

## **The Return of the Good Egg**

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### **SUMMARY**

Cardiovascular diseases (CVD) are the leading causes of death in most industrialized countries of the world. Researchers have shown that cigarette smoking, high blood pressure, and high cholesterol levels in the blood, put people at greater risk for such diseases. There are many factors that lead to increased cholesterol levels in the blood.

For example, the greater the amount of saturated fats consumed, the higher the levels of LDL (low density lipoprotein, "bad" cholesterol) found. [Saturated fats come from products such as dairy, meat, poultry, palm, coconut and certain vegetable oils. These products are usually semi-solid or solid at room temperature. There is a good deal of evidence that they stimulate the production of LDL.]

Another factor that medical professionals tend to focus on, is how much cholesterol is in one's diet. However, when one reviews the medical literature (1) there is little evidence to support a relationship between cardiovascular disease risk, and the amount of cholesterol consumed.

### **Introduction**

Cardiovascular diseases (CVD) are the leading causes of death in most industrialized countries of the world. Cigarette smoking, high blood pressure, and high blood cholesterol levels are major risk factors for CVD, and a number of public health intervention programs to lower CVD risk are directed at these risk factors. The population approach to lowering an elevated plasma cholesterol level is based on dietary modifications, primarily reductions in total fat, saturated fat, and cholesterol. While the evidence is clear that high intakes of saturated fat significantly increases plasma cholesterol levels, especially plasma levels of low density lipoprotein (LDL, the "bad" cholesterol), the relationship between cholesterol in foods and cholesterol in the blood has never been conclusively established and remains a topic of considerable debate.

Over the last two decades a large number of clinical studies and epidemiological surveys investigating the relationships between dietary cholesterol and CVD risk indicate a null relationship between cholesterol in the diet and CVD incidence (1). It has become clear that excluding high cholesterol foods from the diet, such as eggs, has little beneficial effect on CVD risk and may, in fact, have a negative impact on the nutritional quality of the diet. As the cholesterol stigma becomes less of an issue for eggs, the attention of nutritionists has shifted from the old negative messages to a more modern emphasis on the multiple contributions of eggs to the nutritional value of the diet (2).

### **Historical Background**

For over 30 years, many dietary guidelines have included a recommendation limiting dietary cholesterol to less than 300 mg per day. This recommendation was based on three lines of experimental evidence: animal studies indicating that dietary cholesterol raises blood cholesterol resulting in atherosclerosis; epidemiological survey data suggesting a relationship between dietary cholesterol, plasma cholesterol and CVD; and clinical trials showing that cholesterol intakes modified plasma cholesterol concentrations. These three experimental relationships were the basis for dietary cholesterol restrictions in the 70's; however, today there is a substantial body of evidence challenging the theoretical relationship between dietary cholesterol and CVD.

Animal studies are compromised by two factors: extreme doses of cholesterol to achieve hypercholesterolemia in some animals versus extreme sensitivity to dietary cholesterol of other animals, and the species specific, non-human-like plasma lipoprotein profiles of most animal models. Most animals have high density lipoprotein cholesterol (HDL, "good" cholesterol) as the major plasma lipoprotein whereas humans are predominantly a LDL cholesterol species with differing patterns of responses to dietary lipids. Animal studies provide little evidence that dietary cholesterol is a factor in atherosclerosis.

Epidemiological studies using simple correlations for statistical analyses of the data do suggest that dietary cholesterol is positively related to plasma cholesterol levels and CVD incidence. However, due to the co-linearity of dietary cholesterol with dietary saturated fat, this is an inappropriate method for data analysis and requires use of multiple correlation analyses which indicate that dietary cholesterol is not significantly related to CVD (3). No epidemiological study reported in the 90's has found a positive relationship between dietary cholesterol and CVD incidence when using multiple regression analyses.

Over the last 40 years there have been more than 166 clinical feeding studies of the effect of dietary cholesterol on plasma total and lipoprotein cholesterol levels. Meta-analyses of data from these clinical feeding studies have shown that dietary cholesterol does have a small, and barely measurable effect on plasma cholesterol levels in humans (4-6). The data indicate that the average plasma cholesterol response to a change in dietary cholesterol is between 0.022 and 0.025 mg/dl per mg/day cholesterol. Thus, adding 100 mg per day of cholesterol to the diet would be predicted to increase the average plasma cholesterol level by approximately 1%. This effect appears to be independent of other dietary factors such as dietary fat type and

amount, and does not differ between those with normal and high initial plasma cholesterol concentrations.

