SoyConnection
Health & Nutrition News About Soy

Brought to You by U.S. Soy & Soy Nutrition Institute Global

Volume 33, Issue No. 4 | Fall 2025

FEEDING THE MIND: COGNITIVE EFFECTS OF SOY

By Ajla Bristina, BS and Naiman Khan, PhD, RD

What you need to know:

- **Nutrition plays a role in brain function:** Dietary components such as monounsaturated fats, antioxidants, and phytoestrogens are key nutrients and bioactive compounds that may play a role in supporting brain health.
- **Soy foods and isoflavones show promise for promoting cognitive wellness:** They support memory, attention, and mental flexibility through their interaction with estrogen receptors in key brain regions.
- **Continued research is needed to unlock the full potential of soy:** Clarifying soy's role in supporting cognitive development in children and adults can help shape future dietary guidelines for optimal brain health.

Supporting brain health and cognitive function is vital to success and well-being throughout life. From academic achievement in youth to maintaining independence and quality of life in older adulthood, cognitive function supports our ability to learn, respond, and adapt to dynamic environments. The brain is a metabolically demanding organ that is sensitive to environmental and lifestyle influences. Growing research highlights the significant role of nutrition in supporting its function. Nutrients and bioactive compounds found in foods—such as monounsaturated fats, antioxidants, and phytoestrogens—have shown promise in enhancing cognitive health.

Soy Supports Brain Health and Cognition

A significant body of research has examined how soy foods and soybean components may influence brain function. Soy foods are an excellent dietary source of high-quality protein and are uniquely rich sources of isoflavones.[1–3] Soy isoflavones (daidzein, genistein, and glycitein) are phytoestrogens that can interact with estrogen receptors (ERs).[4–6] They have been studied for a variety of potential benefits, including protection against metabolic syndrome, cardiovascular diseases, and obesity. Since brain structure, development, and cognitive function rely on the health of other organ systems, the potential cardiovascular and metabolic benefits of soy may indirectly support brain health and cognitive performance. On the other hand, soy isoflavones preferentially bind to and activate ER β, which is abundant in the hippocampus and prefrontal cortex; brain structures vital for memory, learning, and decision making.

Isoflavones and the Brain: A Closer Look at the Science

Previous systematic reviews and meta-analyses provide insight into the potential of soy foods and soy isoflavones to elicit cognitive benefits.[7,8] A meta-analysis of 16 randomized controlled trials (RCTs) conducted among 1,386 adults found small but significant cognitive improvements from soy isoflavone consumption.[9] The meta-analysis included trials focusing primarily on postmenopausal women; study duration ranged between six to 130 weeks. Effects were observed across several cognitive domains but primarily on memory.

One of the earliest RCTs to be conducted examined the effects of a dietary soy intervention in healthy adults on attention, memory, and frontal lobe function.[10] Participants were allocated to either a high-soy isoflavone (100 mg/d) or an isocaloric low-soy (0.5 mg/d) diet for 10 weeks. The high-soy diet resulted in significant cognitive improvements with effects observed on short-term memory, long-term memory, and mental flexibility. Another relatively small, double-blind study evaluated a 12-week soy isoflavone intervention in 36 postmenopausal women.[11] Participants consumed 60 mg/d of encapsulated isoflavones while the control group received identical placebo capsules. Results from this study show that women consuming the isoflavones had significant improvement in long-term recall of pictures, mental flexibility, attention, and planning. Additionally, a different study demonstrated that cognitive function in men improved following soy isoflavone supplementation. Forty healthy men receiving daily encapsulated supplements comprising 116 mg of isoflavones in a 12-week double-blind placebo-controlled cross-over trial demonstrated enhanced spatial working memory.[12] When compared to the placebo group, treatment group participants had fewer attempts and errors, as well as less time needed to correctly identify information.

More recently, the benefits of soy foods and isoflavones have been extended to brain structural and functional outcomes. For example, a cross-over RCT among 23 healthy older participants (60-70 years) showed that soynut intake over 16 weeks improved psychomotor speed as well as cerebral blood flow in four brain clusters including temporal and frontal lobes.[13] The soynut intervention provided ~25. 5 g of soy protein and 174 mg of isoflavones daily, whereas during the control period, no soynuts were consumed. Further, in a large-scale, observational study focused on the intake of total isoflavones and brain morphology, higher isoflavone intake was selectively associated with a lower decrease in hippocampal volume among older adults.[14] This study utilized longitudinal data from 1,325 adult men and women, with the highest isoflavone intake group consuming 70.5 ± 24.0 mg/d of isoflavones.

