# ALMONDS: NUTRITION AND SCIENTIFIC RESEARCH

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california almonds

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For more than two decades, the Almond Board of California has invested in sound science to better understand the nutrient composition and health benefits of almonds. The ever-expanding body of almond nutrition research totals nearly 200 scientific publications to date, in areas including heart health, weight management, diabetes, nutrient composition, diet quality —and more recently—skin health. Growing interest in weight management and smart snacking has prompted a shift in emphasis from the well-established body of evidence on heart health toward diabetes, weight management, satiety and cognitive research to support a healthy lifestyle.

Almonds offer six grams of plant-based protein, four grams of filling dietary fiber, 13 grams of good unsaturated fats and just one gram of saturated fat per one-ounce or 30-gram serving. They are also a low-glycemic index food and provide important vitamins and minerals including vitamin E, magnesium and potassium—making them an ideal fit for healthy lifestyles and a deliciously easy way to snack smarter.

# ALMONDS: A HEART-SMART SOLUTION

**OVER 25 YEARS OF RESEARCH DEMONSTRATE THAT ALMONDS CAN HELP MAINTAIN A HEALTHY HEART AND HEALTHY CHOLESTEROL LEVELS.**

Although heart disease remains the number one cause of death in the United States and worldwide, it is estimated that at least 80% of premature deaths from cardiovascular disease could be avoided with diet and lifestyle modifications.[1] Diet is integral to managing cardiovascular risk, and more than two decades of research support the role of almonds in helping to maintain a healthy heart. In fact, the U.S. Food and Drug Administration says that scientific evidence suggests, but does not prove, that eating 1.5 ounces of almonds as part of a diet low in saturated fat and cholesterol may reduce the risk of heart disease.

Many randomized controlled studies have been conducted to examine the impact of almond consumption on markers of heart health, such as total and LDL cholesterol, HDL cholesterol, abdominal fat, oxidative stress and inflammation.

## ALMONDS AND CHOLESTEROL

A 2016 meta-analysis and systematic review examined the breadth of research on almonds and heart health. The analysis of 18 published randomized controlled trials with a total of 837 participants showed significant favorable effects of almonds on total cholesterol, LDL cholesterol and triglycerides, with no change in HDL cholesterol levels.[2] The effects of almonds

**PROTEIN**
6g

**VITAMIN E**
7.3mg
50% DV

**FIBER**
4g

**UNSATURATED FATS**
13g

**POTASSIUM**
210mg

**MAGNESIUM**
76mg

**1 OZ = 23 ALMONDS**

on total cholesterol were dose-dependent, with a larger almond intake resulting in a greater reduction in total cholesterol. The evidence strongly indicates that almonds should be encouraged as part of a healthy diet to help maintain healthy blood lipid levels and reduce the risk of heart disease.

## HDL CHOLESTEROL AND ALMONDS

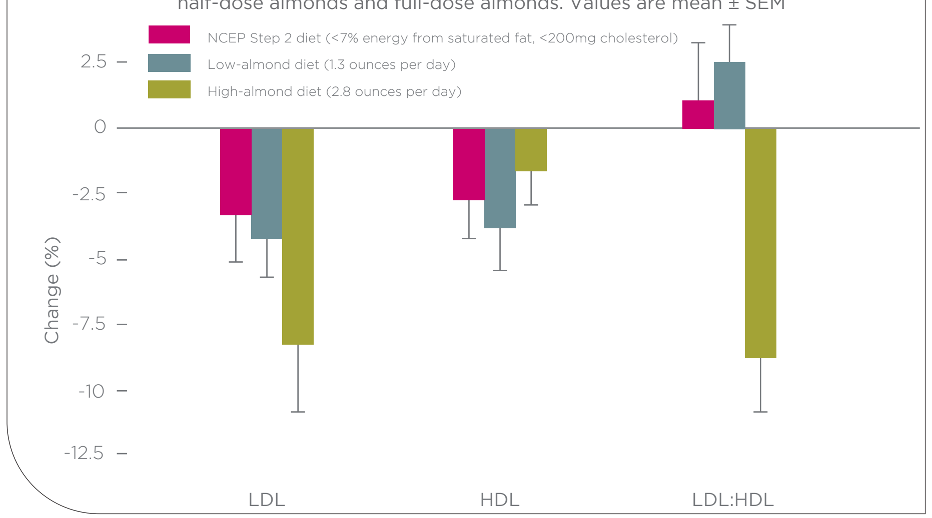
In general, cholesterol-lowering diets reduce HDL cholesterol. However, studies show that when almonds are included in such diets, there is no significant effect—protective HDL is preserved.[2]

Research supporting the role of almonds in heart health began in 1992, with the first study demonstrating that an almond-based diet (with 100 grams or 3.5 ounces of almonds per day) improved cholesterol levels.[3] This landmark study helped set the stage for the almond nutrition research program and provided compelling evidence that despite their high fat and calorie content, almonds could be included as part of a heart-healthy diet.

In the majority of studies of people with high cholesterol, the daily consumption of one to four ounces (28 to 114 grams) of almonds per day resulted in significant reductions in total and LDL cholesterol levels.[4,5,6] In one study, 27 adults with high cholesterol ate heart-healthy diets with one of three snacks over a three-month period: 2.8 ounces (79 grams) of almonds, 1.3 ounces (37 grams) of almonds or a low-saturated-fat whole-wheat muffin as a daily snack[6] (**see Figure 1**). Researchers found that participants lowered their LDL cholesterol level an average of 4.4% with the 1.3-ounce (37-gram) portion of almonds and 9.4% with the 2.8-ounce (79-gram) portion. These results suggest there is a "dose effect of almonds on cholesterol levels—that higher intakes are associated with greater cholesterol-lowering effects."

Another year-long crossover study on 81 U.S. adults (43 men and 38 women, age 49 years, BMI 25 kg/m$^2$) found that daily consumption of usual diet plus 52 grams (1.8 ounces) per day of almonds for six months without any additional dietary advice vs. their usual diet without almonds improved both TC:HDL and LDL:HDL ratios. Participants with high cholesterol levels showed greater response in changes in total cholesterol, LDL and TC:HDL and LDL:HDL ratios than those with normal cholesterol levels.[7]

Figure 2: Change from baseline at four weeks in blood lipids on control, half-dose almonds and full-dose almonds. Values are mean ± SEM




Additionally, a four-week randomized analysis of previously collected data from 27 adults with elevated LDL showed that eating almonds daily as part of a healthy diet improved participants' serum fatty acid profiles and reduced estimated (based on the Framingham equation) 10-year coronary heart disease risk scores by 3.5%.[8] Limitations included lack of randomization in the diet order and lack of control over external factors that may have affected dietary behaviors over the course of the study[7] and a relatively high dropout rate and potential confounding of MUFA intake.[8]

Two recent studies have examined the heart-health impact of swapping out higher carbohydrate snacks for almonds. In one study among Korean adults, researchers compared the effects of almond consumption versus cookies of equal caloric value as a daily snack on cardiovascular risk factors in 84 overweight and obese individuals.[9] They found that participants in the almond group experienced a significant decrease in total cholesterol, LDL cholesterol and non-HDL cholesterol compared to the cookie group. Almonds also enhanced vitamin E status and serum total and LDL cholesterol in the overweight and obese individuals. Thus, including almonds as a snack can help healthy overweight/obese individuals improve nutritional status and reduce risk for CVD. This was the first study to look at almond consumption in a Korean population. Although most of the research has been conducted in North American and European populations, similar results have been seen in studies conducted in

Taiwan, India and now Korea, indicating that the heart-health benefits are similar between these genetically diverse groups.

