



## CALIFORNIA STRAWBERRY COMMISSION

# HEALTH RESEARCH ROUND-UP

For nearly two decades, the California Strawberry Commission has maintained a robust nutrition research program to understand the extraordinary nutritional value of strawberries and a broad range of concomitant health benefits. This initiative contributes to the existing literature and has helped to transform scientific inquiry from asking not *if* strawberries positively influence human health, but *how*.

Strawberries are a nutrition powerhouse. In addition to the nutrients potassium, folate, and fiber,<sup>1</sup> strawberries are the most widely available fresh fruit source for vitamin C.<sup>2</sup> Strawberries are also rich in phytonutrients, particularly anthocyanins and flavan-3-ols, which have been shown to have preventive and therapeutic health benefits.<sup>3</sup> Clinical

research suggests eating just one serving of eight strawberries a day may improve heart health, help manage diabetes, support brain health, and reduce the risk of some cancers. Emerging research is exploring the role that strawberries may play in digestive health. While the depth of knowledge is strong, the California Strawberry Commission is continuing to explore these areas and more.

Here's an in-depth look at some of those areas.

## Heart Health

One of the largest areas of study for California strawberries has been heart health. Several epidemiological studies have demonstrated a link between berry consumption, including strawberries, with reduced risk for heart disease. In one study of women enrolled in the Nurses' Health Study, those who consumed more than three servings of anthocyanin-rich strawberries and blueberries per week had a 32 percent lower risk of heart attack than women who did not consume berries.<sup>4</sup> Another large-scale study of men and women in Japan found that consumption of citrus fruits, strawberries and grapes was associated with a lower stroke risk in women.<sup>5</sup>

Clinical trials have linked strawberries to improvements in various markers for cardiovascular disease, including lipid levels. In one study of obese and overweight adults, daily consumption of strawberries significantly reduced total cholesterol (TC) and low-density lipoprotein (LDL) cholesterol levels, small LDL particle concentrations, and decreased lipid peroxidation.<sup>6</sup>

These results were also seen in meta-analyses of randomized clinical trials. In one, strawberry interventions significantly reduced total and LDL-cholesterol among people with high baseline levels.<sup>7</sup> In another, strawberry supplementation decreased circulating oxidized LDL, malondialdehyde (a marker for oxidative stress), C-reactive protein, TC and diastolic blood pressure. Subgroup analyses revealed additional findings. In one, higher doses of strawberries demonstrated a beneficial effect on hemoglobin A1c and LDL levels, while another, with dyslipidemic patients, showed a decrease in triglyceride levels. Although the meta-analysis demonstrated increased fasting blood sugar (FBS), a sensitivity analysis removing certain studies showed the increase in FBS to be non-significant.<sup>8</sup>

Strawberries have also been linked to improved vascular function in populations ranging from adolescent males, post-menopausal women and adult men and women. In overweight and obese adolescent males, daily strawberry consumption demonstrated the potential to improve markers of microvascular health<sup>9</sup> while several measures of vascular function improved in postmenopausal women with pre- and stage 1 hypertension.<sup>10</sup>

Such changes were seen shortly after strawberry intake in a study of 34 adult men and women with moderate hypercholesterolemia. Vascular function, as

indicated by flow-mediated dilation, improved at one hour after strawberry intake.<sup>11</sup>

Strawberries may also positively impact blood pressure. In the study of postmenopausal women with pre- and stage 1 hypertension, daily consumption of strawberries lowered systolic blood pressure.<sup>10</sup>

## Brain Health

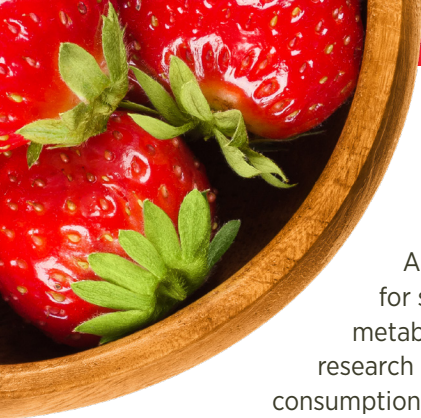
Another area of strawberry research that has been well-explored is brain health, with positive associations found in both epidemiological studies and clinical trials. Researchers attribute the benefits to specific compounds found in berries, including strawberries. In a prospective study of women 70 or older in the Nurses' Health Study, greater intakes of anthocyanidins and total flavonoids and higher consumption of strawberries, specifically, (at least 2 servings per week) were associated with slower rates of cognitive decline. In fact, strawberry consumption appeared to delay cognitive aging by up to 2.5 years.<sup>12</sup> Another prospective analysis from the Nurses' Health Study, as well as the Health Professionals Follow-Up Study, found higher intake of total flavonoids and the consumption of many flavonoid-rich fruits and vegetables, including strawberries, were significantly associated with lower odds of subjective cognitive decline (SCD).<sup>13</sup>