### **Cholesterol Research in the 90's**

Analysis of cholesterol feeding studies (166 studies in 3,498 individuals) indicates that the plasma total cholesterol response to dietary cholesterol is 0.023 mg/dl per mg/day cholesterol (7). Of this effect, 0.019 mg/dl is in the LDL cholesterol fraction and 0.004 mg/dl in the HDL cholesterol fraction. The data indicate that dietary cholesterol increases both atherogenic LDL and anti-atherogenic HDL with little effect on CVD risk because the LDL:HDL ratio, a major determinant of CVD risk, is unaffected. For example, a person with a total cholesterol of 240 mg/dl and an HDL cholesterol level of 45 mg/dl who adds one egg a day (200 mg of cholesterol) to their diet would increase their plasma total cholesterol by 5 mg/dl, their LDL cholesterol by 4 mg/dl, and their HDL cholesterol by 1 mg/dl. Based on these changes, the LDL:HDL ratio would remain the same at 3.67 and, since the LDL:HDL ratio does not change, their risk of heart disease would not change. It is this absence of a dietary cholesterol effect on the LDL:HDL ratio which explains the findings from epidemiological surveys that dietary cholesterol is unrelated to CVD risk.

Evidence from many studies show that some individuals are genetically predisposed to a greater plasma cholesterol response to dietary cholesterol. Data indicate that approximately 20% of the population exhibits this hyper-response to dietary cholesterol while 80% of the population has an attenuated (hypo-responder) plasma cholesterol response to dietary cholesterol. The plasma cholesterol changes seen in hyper-responders to dietary cholesterol (0.039 mg/dl per mg/day cholesterol) is almost 3-fold that of hypo-responders (0.014 mg/dl per mg/day cholesterol) (7). What this means is that a 200 mg/day change in dietary cholesterol (an egg a day) would increase plasma cholesterol levels by 8 mg/dl in the 20% of the population who are hyper-responders and only 3 mg/dl in the remaining 80% of the population who have a low response.

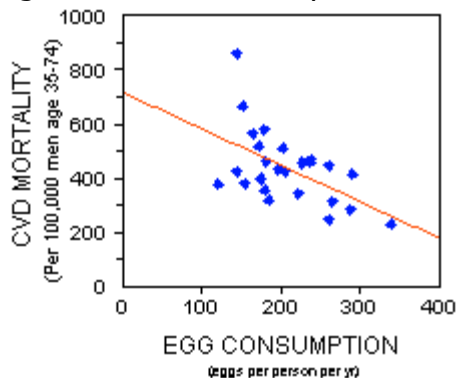
### **Epidemiological Surveys**

The April 21<sup>st</sup> issue of the Journal of the American Medical Association reported a study by Hu and colleagues ((8) from the Harvard School of Public Health which found no relationship between egg consumption and CVD in a population of over 177,000 men and women. There was no difference in heart disease risk between those who consumed less than one egg a week and those who ate more than one egg a day. The investigators followed 80,082 women for 14 years and 37,851 men for 8 years and related the incidence of fatal and non-fatal coronary heart disease, and stroke incidence to daily egg consumption. Weekly egg consumption was unrelated to CVD risk. The authors concluded that "These findings suggest that consumption of up to 1 egg per day is unlikely to have substantial overall impact on the risk of CHD or stroke among healthy men and women."

This is only one of many recent reports showing that egg consumption, and dietary cholesterol intakes are unrelated to either hypercholesterolemia or CVD incidence. These Harvard investigators also reported that dietary cholesterol was not related to coronary heart disease relative risk in both the Nurses' Health Study (9) and the Health Professionals Follow-Up Study (10). Similar findings of a non-

significant relationship between dietary cholesterol and CVD risk have been reported from the Lipid Research Clinics Follow-Up Study (11), the Framingham Heart Study (12), and the Alpha-Tocopherol, Beta-Carotene Cancer Prevention Study (13). Data from the Multiple Risk Factor Intervention Trial (MRFIT) reported an inverse relationship between dietary cholesterol intakes and plasma cholesterol levels at baseline as well as an inverse relationship between egg consumption and plasma cholesterol levels (14).