In another study, 48 middle-aged women and men, normal and overweight, with elevated LDL cholesterol and normal HDL cholesterol levels at baseline, were assigned a cholesterol-lowering diet that included either almonds (43 grams or 1.5 ounces per day) or a calorie-matched high-carbohydrate snack (muffin).[10] Researchers assessed almond consumption vs. high-carbohydrate snack on HDL particle type, distribution and transport of cholesterol to the liver for elimination. Compared with the control diet, the almond diet increased alpha-1 HDL (larger, more mature HDL; generally a marker of heart-health protection) as well as cholesterol efflux (removal of cholesterol from peripheral tissues for elimination), an important part of the cardioprotective role of HDL cholesterol.

Research has also investigated the effects of almonds as part of a group of cholesterol-lowering foods including plant sterols and soluble fiber. This diet, known as the Portfolio Eating Plan, consists of a National Cholesterol Education Program (NCEP) "Step 2" diet (saturated fat less than 7% of calories, less than 200 mg cholesterol) plus almonds (30 grams or one ounce per day); viscous fiber (20 grams per day) such as oats, barley, psyllium, legumes, eggplant and okra; vegetable protein (80 grams per day, half from soy) such as soy foods, beans, chickpeas and lentils; and plant sterols (2 grams per day) such as plant sterol margarine. Initial studies that were done in a controlled environment (with all meals provided) resulted in LDL cholesterol reductions of nearly 30% in study participants (46 adults with high cholesterol).[11] Later studies conducted in people with high cholesterol who followed the Portfolio Eating Plan on their own showed more modest, but still significant, reductions in LDL cholesterol, with an average reduction of 13% after one year of following the diet. The results from this collection of studies demonstrate that almonds can be part of a heart-healthy diet that—in combination with other cholesterol-improving components—effectively lowers cholesterol in study participants with high cholesterol.

While the majority of studies have been conducted in people with elevated cholesterol levels, there have also been studies investigating the impact of eating almonds on cholesterol in healthy people. The studies suggest that almonds have no detrimental effects on blood lipids, and in fact, in one controlled-feeding study, eating 2.4 ounces (68 grams) of almonds per day for a period of four weeks actually improved the blood lipid profiles of healthy men



and women by significantly reducing total and LDL cholesterol levels and improving the ratio of LDL to HDL compared to no almond consumption, a remarkable finding given that all participants were consuming a low saturated fat, National Cholesterol Education Program (NCEP) Step 1 diet.[12] A second study assessed the effect of eating a low-almond diet (10% of calories), a high-almond diet (20% of calories) or control diet (no almonds) in 16 healthy men and women (mean age 41 years).[13] The high-almond diets significantly lowered average total cholesterol (-10 mg/dL) and LDL cholesterol (-10 mg/dL) compared to the control diets, while also increasing vitamin E levels in a dose-response manner.

Another recent study looked at the impact of consuming almonds as a snack compared with just before meals amongst 169 young, healthy participants in South Korea.[14] The researchers examined the effects of consuming 56 grams (~two servings) of almonds daily directly pre-meal vs. as a between-meal snack on body composition, blood lipid profile, and oxidative and inflammation indicators. Consuming almonds as a daily snack reduced the levels of total cholesterol and LDL cholesterol compared to control without changing HDL cholesterol. While there was no change in total body weight, body fat mass decreased for both almond groups, indicating small, but significant, improvements to body composition. Additionally, the pre-meal almond consumption group saw reductions in percentage body fat and visceral (belly) fat. By the end of this 16-week intervention, LDL cholesterol levels had decreased for those in the almond snack group relative to control, with no significant changes between groups related to HDL cholesterol. The results show that almond consumption reduced levels of both total and LDL cholesterol as well as reduced total fat mass vs. the control group. Further, consuming almonds directly pre-meal had greater body composition benefits, reduced total fat mass, % body fat and visceral (belly) fat, and is a future area of investigation.

A recent review paper[15] suggests that daily inclusion of almonds as part of a healthy Indian diet may help reduce dyslipidemia, one of the most important risk factors for cardiovascular disease among Indians.

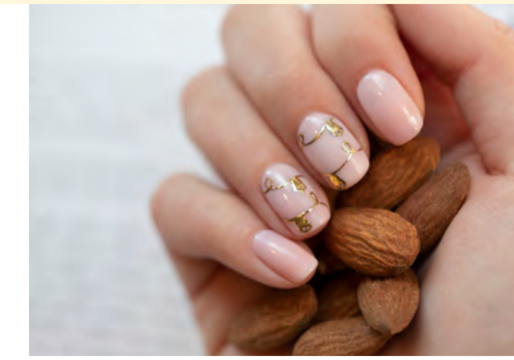
Dyslipidemia is marked by high LDL cholesterol and triglyceride levels, and low HDL cholesterol levels. The review was composed of published epidemiological studies, clinical trials, meta-analyses and systematic reviews. The review concluded that almonds have been shown to reduce LDL cholesterol in several well-conducted clinical trials and the consumption of almonds has helped maintain or even increase HDL cholesterol levels. The researchers affirmed that daily consumption of around 45 grams of almonds can potentially help reduce one of the most important risk factors for CVD in Indians, through improvements in dyslipidemia.

A recent study[16] in a UK population investigated a number of heart health risk factors as part of a multifactorial investigation called ATTIS. This six-week randomized control, parallel-arm trial had 107 participants (with above average cardiovascular disease risk) consume either almonds or a calorie-matched control snack providing 20% of each participant's estimated daily energy needs. Compared to the control group, those in the almond group saw improved endothelial function, assessed by measuring flow-mediated dilation (FMD), a key indicator of vascular health. This was a novel finding for almond nutrition research. Improved FMD means that arteries can dilate more easily in response to increased blood flow, which is a strong indicator of cardiovascular health, and poor endothelial function is seen as a strong predictor of the initiation and progression of atherosclerosis. Further, LDL cholesterol levels decreased in the almond group relative to the control group. There was no difference between the two groups in liver fat and several other measures (triglycerides, HDL cholesterol, glucose, insulin). Those in the almond group, compared to those in the control group, increased endothelium-dependent vasodilation (mean difference 4.1% units of measurement). Plasma LDL cholesterol concentrations decreased in the almond group relative to control (mean difference -0.25 mmol/L).

A modeling study[17] published in 2020 estimated the cost-effectiveness of almond consumption in preventing coronary heart disease through changes in LDL cholesterol levels in a U.S. population, using both short-term base case analysis and 10-year risk prevention. The researchers developed a model to estimate the impact of eating 1.5 ounces (43 grams) of almonds per day versus none. CVD parameters included the probabilities of increased LDL cholesterol levels, acute myocardial infarction (MI), MI-related surgeries, death due to the disease and surgeries, and the cost of disease and procedures in the U.S. population in 2012. Interestingly, the base-case model used in this research was a study of 150 U.S. adults with increased risk of type 2 diabetes, which showed that eating 43 grams (about 1.5 oz.) of almonds per day would result in an annual cost savings of $363 compared to eating no almonds. (The cost of almonds used in this research was also factored into the model and was based on price in the U.S. market in 2012.) The almond eaters had reductions in CVD risk factors including LDL cholesterol, total cholesterol, body weight and apolipoprotein B (also known as Apo-B, the main protein found in harmful LDL cholesterol), which is consistent with previous research.