Understanding the Variability in Research Findings

Although the literature overall points to a small but positive effect, the evidence supporting the role of soy and isoflavones on cognitive function is not consistent. For example, in a two-and=a-half year double-blind RCT involving 350 healthy postmenopausal women who consumed either 25 g/d isoflavone-rich soy protein (91 mg isoflavones) or milk protein, there were no differences between groups on a battery of neuropsychological tests.[15] Possible explanations for the inconsistency could be due to differences in demographic characteristics of populations studied, habitual soy food and isoflavone intake, isoflavone dose, and study duration.

Another factor to consider is equol producer status. Equol is a metabolite produced by certain gut microbiota from the soy isoflavone daidzein; it is more biologically active

than its parent isoflavone.[16] Following soy consumption, ~50% of Japanese individuals convert daidzein to equol, whereas 'producer status' within the U.S. population is estimated to only be 20-30%.[17-21] Equol producer status should be considered when investigating the effects of soy consumption.

Exploring Soy's Role in Childhood Brain Development

Work testing the effects of soy foods or isoflavones on brain health and cognitive function has been limited to adults. Given the significance of establishing healthy eating habits early in life,[22–24] it is important to determine the health effects of soy consumption in childhood. Nutrition in childhood and adolescence predicts long-term physical and cognitive health.[25,26] Adolescence is marked by the development of brain regions responsible for crucial cognitive processes (e.g., executive function).[27] Executive functions have demonstrated importance for academic success, specifically within math and reading achievement.[28] Research shows that isoflavones are more bioavailable in children versus adults[29] and nutritional habits in childhood track into adulthood; therefore, the absence of studies involving children may be a missed opportunity to optimize neurocognitive development.

To address this gap in the literature, the Neurocognitive Health Behavior Laboratory at the University of Illinois is conducting a RCT investigating the effects of daily soy consumption on child health outcomes. The Plants Optimizing Development Study will examine effects on cognition, metabolic health, reproductive hormones, and body composition following a three-month dietary intervention in children (N=96) ages 8–11 years. Treatment group participants will consume a daily mix of soy foods (e.g., soy milk, soynuts, tofu) with the target isoflavone intake goal being 50 mg/d, whereas control group subjects will consume isocaloric plant-based alternatives (e.g., pea milk, chickpeas). This study is registered at ClinicalTrials.gov under the number NCT6276426.

Conclusion

Intriguing evidence indicates that because they contain isoflavones, soy food intake has the potential to improve brain function and cognitive performance. However, further research is needed to determine the overall efficacy of consuming soy foods across different populations and to establish appropriate soy consumption recommendations to elicit effects for brain health and cognitive function.

ABOUT THE AUTHORS

Ajla Bristina, BS, is a Neuroscience PhD student at the University of Illinois. Her research focuses on examining the effects of soy food consumption on childhood cognition, metabolic health, and body composition. She is currently administrating a randomized-controlled clinical trial involving a three-month daily soy food intervention to better understand these effects.

Naiman Khan, PhD, RD, is an Associate Professor in the Department of Health and Kinesiology at the University of Illinois and Director of the Neurocognitive Health Behavior Lab. His research explores how nutrition and physical activity impact attention, memory, and learning in children, with over 140 publications and funding from government and industry sources.

HOW DIET MAY HELP SLOW AGE-RELATED COGNITIVE DECLINE

By Mark Messina, PhD, MS

What you need to know:

- **Diet and reduced cognitive decline:** Growing research links healthy dietary patterns—such as the Mediterranean and Nordic diets—to a reduced risk of dementia and improved cognitive function; particularly when adopted early in life.
- **Plant protein and brain health:** Higher protein intake, specifically from plant sources, may help lower the risk of cognitive decline.
- **Soy and isoflavones:** Intriguing evidence suggests soy foods, good sources of plant protein and isoflavones, may support cognitive function in aging—particularly among postmenopausal women.

There is a strong need to identify the role of various lifestyle factors, including diet and physical activity, in age-related cognitive decline. As U.S.[1] and European populations[2] age and as life expectancy in these regions increase,[3] this need becomes even more urgent. According to the World Health Organization, the pace of population aging is accelerating. As of 2024, there are approximately 830 million people globally aged 65+ years, accounting for almost 10% of the world's population.[4] This segment has been growing at an increasing rate and is expected to be about a quarter of the global population by the year 2100.

