content in foods. One such company, Impossible Foods, uses soy as the main source of protein in its Impossible™ Burger. In addition, the Impossible Burger contains a unique ingredient called soy leghemoglobin (LegH), which is responsible for much of its meaty flavor.

What is Leghemoglobin?

Leghemoglobin (short for legume hemoglobin) is naturally found in the root nodules of legumes, such as soybeans, where it plays a crucial role in nitrogen fixation.[1] LegH is an oxygen-binding protein that is structurally similar to myoglobin and hemoglobin, the major oxygen-binding proteins in animal muscle and blood, respectively.[1,2] What enables LegH (and myoglobin and hemoglobin) to bind oxygen is an iron-containing molecule called "heme." The heme molecule in LegH is identical to the heme found in both myoglobin and hemoglobin.[2]

Why is Soy Leghemoglobin Used in the Impossible Burger?

Scientists at Impossible Foods discovered that heme plays an important role in the creation of aromas and flavors that characterize cooked meat.[3] Heme is also responsible for the bloody flavor and red color of raw meat and for the color transition from red to brown during cooking. The heme-iron provided by soy LegH is similar to the highly bioavailable form of iron that is found in animal tissue.[1,4]

How is Soy Leghemoglobin Made?

Impossible Foods transferred the soy LegH gene into yeast in order to produce large quantities of LegH protein as sustainably as possible. Production of this ingredient by yeast fermentation has a smaller environmental footprint than digging up soybean root nodules and extracting the protein; however, it is identical to the LegH protein found in such root nodules.[5]

Is Soy Leghemoglobin Safe?

Heme has a long history of safe consumption while soy LegH is a novel food ingredient. Therefore, soy LegH was subjected to rigorous safety testing, including tests for allergenicity, mutagenicity, chromosome damage, and toxicity.[5,6,7] In addition to being rapidly digested by pepsin, soy LegH does not share any meaningful similarity to known allergens or toxins.[5,7] Feeding studies in rats found no indication of toxicity or adverse effect at consumption levels over 100 times greater than the 90th percentile estimated daily human intake.[6,7] All of these data and more were submitted to the U.S. Food and Drug Administration (FDA) as part of the Generally Recognized As Safe (GRAS) notification process; the FDA issued its "no questions" letter in mid-2018.[7]

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ABOUT THE AUTHOR

Sue Klapholz, MD, PhD is the Vice President of Nutrition and Health at Impossible Foods Inc.