## EMERGING CVD RISK FACTORS: INFLAMMATION, BELLY FAT AND HEART RATE VARIABILITY

Several studies have investigated the effects on emerging risk factors for cardiovascular disease such as inflammation and abdominal (belly) fat. One randomized controlled crossover feeding study assessed the effects of almonds on markers of inflammation in 25 healthy adults (ages 22 to 53). Participants were fed three different diets for four weeks each: a heart-healthy control diet (no nuts, <30% of calories from fat), a moderate-almond diet (10% of calories from almonds) and a high-almond diet (20% of calories from almonds).[18] E-selectin (an inflammation marker) decreased as percentage of energy from almonds increased. C-reactive protein (another inflammatory marker) was lower in both almond diets compared to the control diet, and E-selectin decreased as percentage of energy from almonds increased. While not all markers of inflammation were improved, these findings suggest including almonds in a heart-healthy diet may help improve two important markers, C-reactive protein

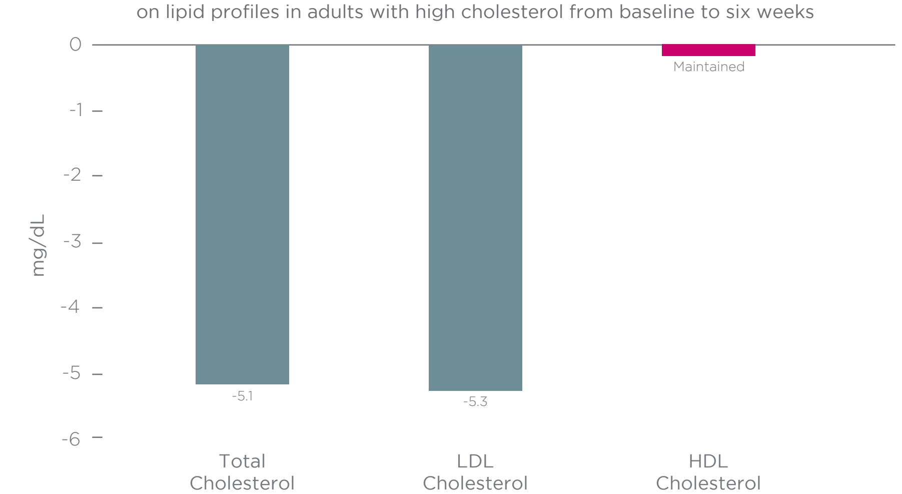
and E-selectin, and in turn, contribute to the prevention of heart disease. In another study, 30 normal-weight Iranian men with mildly elevated cholesterol consumed 60 grams (2 ounces) of almonds daily for four weeks in addition to their usual diets. After four weeks, eating almonds significantly decreased total and LDL cholesterol, as well as apolipoprotein B100, a protein that plays a role in moving cholesterol throughout the body and a form of LDL cholesterol.[15] Apo-B100 is thought to be an important determinant of cardiovascular risk. Almond consumption was also associated with an improvement in lipid oxidation parameters, suggesting that almonds may reduce the ability of fats to become oxidized in the body, a process that can lead to increased heart disease risk.

A study from Penn State University showed that snacking on almonds daily for six weeks not only reduced LDL and total cholesterol but also reduced abdominal fat and waist circumference in study participants.[19] During this study, 52 adult participants (who were overweight with elevated LDL and total cholesterol but otherwise healthy) ate standard healthy diets that were identical except for the snack, either 1.5 ounces (43 grams) of almonds or a high-carbohydrate muffin with the same number of calories. Compared with snacking on muffins, eating almonds significantly decreased total cholesterol (-5.1 mg/dL) and LDL cholesterol (-5.3 mg/dL) and maintained HDL cholesterol. HDL cholesterol actually decreased among participants in the muffin group (**see Figure 2**). There was a small weight loss in both groups that did not differ between the diets, but snacking on almonds actually reduced abdominal fat (-0.15 pounds or -.07 kg) and waist circumference (-0.31 inches or -.80 cm) compared with snacking on muffins. The overall diets were not matched for macronutrient content. The study suggests that regularly choosing almonds instead of a high-carb snack may be a simple dietary strategy to help improve body composition.

Heart rate variability (HRV), a measure of the fluctuation in time intervals between consecutive heartbeats, is an important indicator of the cardiovascular system's response to stress and it is thought that lifestyle factors that can influence cardiovascular disease, including physical activity and diet, might impact HRV. Higher HRV represents greater adaptability of the heart in response to environmental and psychological challenges, while low HRV is linked to cardiovascular disease and sudden cardiac death.

This new research finding was a part of the ATTIS study (described above), in which 107 participants with previously average cardiovascular disease risk consumed a daily snack of almonds or a calorie-matched control snack providing 20% of each participant's estimated daily energy needs for six weeks. In this secondary study,[20] researchers measured participants' real-time heart rate HRV at rest (lying down for five-minute periods) and during a Stroop test (in which participants were asked to read colored words (ex. read the word "red," displayed in a green font) to simulate short periods of mental stress). During acute mental stress, participants in the almond group showed better heart rate regulation compared to the control group, indicated by statistically significant differences in high frequency power, which specifically evaluates beat-to-beat intervals (a measure of HRV).

Figure 3: Effects of eating 1.5 ounces of almonds per day compared to 150-calorie muffin on lipid profiles in adults with high cholesterol from baseline to six weeks




Data is mean ± standard error, n = 48.

The study demonstrates that eating almonds in place of typical snacks may diminish the drop in HRV that occurs during mental stress, thereby improving cardiac function. These results suggest that consuming almonds has the potential to increase cardiovascular resilience to mental stress, along with other heart health benefits seen in the primary findings of the ATTIS study (lowering LDL cholesterol and improving blood vessel function.)

## CONCLUSIONS

Dietary changes are often the first and one of the most effective steps to reduce the risk of cardiovascular disease, and the body of research suggests that eating almonds can help maintain a healthy heart and healthy cholesterol levels. Research studies from several genetically diverse groups, and for people with a range of BMI, consistently show a reduction of total and LDL cholesterol with preservation of HDL cholesterol. In more recent studies, other heart disease risk factors including HRV, inflammation and belly fat improve with almond consumption as part of a heart-healthy diet.

# **ALMONDS:** AND DIABETES

**THE UNIQUE NUTRIENT PACKAGE IN ALMONDS MAKES THEM A SMART CHOICE FOR MANAGING HEALTHY BLOOD SUGAR LEVELS.**

The prevalence of type 2 diabetes (T2D) is rapidly increasing. According to the most recent 2019 report from the International Diabetes Federation, more than 463 million adults globally were living with diabetes, and by 2045, that number is expected to increase to 700 million. One in two adults has diabetes and don't know it. And another 374 million people—more than one in 13 adults—have prediabetes.[21] Diabetes is also a contributing risk factor for other chronic diseases, such as heart disease and stroke. Dietary and lifestyle interventions are a critical component of diabetes management, and evidence continues to mount supporting the role of almonds and other tree nuts as part of an overall dietary pattern that is beneficial for those with T2D. The nutrient profile of almonds—low-glycemic index and providing a satisfying combination of protein (6 grams per ounce), fiber (4 grams per ounce) and monounsaturated fats—makes them an ideal snack and addition to meals for individuals with impaired glucose tolerance or T2D.

Many randomized controlled studies have been conducted to examine eating almonds in relation to blood glucose control. These studies were conducted in different population groups, including people with normal blood glucose control, people with prediabetes and people with T2D.

## IMPACT OF ALMONDS IN PARTICIPANTS WITH TYPE 2 DIABETES

A number of randomized, controlled studies of the effects of almonds on measures related to blood glucose control have been conducted in participants with T2D, evaluating both post-meal effects and longer-term measures (over at least four weeks). In four of the five longer-term studies, eating an almond-enriched diet resulted in significant reductions in fasting glucose and insulin levels control, when compared to an almond-free diet. One randomized trial in 19 U.S. adults (including seven with T2D) reported a 30% reduction in postprandial glycemia in participants with T2D following the consumption of a test meal containing one ounce (28 grams) of almonds compared to an almond-free test meal similar in calories, fat and available carbohydrate, although the effect was not significant in those without T2D.[22] These same researchers conducted a pilot study on the longer-term effects of almonds on glucose control in 13 adults with T2D. Participants consumed a daily one-ounce serving of almonds (five days per week for 12 weeks) or a cheese snack with the same number of calories. After 12 weeks, hemoglobin A1c in individuals with T2D was reduced by 4% in participants who consumed almonds daily compared to baseline.