Multiple cross-sectional studies have shown that there is an improvement in crystallized abilities (referring to knowledge, vocabulary, and skills gained through education, learning, and life experience) until approximately age 60 followed by a plateau until age 80. Further, there is steady decline in fluid abilities (defined as the capacity to reason, solve new problems, think abstractly, and process information quickly without relying on prior knowledge) from age 20 to age 80.[5] Tests of general knowledge (e.g., reading comprehension, math, science), historical information, and vocabulary reflect crystallized abilities whereas tests of fluid abilities require the subject to attend to one's environment and process new information quickly to solve problems.[6]

As in the case of a wide variety of chronic diseases, research suggests dietary habits impact cognitive abilities and risk of developing cognitive impairment, including dementia, which is a general term for loss of memory, language, problem-solving, and other thinking abilities that are severe enough to interfere with daily life. Several medical conditions lead to major neurocognitive disorder; however, Alzheimer's disease (AD) is the most common cause and accounts for about 70% of cases. According to the dominant theory, AD-associated changes in the central nervous system occur many years prior to the first symptoms of the disease appearing.[7] Consequently, there is a possible therapeutic window to preclude or, at least, delay debilitating memory loss and other dementia symptoms.

However, the relationship between diet and cognition among adults, and especially older adults, is much less understood than the relationship between diet and cardiovascular disease. Nevertheless, exciting insights into the diet and cognitive function relationship have been gained within the past few years. Notable in this regard are recent results

from the UK Biobank, an ongoing, multi-center prospective cohort study involving over half a million participants, that provides a resource for investigating the determinants of disease in middle and older age. A recent analysis of incident all-cause dementia risk in 60,298 participants who were followed for an average 9.1 years found higher adherence to a Mediterranean diet was associated with an approximate 23% lower dementia risk.[8,9] Two different methods were used to determine adherence, but in general the Mediterranean diet emphasizes whole, plant-based foods like fruits, vegetables, legumes, nuts, and whole grains, along with moderate amounts of fish, poultry, and dairy.

In alignment are the results of a randomized controlled trial that found after two years of complex intervention, cognition improved in the experimental group compared to the control group. Over 1,000 participants aged 60–77 were randomized into intervention or control groups. The intervention group included nutritional guidance, physical exercise, cognitive training, social activities, and managing vascular and metabolic risk factors. The control group received regular health advice. Adherence to healthy diet at baseline predicted improvement in global cognition, regardless of intervention allocation. Dietary improvement was associated with beneficial changes in executive function, especially in the intervention group. Dietary guidance adhered to Finland's national recommendations, emphasizing fish, fruits, vegetables, and whole grains, aligning with the "healthy Nordic diet" for brain health.[10]

Protein intake may also influence cognition and may affect the progression of mild cognitive impairment to AD. A two-year interim analysis of a three-year longitudinal study found that plasma concentrations of all nine essential amino acids were lower in the AD-convert group with the three branched-chain amino acids (valine, leucine, and isoleucine) showing the most significant difference.[11] In agreement, an analysis of participants of the Nurses' Health Study and the Health Professionals Follow-up Study who were followed for over 20 years, indicated that in comparison with carbohydrates, consumption of protein is associated with lower chances of developing cognitive decline later in life.[12] When substituting 5% energy from protein for the equivalent percentage of energy from total carbohydrates, the pooled multivariable-adjusted odds ratios (95% confidence intervals) were 0.89 (0.85, 0.94) for total protein, 0.89 (0.84, 0.94) for animal protein, and 0.74 (0.62, 0.88) for plant protein. When substituting 5% of energy from animal protein with plant protein, the odds ratio was 0.84 (95% confidence intervals: 0.72, 0.97).

While soy foods are recognized as important sources of plant protein, it is the isoflavone component of soybeans that has attracted the attention of investigators studying cognitive function. Clinical research evaluating the impact of isoflavone intake, either through tablets or protein powders, on cognition has been underway for more than 20 years, although most work has involved postmenopausal women. The results can be summarized as encouraging but also inconsistent. For a comprehensive review of the evidence and emerging research in this area, see the lead article in this issue, "Feeding the Mind: Cognitive Effects of Soy". This piece examines the biological mechanisms, clinical findings, and potential applications of soy isoflavones in supporting brain health across the lifespan.

Importantly, a meta-analysis of 16 randomized controlled trials involving 1,386 participants with a mean age of 60 years found that soy isoflavones improved overall cognitive function; however, when looking at individual cognitive function domains (e.g., visuospatial reasoning, executive function, psychomotor speed, etc.), only memory was

significantly improved.[13] Of the total number of participants, 90% were postmenopausal women.

In summary, several lines of evidence suggest that diet influences cognitive function. Adopting a healthy diet—especially earlier in life—may help reduce the risk of cognitive decline. The potential benefits of a higher-protein diet, particularly one rich in plant protein, combined with the findings from isoflavone research, suggest soy foods may play a role in maintaining cognitive function during the aging process.

ABOUT THE AUTHOR

Mark Messina, PhD, MS, is chairperson of the Soy Connection editorial board and director of nutrition science and research for Soy Nutrition Institute (SNI) Global. He is also an adjunct professor at Loma Linda University. His research focuses on the health effects of soy foods and soybean components.