Strawberry intake alone was the focus of a prospective analysis of adults 58 to 98 enrolled in the Memory and Aging Project (MAP), where strawberry intake was associated with a 34 percent reduced risk of Alzheimer's dementia compared to no or rare intake. The authors attributed the results to a specific anthocyanidin found in strawberries, pelargonidin.<sup>14</sup>

Researchers at the Human Nutrition Research Center on Aging at Tufts University have studied the link between berries and brain health for several years. Most recently, the researchers' initial findings in a study of women and men aged 60 to 70 showed improvements in word recognition and spatial memory among participants consuming the equivalent of two cups per day of fresh strawberries.<sup>15</sup> In a study conducted in Sweden, subjects consuming a mixed berry beverage, including strawberries, for five weeks, performed better in a working memory test than after the control beverage.<sup>16</sup> Additional randomized clinical trials are underway.







## Metabolic Health

An emerging area of research for strawberries has been metabolic health. Epidemiological research has linked strawberry consumption to a reduced risk for diabetes. Data from the Women's Health Study revealed that, compared to women who rarely or never ate strawberries, those who ate at least two servings of strawberries each week had a 10 percent lower risk of developing diabetes. Researchers also found that women who ate fewer servings of strawberries were more likely to have higher hemoglobin A1c levels, increasing their risk for diabetes.<sup>17</sup> Strawberry consumption is also associated with weight control in prospective cohort studies from the Health Professionals Follow-up Study, Nurses' Health Study, and Nurses' Health Study II. The study noted an inverse association between increased intake of most flavonoid subclasses with weight gain. The strongest magnitude of association was seen for anthocyanins, flavonoid polymers and flavonols. The main food sources of anthocyanins were blueberries and strawberries.<sup>18</sup>

Researchers at the University of California at Davis and the Illinois Institute of Technology have looked closely at how strawberries may attenuate the postprandial changes in insulin, glucose, inflammatory markers and plasma anthocyanins in both short- and long-term trials. In a six-hour study, consumption of a beverage with freeze-dried strawberry powder significantly reduced inflammatory responses and postprandial insulin response.<sup>19</sup> Various doses of strawberries were evaluated in another study where strawberry intake reduced the insulin demand to manage post-meal glucose and demonstrated a role for strawberries in improving insulin sensitivity in people with insulin resistance (IR).<sup>20</sup> A third study explored the effect of timing on metabolic markers. After consuming a beverage containing the equivalent of one cup fresh strawberries, or a control beverage, two hours before a meal, with a meal, and two hours after a meal, strawberry consumption improved metabolic and anti-inflammatory outcomes, especially if consumed before the meal.<sup>21</sup>

To look at the longer-term effects, the authors randomized subjects to a strawberry or placebo beverage followed by a high-fat, high-carbohydrate meal and assessed for six hours postprandially. In this study, chronic strawberry consumption attenuated postprandial increases in pro-inflammatory and pro-thrombotic/hypo-fibrinolytic responses.<sup>22</sup>

Researchers at the University of Nevada have looked more closely at people with metabolic syndrome and found consuming 2.5 servings per day of strawberries for four weeks may significantly improve insulin resistance, lipid particle profiles, and serum PAI-1, a predictor of type 2 diabetes.<sup>23</sup> The authors also conducted a review of RCTs among adults with signs of metabolic syndrome and concluded that freeze-dried strawberry powder distinctly improved postprandial insulin and markers of oxidative damage and inflammation.<sup>24 25</sup>

## Digestive Health

The ability of strawberry intake to impact digestive health is a new area of study for the California Strawberry Commission. Several studies that were recently published or are underway are looking closely at how strawberry consumption might impact the gut microbiome and, in turn, other aspects of health. To determine if daily consumption of freeze-dried California strawberry powder (SBP) would impact the intestinal microbiota, fecal cholesterol and bile acid microbial metabolites, fifteen healthy adults consumed a diet low in fiber and polyphenols (a "beige diet") plus 26 g of SBP for four weeks, followed by two weeks of beige diet only. Stool samples were collected at 0, 4, and 6 weeks. The researchers noted a significant increase in the number of specific intestinal bacteria that have been associated with lean body mass, health and longevity. These results were partially reversed after two weeks of a customary diet without strawberries.<sup>26</sup>

The research on digestive health is continuing. One of the objectives of a study currently underway at the University of California at Davis is to evaluate changes in the gut microbiota after habitual strawberry consumption to see the potential impact on cardiovascular health. The link between changes in the gut microbiome and cognitive health are being studied by researchers at the Illinois Institute of Technology and University of Cincinnati.



# ENDNOTES

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California Strawberry Commission  
P. O. Box 269 | Watsonville, CA 95077  
p. 831.724.1301 | f. 831.724.5973  
[www.CalStrawberry.com](http://www.CalStrawberry.com)  
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