A longer-term 12-week study[23] assessed the impact of almond consumption (~two ounces or 60g/day) in a cholesterol-lowering diet on short- and long-term glycemic control, blood lipids, endothelial function, oxidative stress and inflammation in 33 Chinese (Taiwanese) adults with T2D. Results showed that among patients with baseline HbA1c ≤8%, the diet with almonds reduced fasting HbA1c by 3% and reduced fasting blood sugar levels by 5.9% as compared to the control diet, suggesting that including almonds in a healthy diet might help further improve blood sugar control in T2D patients with HbA1c ≤8%.

Serum cholesterol levels and biomarkers for inflammation and oxidative stress remained unchanged over the course of the study.

Another 12-week study in 20 Chinese adults with T2D and mild hyperlipidemia (9 male, 11 female: age 58 years; BMI 26 kg/m$^2$) investigated the effects of a four-week diet containing two ounces (56 grams) of almonds per day versus a no-almond control diet.[24] The study demonstrated that almond consumption helped improve glycemic control by lowering fasting insulin and fasting glucose as well as decreasing the risk for heart disease through significant reductions in total cholesterol (-6%), LDL cholesterol (-11.6%) and LDL:HDL ratio when compared to the control. In a third long-term study, participants (65 overweight and obese adults) consumed three ounces (85 grams) of almonds per day as part of a healthy diet for 12 weeks and showed improvements in HbA1c.[25]

A six-month study among 50 Asian Indians with T2D and elevated cholesterol examined the effect of almonds on CVD risk factors.[26] During a three-week run-in period, participants ate a standard diet compliant with the dietary guidelines for Asian Indians and appropriate for diabetes. During this period, participants were also asked to walk for 45 minutes at least five days a week to standardize their physical activity and were instructed to maintain the same level of activity for the rest of the study. Whole natural unroasted almonds (20% of energy intake) were substituted for fat (such as cooking oil and butter) and some carbohydrates in the intervention group. Following the almond intervention, waist circumference, waist-to-height ratio, total cholesterol, triglycerides, LDL cholesterol, C-reactive protein (an indicator of inflammation) and HbA1c improved in participants.

The study findings illustrate that incorporation of almonds in a well-balanced healthy diet leads to multiple beneficial effects on glycemic and cardiovascular risk factors. Asian Indians have a genetic predisposition to T2D, and these findings illustrate the multiple beneficial effects of almonds on cardiovascular risk factors that are associated with T2D.

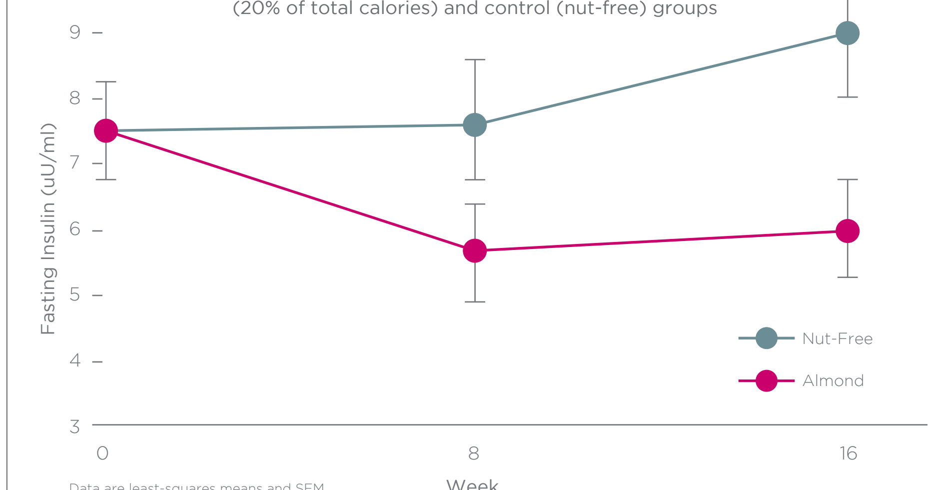
The summary of these results suggests that modest almond consumption improves both short-term and long-term markers of glucose control in individuals with T2D. The studies were well controlled and of sufficient duration to determine effects on glycemic control; they are limited by their small sample size and, in some cases, have limited generalizability to free-living conditions in the studies in which meals were provided to participants.

## ALMONDS AND PREDIABETES

Studies also suggest that almonds may have benefits for people with prediabetes. One short-term, post-meal study in 14 adults with impaired glucose tolerance showed that the consumption of a 580-kcal breakfast meal containing 1.5 ounces (43 grams) of almonds resulted in significant reductions in participants' blood glucose levels both acutely after breakfast and after a second meal relative to the consumption of a 347-kcal control breakfast meal, which differed in total dietary energy but provided the same amount of available carbohydrate.[27]

A long-term 16-week randomized control trial on 65 middle-aged U.S. adults (48 women and 17 men) with prediabetes investigated the effects of consuming an American Diabetes Association diet consisting of 20% of calories from almonds (approximately 2 ounces or 57 grams per day) on the progression of T2D and CVD. The group that consumed the almond-enriched diet showed significantly improved LDL cholesterol levels and measures of insulin sensitivity, both of which are risk factors for heart disease and T2D[28] (**see Figure 3**). The study was of sufficient duration to examine effects on markers of long-term blood glucose control; however, reliance on a single fasting sample for measurement of insulin resistance is an analytical limitation.

Figure 4: Change in fasting insulin in almond-consuming (20% of total calories) and control (nut-free) groups



Finally, a larger study among 275 adolescents and young adults in India with prediabetes looked at the effect of almond consumption on factors of metabolic dysfunction including blood glucose, lipids, insulin and selected inflammatory markers. Results showed that those in the almond group, who ate 56 grams (about 2 one-ounce servings) of unroasted almonds every day for three months, had significantly decreased HbA1c levels compared to the control group (who ate a calorie-equivalent savory snack commonly consumed by this age group in India). Additionally, those in the almond group had significantly reduced total cholesterol and LDL cholesterol compared to the control group, while maintaining HDL cholesterol levels.[29]

### EFFECT OF ALMONDS ON BLOOD GLUCOSE MEASURES IN HEALTHY PEOPLE

Post-meal studies conducted in healthy or hyperlipidemic participants with normal blood glucose control cumulatively suggest that almonds have neutral or beneficial effects on post-meal blood glucose and insulin responses; in some studies, almonds actually reduced post-meal blood glucose and insulin spikes as well as blood glucose and insulin levels over a two-hour time period relative to an almond-free meal.[30,31]

In longer-term four-week studies, eating about 1.2 or 2.5 ounces (35 or 70 grams) of almonds per day resulted in significant reductions in a marker of insulin secretion, suggesting a decrease in insulin resistance,[32] as well as significant dose-dependent improvements in total cholesterol and other blood lipids.[33] Calorie intake was similar between the control and almond diets in both studies, but the duration was too short to discern effects on long-term blood glucose control.

A study of breakfast-skipping healthy college freshmen examined the effect on blood sugar regulation and other cardiometabolic measures. The students ate either a morning snack of almonds (two ounces or 57 grams) or graham crackers of similar caloric value. While fasting blood sugar levels were improved in both snack groups, benefits were greater in the almond group. Glucose tolerance and whole-body insulin sensitivity were better for the almond group, indicating that blood sugar regulation was better for the almond snackers.[34]

### CONCLUSIONS

Based on the totality of scientific evidence from randomized controlled studies, almonds, when eaten as part of a healthy diet, may have beneficial effects on blood glucose and insulin responses, both in the short term after consuming a meal and over the longer term, especially in those with impaired glucose tolerance and/or T2D. Dietary changes are often the first and one of the most effective ways to manage diabetes, and the body of research suggests that eating almonds can help maintain healthy blood sugar levels.