BEST FOODS FOR BRAIN HEALTH

By Dr. Jenna Stedman, DCN, RD, CSSD

What you need to know:

- **Soy and fish may support cognitive function:** Soy is a source of isoflavones and choline for memory and anti-inflammatory benefits; fatty fish supply omega-3s essential for brain function.
- **Nuts, seeds, and dark chocolate may enhance cognitive resilience:** A source of essential fats, vitamin E, and flavonoids, these foods may support brain protection, blood flow, and improved memory.
- **Hydration is critical for brain performance:** Even mild dehydration impairs focus and mood, making adequate water intake vital for maintaining brain structure and function.

The brain is one of the hungriest organs in the body, demanding a steady stream of nutrients to function at its best. What you eat doesn't only fuel your body; it shapes your cognitive performance, mood, and resilience over time. From essential fatty acids that build brain cell membranes to antioxidants that protect against oxidative stress, diet plays a profound role in maintaining brain health across the lifespan. This ability is especially important during demanding times—studying for an exam, preparing for a big presentation, completing a challenging sports activity, or simply aiming to stay sharp as you age.

Although additional research is needed and many existing studies have design limitations, the evidence to date suggests that a healthful dietary pattern may support cognitive function, including improvements in memory and mental clarity, and may help slow age-related cognitive decline.[1] Notably, the foods most frequently associated with

cognitive benefits are nutrient-dense and confer multiple health advantages, providing a strong rationale for incorporating them into the daily diet.

Below are some of the best foods to fuel your brain, backed by research and easy to include in everyday meals.

Fish and Seafood

Fatty fish such as salmon, mackerel, sardines, and trout contain omega-3 fatty acids, particularly docosahexaenoic acid (DHA), which makes up a large portion of brain cell membranes. Omega-3s support communication between brain cells and are associated with improved memory, mood, and mental clarity.[2] Aim for two to three servings of fish per week for optimal benefit.

Soy Foods

Soy foods like tofu, tempeh, edamame, and soymilk are nutrient-rich plant proteins that contain isoflavones; compounds with antioxidant and anti-inflammatory properties. These compounds may help protect the brain from oxidative stress, which contributes to aging and cognitive decline.[3,4] Soy is also a source of choline—a key nutrient involved in the production of acetylcholine, a neurotransmitter important for memory and learning.

Nuts and Seeds

These compact powerhouses are a source of vitamin E, zinc, and predominantly unsaturated fats, all of which contribute to brain protection and cognitive longevity. Walnuts in particular are a predominant source of alpha-linolenic acid (ALA), a plant-based omega-3.[5] Flaxseeds, chia seeds, and pumpkin seeds also offer brain-friendly nutrients, and they're easy to sprinkle into oatmeal, smoothies, or yogurt.

Olive Oil

Extra virgin olive oil is a cornerstone of the Mediterranean diet, which has been linked to a lower risk of Alzheimer's disease and cognitive decline. A predominant source of monounsaturated fats and polyphenols, olive oil may help reduce inflammation and supports the integrity of blood vessels, ensuring that oxygen and nutrients can reach the brain efficiently.[6] Use it on salads, vegetables, and whole grains.

Cocoa and Dark Chocolate

Cocoa contains flavonoids that enhance blood flow to the brain and may improve attention, processing speed, and memory.[7] The darker the chocolate, the better. Look for varieties that are at least 70% cocoa. A small square or two of dark chocolate can be a satisfying and smart treat.

Hydration

Even mild dehydration can impair focus, short-term memory, and mood.[8] The brain is about 75% water,[9] and staying hydrated helps maintain its structure and function. Aim for at least 6–8 cups of fluid per day; more if you're physically active. Water, herbal teas, and foods with high water content like fruits and vegetables all count.

The Bottom Line

Current evidence indicates that no single food can independently optimize brain health. However, a dietary pattern rich in nutrient-dense, whole foods is associated with improved cognitive outcomes, including enhanced attention, mood regulation, memory, and long-term cognitive resilience. Each meal represents an opportunity to provide essential nutrients that support optimal brain function and overall neurological health.

ABOUT THE AUTHOR

Dr. Jenna Stedman, DCN, RD, CSSD, is a cognitive performance nutrition expert and founder of Master Nutrition Lab, a private practice and free platform for you to experiment with your nutrition to improve your brain health. She has worked for several military branches, helping thousands of service members improve their physical and cognitive performance. Dr. Stedman is an Adjunct Professor for University of New England's Graduate Program in Applied Nutrition. She is an active member of the American Sports and Professional Dietetic Association.

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Best Foods For Brain Health

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Fueling Brain Function: How Diet Shapes Cognitive Health
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