# ALMONDS: A SATISFYING WEIGHT-WISE SNACK

### A DAILY HANDFUL OF ALMONDS IS A DELICIOUS WAY TO MANAGE CRAVINGS AND HELP MAINTAIN A HEALTHY BODY WEIGHT.

The prevalence of overweight and obesity continues to be a major public health issue worldwide. According to the latest data from the World Health Organization, 39% of all adults throughout the world were overweight and 13% were obese in 2016.[35] Given that snacking has become nearly universal behavior, combined with persistently high obesity rates, identifying nutrient-rich snack options that pose little risk for weight gain is of growing importance. The nutrients in almonds, including monounsaturated fat, protein and fiber, are associated with improved satiety, suggesting they would be an ideal snack for those concerned about weight management.

Many randomized controlled studies have been conducted to examine the effects of almonds, consumed as part of a sensible eating plan, on outcomes related to satiety (i.e. hunger, fullness, desire to eat and prospective food consumption) and/or body composition (i.e. body weight, body mass index (BMI), body fat and waist circumference). These studies were conducted in different population groups, including people with normal weight, as well as overweight or obese people in tandem; evaluating bioaccessibility and its impact on calorie content and therefore energy intake is an important part of the puzzle in identifying foods that support weight management.

### ALMONDS AND CALORIES

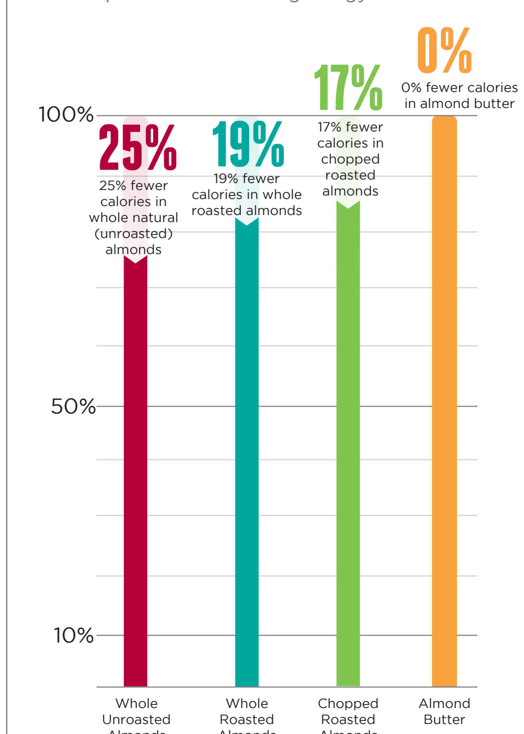
Data from the U.S. Department of Agriculture (USDA) shows that both roasted and unroasted almonds provide fewer calories than thought—and that the number of calories is largely dependent on form[36] (**see Figure 4**). The study, conducted by scientists from USDA's Agricultural Research Service (ARS) and jointly funded by the Almond Board of California and USDA ARS, shows that compared to the number of calories listed on nutrition labels, participants actually absorbed 25% fewer calories from whole unroasted almonds, 19% fewer calories from whole roasted almonds and 17% fewer calories when almonds were roasted and chopped. Measured calories in almond butter did not differ from calories listed on labels. Much of this finding has to do with particle size after chewing and digestion.

The larger the particle size, after chewing for example, the less the almond is able to be broken down by digestive enzymes and more of the almond is excreted, so fewer calories are absorbed. The reverse is also true: the smaller the particle size, the more almond cells are exposed to digestive enzymes and the more calories are absorbed. In addition to chewing and digestion, mechanical processes, such as chopping, grinding and roasting almonds, can also impact particle size.

Recent findings by researchers in Canada also examined bioaccessibility of calories in almonds among subjects with high blood cholesterol levels. Similar to the results from USDA ARS, researchers found that after digestion, about 20% of calories derived largely from fat in almonds remained unabsorbed. The researchers concluded the energy content of almonds may not be as bioaccessible as predicted by Atwater factors.[37]

While the composition of almonds hasn't changed, for the aforementioned studies, researchers used a new method of measuring the calories in almonds, which built on traditional methods and allowed them to determine the number of calories actually digested and absorbed from almonds. Further research is needed to better understand how this technique could potentially affect the calorie count of other foods.

**Figure 4**: Food processing and structure impact the metabolizing energy of almonds



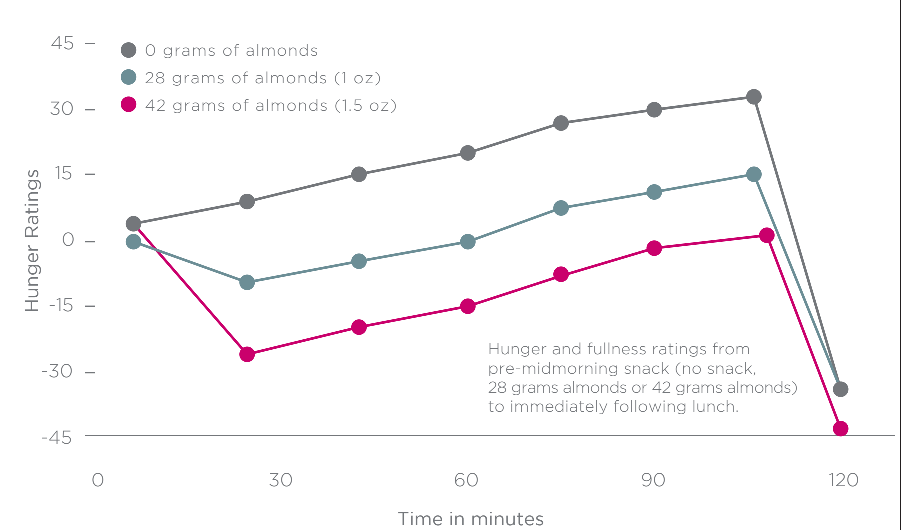



Figure 6: A midmorning snack of almonds generates satiety

## IMPACT OF EATING ALMONDS ON MEASURES OF HUNGER, SATIETY AND SUBSEQUENT CALORIE INTAKE IN NORMAL-WEIGHT PEOPLE

In post-meal studies, the daily consumption of almonds is associated with improving ratings of hunger and satiety in healthy people. In one study, the daily consumption of 2.8 ounces (80.4 grams) of almonds reduced subjective ratings of hunger,[38] and a second study investigated the effects of two different portion sizes of almonds (1 and 1.5 ounces, 28 grams and 43 grams) as a midmorning snack on satiety and energy intake, in comparison to having no snack (**see Figure 5**). There were no significant differences in total daily energy intake between any of the groups, indicating that participants (32 healthy, Caucasian women) naturally compensated for the almond calories consumed, whether they had one (160 calories) or 1.5 servings (250 calories) of almonds as the midmorning snack.[39] After eating their usual breakfast and having the midmorning almond snack, participants were fed lunch midday and permitted to eat as much as they wanted until they were comfortably full. Ratings of appetite and fullness were dose dependent, with participants reporting being the least hungry when they ate 1.5 ounces (43 grams) of almonds and the hungriest on the day when they didn't eat almonds. Although habitual almond intake was not controlled for and a control snack was not tested, the studies suggest that snacking on nutrient-rich almonds may improve satiety and help control cravings.

A longer-term four-week randomized, controlled clinical study in which 137 adults who were at risk of T2D but otherwise healthy were given 1.5 ounces (43 grams) of almonds as a snack or with meals also showed significantly greater reductions in daylong ratings of hunger and desire to eat in participants who consumed almonds either as a snack or part of a meal relative to those who did not consume almonds.[40] Despite consuming approximately 250 calories from almonds every day for over four weeks, participants did not increase their daily total calorie intake or experience any change in weight over the course of the study. Although the study was of relatively short duration, these findings suggest almonds may be a satisfying snack option to help maintain a healthy weight.

In another 10-week study, 20 healthy adult women consumed their normal diets plus 344 calories (approximately 2 ounces or 56 grams) of almonds per day for 10 weeks and then followed their normal diet without almonds for 10 weeks, with a three-week washout period in between[41] (**see Figure 6**). There were no differences in body weight, metabolic rate or energy expenditure observed, suggesting that the almonds replaced other foods in the diet and, therefore, did not increase overall calorie intake.

Researchers have also investigated body fat distribution types in relation to almond consumption. In one six-month study, healthy adults with normal HbA1c levels were assessed and classified as either having high VAT (visceral adipose tissue, or abdominal fat around the organs ), high SAT (subcutaneous adiposity tissue, or fat under the skin) or gluteal-femoral (fat stored in hips and thighs). Those in the almond group were instructed to eat 1.5 ounces (43 grams) of almonds with their breakfast and as their afternoon snack. The control group did not get a snack and was told to follow their usual routine avoiding nut consumption. Among the 118 participants who completed the study, there were no differences in hunger, fullness or desire to eat in either the almond or control group, and these results held true across all participants with the different body fat distribution classifications. Participants classified as high SAT who were part of the almond group had a greater reduction in android fat mass percentage, preserved android lean mass percentage and tended to decrease android VAT mass compared to high-SAT participants in the control group. Additionally, although those in the almond group consumed 200 kcals/day more than participants in the control group, there was no weight gain in either group. The findings of this study help explain how almonds can affect people of differing BFD types and demonstrate that despite consuming more calories daily, eating about 1.5 ounces (43 grams) of almonds does not promote weight gain over the long term.[42]

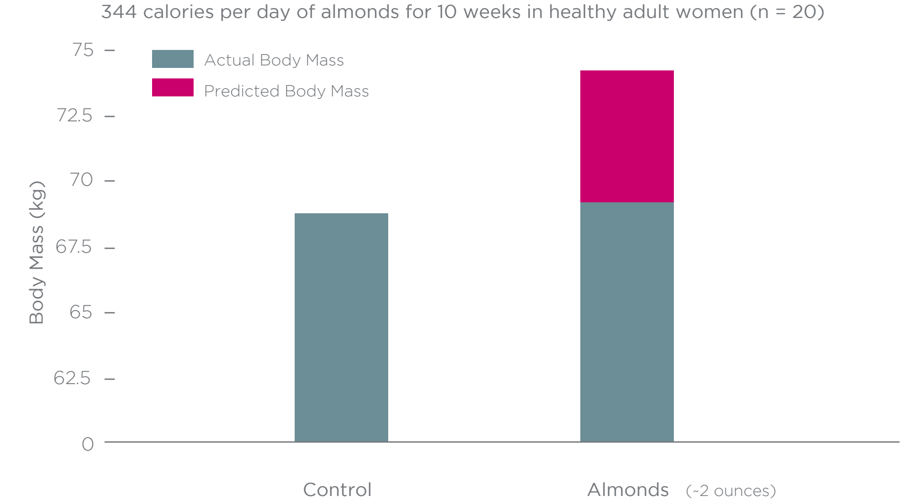


Figure 7: Changes in body composition due to the consumption of 344 calories per day of almonds for 10 weeks in healthy adult women (n = 20)

Findings[43] from British researchers reveal additional insights related to almonds' impact on satiety. In this study, 42 healthy women who snacked on almonds as a midmorning snack, compared to crackers with equivalent energy, reported a lower overall hunger drive. Snacking on almonds also led to suppressed unconscious desire (implicit wanting) to consume other high-fat foods, which could be useful in a weight management strategy. The study did not see a difference in the total daylong calorie intake with the almond snack but did see a reduction in calories consumed during the lunch meal eaten two hours after the snack. The satiety quotient (measure of the satiating capacity of foods relative to energy content) was stronger immediately after eating the almonds than the crackers, and participants perceived the almonds to be a healthier snack.

## EFFECTS OF EATING ALMONDS ON SATIETY AND WEIGHT IN PEOPLE WHO ARE OVERWEIGHT OR OBESE

There have been a number of studies investigating the short- and long-term effects of almonds on measures related to body composition and weight in overweight and obese adults (BMI ≥ 25 kg/m$^2$). In one study, overweight women who consumed a meal containing one ounce (28 grams) of almonds reported feeling more hungry, less full, more desire to eat, with a greater food consumption later in the day relative to when they consumed a control meal containing a mixture of safflower and corn oils, although differences in satiety ratings were not observed in overweight men.[44] In another study conducted in obese adults, the consumption of a meal containing 1.5 ounces (43 grams) of almonds boosted fullness ratings in the afternoon and throughout the day relative to the consumption of a control meal without almonds, which was lower in total dietary energy but provided the same amount of available carbohydrate.[45]

Long-term studies cumulatively suggest that almonds have no detrimental effects on body composition in overweight or obese participants; in fact, significant improvements in body composition have been observed in two studies.

In obese adults with T2D, the consumption of one ounce (28 grams) of almonds five days per week for 12 weeks resulted in a significant decrease in BMI relative to no almond consumption.[46] In another study, 65 overweight and obese[47] participants who consumed three ounces (84 grams) of almonds daily for 24 weeks had significantly greater reductions in body weight, BMI, waist circumference, fat mass and total body water compared to participants who did not consume almonds[48] (**see Figure 7**). These findings are remarkable, given that participants consumed the almonds as part of a healthy low-calorie diet.

Another 18-month clinical trial examined the effects of a low-calorie diet containing two ounces (56 grams) per day of almonds compared to a low-calorie, nut-free diet on weight loss and heart disease risk factors in 123 overweight or obese adults. Although both groups had lost similar and significant amounts of weight after 18 months, compared with the nut-free group, the almond-enriched diet was associated with greater reductions in total cholesterol, TC:HDL ratio and triglycerides.[49] Strengths of the long-term studies include sufficient study duration to discern the effects on body weight and adequate control of the total energy intake between the control and almond diets.

## CONCLUSIONS

The body of scientific evidence suggests that despite their relatively high energy density, almonds, when eaten as a part of a healthy diet, do not cause weight gain and may even have beneficial effects on body composition, especially in overweight or obese adults. Several mechanisms provide explanations for the positive associations between almonds and other nuts and energy balance and body weight, including their strong satiating quality, incomplete calorie availability and possible enhancement of resting energy expenditure.[47] Although many commonly consumed snacks provide empty calories, almonds are a healthy, nutrient-rich snack choice. The unique nutrient package in almonds makes them a satisfying, weight-wise snack.

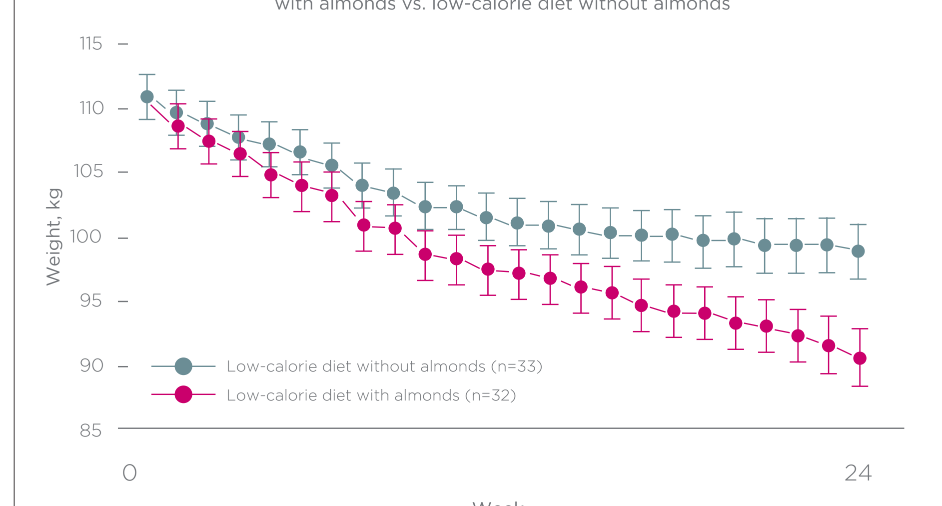


Figure 8: Weekly change in body weight in low-calorie diet with almonds vs. low-calorie diet without almonds

# ALMONDS: AND THE GUT MICROBIOME

Of the many fields of study, research related to the gut microbiota may be one of the most challenging and complex. The gastrointestinal system is known to play an important role in health, and numerous factors may be associated with the development of chronic disease: environment, behavior and the food we eat can all influence the gut microbiome, for better or for worse. Research on the link between almonds and gut health is limited, but new studies are currently underway.

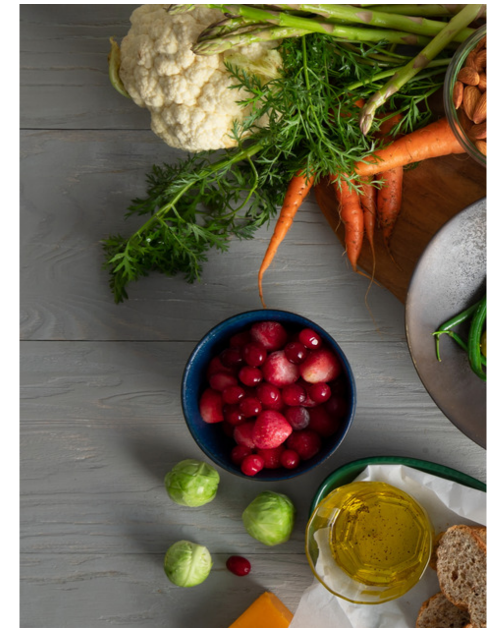
In a study designed to measure the metabolizable energy of different almond forms,[36] researchers collected fecal samples that were later analyzed to track changes to gut microbiota.[50] A study group of 18 healthy adult men and women consumed 1.5 servings of either whole almonds, roasted almonds, chopped almonds or almond butter every day for a three-week period. Participants repeated this for each almond form, and fecal samples were collected at the end of each three-week period. Researchers found that, overall, almond consumption increased the relative abundance of specific beneficial bacteria in the gut, and that the degree of processing—whole or chopped—also had an impact. Almond butter showed no effect. The researchers suggest that the fiber and unsaturated fatty acids, in particular, found in almonds may be partly responsible for modulating the composition of the gut microbiome.

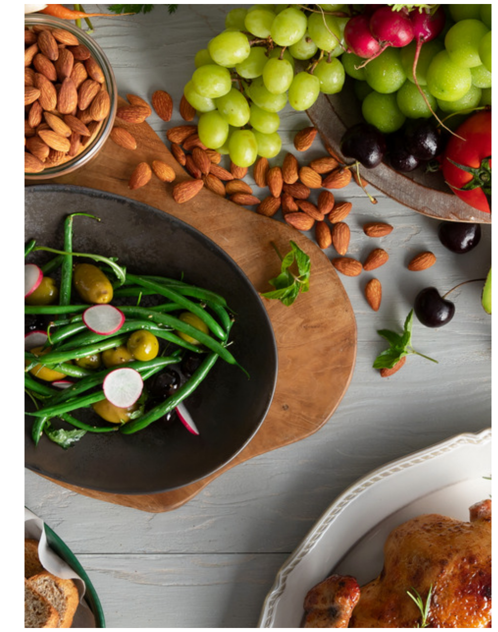
In another study, researchers examined microbiome data gathered as part of a study looking at almond intake in college freshmen.[51] The researchers looked at gut microbiome diversity and abundance among those who had a morning snack of almonds versus those who ate graham crackers. Those in the almond group had a 3% greater quantitative alpha-diversity and an 8% greater qualitative alpha-diversity than the cracker group after the intervention. Increased bacterial richness, as suggested in the original study, is associated with favorable health outcomes such as glucose tolerance and insulin sensitivity. The fiber, monounsaturated fats and polyphenol content of almonds are likely responsible for the greater alpha-diversity, according to the researchers. Further, the researchers concluded that incorporating a morning snack of almond in the dietary regimen of predominately breakfast-skipping college freshmen improved the diversity and composition of the gut microbiome.

## CONCLUSIONS

Several nutrients naturally found in almonds—fiber, unsaturated fatty acids and polyphenols—are thought to be responsible for the potential benefits relating almonds to improvements in gut microbiota. While promising, it's important to remember that gut health in general is an area of study still in its infancy—there is more to discover and more to understand. Though findings from these initial studies on almonds are promising, further research is warranted.

# ALMONDS: AND DIET QUALITY





The 2020–25 Dietary Guidelines for Americans recommend improving diet quality, and one way to do this is by replacing high-calorie snacks with nutrient-rich options. One study that evaluated the potential effects of replacing typical snack foods with almonds and other tree nuts shows that this simple swap would decrease empty calories, solid fats, saturated fat and sodium in the diet, while increasing intake of key nutrients.[52] Using data of more than 17,000 children and adults from the National Health and Nutrition Examination Survey (NHANES; 2009–2012), the researchers applied food pattern modeling to assess the hypothetical impact of replacing all snack foods, excluding beverages, with tree nuts (model 1) and replacing all but "healthy" snack foods (whole grains, whole fruits and non-starchy vegetables) with tree nuts (model 2). Almonds are the most frequently consumed nut, and in this study, 44% of all tree nuts eaten were almonds. Therefore, assessments using the NHANES data were repeated using almonds only. All reported snacks were replaced calorie for calorie with almonds or other tree nuts, reflecting typical American consumption patterns. The Healthy Eating Index 2010, which measured adherence to the 2010 Dietary Guidelines for Americans, was used to assess diet quality.

In both models examined, where tree nuts hypothetically replaced all snack foods and where tree nuts hypothetically replaced only less-healthy snack foods, consumption of empty calories, solid fats, saturated fat, sodium, carbohydrates and added sugars all declined, while consumption of oils and good fats increased significantly. Fiber and magnesium also increased, while protein increased by a small margin. The findings were the same in the almond-only model.

This study echoes findings from a similar NHANES analysis on almond eaters, which examined the characteristics of almond eaters. It found that people who reported eating almonds had higher intake of key nutrients (such as dietary fiber, calcium, potassium and iron, as well as higher intakes of several other "shortfall nutrients," including vitamins A, D, E and C; folate; and magnesium), better overall diet quality (measured by Healthy Eating Index scores) and lower body mass index and waist circumference compared to non-almond eaters.[53] Almond consumers (defined as those eating about one ounce (28 grams) per day) also tended to be more physically active and less likely to smoke than their non-almond-eating counterparts, suggesting that including almonds as a regular part of the diet is associated with a portfolio of healthy lifestyle attributes.

Another study on diet quality conducted by the University of Florida examined the impact of eating almonds and/or almond butter on diet quality in addition to microbiota composition in 29 parents and their children. Participants ate either 1.5 ounces (43 grams) of almonds and/or 0.5 ounces (14 grams) of almond butter on a daily basis for three weeks, as part of their usual diet. This was followed by a four-week washout period and a three-week control period in which no almonds were eaten.

Diet quality was assessed based on the U.S. Dietary Guidelines. When parents and children ate almonds, their overall diet quality improved, as measured by an increase in Healthy Eating Index (HEI) scores (a standard measure of adherence to recommended dietary guidance).[54] Specifically, parent and child scores increased for fatty acids, total protein, seafood and plant protein, and decreased for fruit and empty calories. In addition, when eating almonds, participants also consumed significantly more vitamin E and magnesium, two nutrients commonly underconsumed by the majority of adults and children. Although no specific changes in immune markers were observed, almond consumption did result in detectable changes in gut microbiota. More research is necessary to understand these changes and their potential health impacts.

A new British study[55] investigated the association of almond snack consumption with CVD risk factors including BMI, total cholesterol and LDL cholesterol, among other measures. Cross-sectional analysis was conducted using UK National Diet and Nutrition Survey (NDNS) data from 6,802 adults (≥19 years old) who completed a four-day estimated food diary. Almond snack consumption was defined as average intake of any amount of whole almonds alone or whole almonds plus the proportion of almond kernels in mixed nut portions.

Although average almond intake was low among adults who said they eat almonds (7.6% of the population reported eating whole almonds and average intake was 5g/day (0.18 ounces)), almond consumers reported higher diet quality scores compared to those who reported not consuming almonds. The almond eaters had higher reported intakes of protein, total fat, monounsaturated, omega-3 and omega-6 fats, fiber, folate, vitamin C, vitamin E, potassium, magnesium, phosphorus and iron. Further, they had lower intakes of trans-fatty acids, total carbohydrates, sugar and sodium. These dietary quality findings suggest that UK adults with healthier dietary patterns are more likely to include almonds. The researchers also found that almond consumers had lower BMI and waist circumference measurements. BMI was significantly lower for the whole almonds group by 0.8 $kg/m^2$ and waist circumference was lower by 2.1cm. There were no differences between almond consumers and non-consumers with regard to other CVD risk factors.

## CONCLUSIONS

Multiple studies across different national diet databases have consistently suggested that almond eaters, in general, have better diet quality. This is reflected in improved intake in nutrients like fiber, unsaturated fats, vitamin E, folate and more, with decreased consumption of saturated fat, added sugar and sodium. The research also suggests inverse associations between almond consumption and smoking and overweight.

# ALMONDS: AND SKIN HEALTH

Almonds have been linked to skin health for centuries. Within ancient medicine such as Ayurveda, almonds have been associated with benefits for the skin. Further, almonds are often used as a topical ingredient in skin creams and beauty treatments, which may infer to a consumer that eating almonds will have a similar benefit. As nutrition emerges as an important factor in skin aging processes, almonds have potential as an avenue of investigation due to their nutritional profile of a range of fatty acids, polyphenols and other phytochemicals with antioxidant properties.

## EFFECT OF ALMOND CONSUMPTION ON WRINKLES AND SKIN PIGMENTATION IN POSTMENOPAUSAL WOMEN

A pilot study[56] evaluated whether daily almond consumption in place of other nut-free snacks might effect the development of facial wrinkles in postmenopausal women. The study examined almond consumption in association with skin aging measures including wrinkle severity, wrinkle width, sebum production and transepidermal water loss (TEWL). Sebum production and TEWL are measures of skin barrier function. Within the study protocol, 28 postmenopausal women with Fitzpatrick skin type I (always burns, never tans) or II (usually burns, tans minimally) were randomly assigned to either an intervention or a control group. Almonds were provided as 20% of total daily calorie intake for the intervention group (340 calories/day on average), about two one-ounce (two 30-gram) servings. The control group consumed a calorie-matched nut-free snack in place of almonds daily.

After a four-week dietary washout period, participants were randomized to one of the two study groups. Facial wrinkles were assessed using high-resolution facial photography and validated by 3-D facial modeling and measurement at baseline, 8 weeks and 16 weeks during study visits. The severity score is a calculation of the depth and length of a wrinkle. Sebum production and transepidermal water loss (TEWL) were also measured.

Photographic image analysis showed that the almond group had statistically significant reductions in wrinkle width (by 10%) and severity (by 9%), compared to the control group at the 16-week time point. There were no significant differences in sebum production or TEWL between groups after 8 and 16 weeks. After 16 weeks, there were no differences between groups in measures of skin barrier function relative to baseline.

These promising results spurred a second follow-up study exploring the impact of daily almond snacking on not only facial wrinkles, but also overall skin pigmentation in postmenopausal women. In this six-month randomized controlled trial[57] by the same research team, 49 healthy postmenopausal women with Fitzpatrick skin types I or II completed the study. Participants were randomly assigned to one of two groups: in the intervention group, women ate almonds as a snack, which accounted for 20% of their total daily calorie intake, or 340 calories per day on average (about two one-ounce or two 30-gram servings). The control group ate a calorie-matched snack that also accounted for 20% of calories: a fig bar, granola bar or pretzels. Aside from these snacks, study participants ate their regular diets and did not eat any nuts or nut-containing products. Skin assessments were made at the start of the study and again at 8 weeks, 16 weeks and 24 weeks. At each of these visits, facial wrinkles and facial pigment intensity were assessed using high-resolution facial imaging and validated 3-D facial modeling and measurement. Skin hydration, TEWL and sebum excretion were also assessed.

Researchers found a statistically significant reduction in wrinkle severity in the group consuming almonds: at 16 weeks, there was a reduction of 15% and at 24 weeks, a reduction of 16%. There was also a statistically significant decrease in overall facial pigment intensity (unevenness of skin tone) in the almond group: a 20% reduction by week 16 that remained so at week 24. Further, body weight remained constant for both the almond group and the control group from baseline to 24 weeks.

## EFFECT OF ALMOND CONSUMPTION ON UVB PROTECTION IN YOUNG ASIAN WOMEN

Researchers at the University of California, Los Angeles (USA) investigated whether daily almond intake could increase resistance to UVB light (the main source of skin damage from sun exposure) and improve skin texture.[58] The participants in the study were young women who self-identified as Asian, ages 18-45 years, with skin types that ranged from "burns and does not tan easily" to "burns a little and tans easily," technically classified as Fitzpatrick skin types II, III or IV. The women were randomly assigned to eat 1.5 ounces (42 grams, 246 calories) of almonds or 1.8 ounces (51 grams, 200 calories) of pretzels daily for 12 weeks. Data from 29 participants was analyzed at the completion of the study. UVB resistance was measured by quantifying the minimal erythema dose (MED) for each study participant at the beginning and end of the study. MED is the lowest dose of UVB light needed to cause slight skin reddening or erythema to a specific site on the skin. (Erythema is the first indication of skin photodamage, so increased MED indicates improved protection—or resistance—against UVB photodamage.)

At the beginning of the study, there were no differences in MED between groups. After the 12-week intervention, there was an increase in both MED (~20%) and in exposure time to reach minimal erythema for women in the almond group compared to the pretzel group. No statistically significant changes in MED or exposure time were observed in the pretzel group. Secondary outcomes investigated in the study included measures of skin texture, sebum and hydration that were assessed by dermatologists. No significant differences were seen in these measures over time or between groups.

## CONCLUSIONS

Results of these recent skin health studies—the first of their kind for any nut—suggest that daily consumption of almonds may play a beneficial role. Further study in larger participant groups and expanded population groups is warranted. More research is needed to investigate the effects of almond consumption for older subjects with moderate-to-severe photoaged skin and for other skin types/ethnicities. Almond research is leading the field in investigating the connection between nutrition and improved skin health.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