The findings from these epidemiological surveys are consistent with other findings as well. An analysis of the relationship between per capita egg consumption



(data from the International Egg Commission) and cardiovascular mortality rates in 24 countries (data from the World Health Organization) indicates a significant, and negative relations ( $r = 0.54$ ,  $P = .0053$ ). Three of the highest egg consuming countries in the world are Japan, Spain and France; countries which also have the lowest rates of CVD mortality. While such simple correlation analyses do not consider the many dietary differences between these countries, it shows that eggs are not a contributor to CVD

risk.

### **Eggs: Nutritional Powerhouses**

The emphasis on the cholesterol content of eggs has obscured the many valuable nutrient contributions eggs make to the diet. Research has put a new emphasis on this message and expanded it beyond the high quality protein and the nutrient density story to one involving phytochemicals and value added antioxidants and fatty acids.

### **Carotenoids: lutein and zeaxanthin**

Lutein and zeaxanthin are two terms in the news lately, and consumers are seeing more and more products touting the fact that they contain added lutein. Why are these carotenoids so important all of a sudden? Research shows that they may be very important in reducing the risk of cataracts and age-related macular degeneration (15) as well as cardiovascular disease (16). Age-related macular degeneration is a leading cause of vision loss in the United States and affects up to 30% of those over age 75.

The carotenoids lutein and zeaxanthin accumulate in the macular region of the eye and are thought to help protect the eye from damage due to ultraviolet radiation. Some studies suggest that high intakes of lutein and zeaxanthin from foods like spinach and broccoli help reduce the risk of cataracts and age-related macular degeneration. There is a clear relationship between high levels of lutein in the blood and lutein in the macula of the eye.

Both lutein and zeaxanthin are found in egg yolks. On average, eggs in the US have 30  $\mu\text{g}/100\text{ g}$  lutein and 25  $\mu\text{g}/100\text{ g}$  zeaxanthin. [The lutein and zeaxanthin content of eggs is highly variable and dependent upon the feed used.] Not only are

they found in egg yolks but studies show that the bodies ability to utilize the lutein and zeaxanthin from egg yolks is better than from green leafy vegetables. Studies show that adding 1.3 egg yolks per day to the diet significantly increases blood lutein and zeaxanthin levels by 38% and 128% respectively (17). Based on available data, this increase would be predicted to lower overall risk for age-related macular degeneration. In fact, data from the Beaver Dam Eye Study indicated that egg consumption was inversely associated with cataract risk in study participants who were younger than 65 years of age when the study started (18). The relative risk of cataracts was 0.4 for people in the highest category of egg consumption compared to a risk of 1.0 for those in the lowest category. These studies provide solid evidence that egg consumption has beneficial effects on the aging eye and that egg restrictions in the elderly deprive them of a nutrient dense, low calorie food which is a good source of two important xanthophylls.

### **Choline and Phospholipids:**

Another hot new nutrient is choline and the phospholipid in eggs, lecithin, also known as phosphatidylcholine, is an excellent source of dietary choline. The National Academy of Sciences recently recognized choline as an essential nutrient with a recommended adequate intake (AI) for men, women and children. The AI for children ranges from 125 mg per day in new borns up to 375 mg per day in young children. For adults the AI values are 425 mg per day for women and 550 mg per day for men. Pregnant and lactating women are advised to increase their choline intakes. A large egg has 215 mg of choline, almost 50% of the recommended AI (19).

Studies in animals indicate that choline plays essential roles in the development of brain function and in memory. Choline supplementation during gestation in rats leads to augmentation of spatial memory in adulthood. Other studies extend the description of long-term functional enhancement produced by perinatal choline supplementation to include the ability to use and remember visual configural associations, working spatial memory, and to relate these effects to modifications in cholinergic basal forebrain systems (19). Data also indicate that dietary choline treatment can render new long-term memories less susceptible to disruption following training.

The administration of phosphatidylcholine to mice with dementia improved memory and generally increased brain choline and acetylcholine concentrations to or above the levels of the control normal mice. Serum choline concentration in mice treated with phosphatidylcholine increased to a similar level in both strains of mice, indicating that the absorption of phosphatidylcholine was not impaired in mice with dementia. The results suggest that administration of egg phosphatidylcholine to mice with dementia increases brain acetylcholine concentration and improves memory

These studies all indicate that dietary sources of choline play an important role in brain development and function. And eggs are an excellent source of dietary choline without a high fat intake. Choline experts have even recommended that pregnant women and lactating mothers increase their egg intake to assure optimal dietary choline intake.

## Summary

The egg nutrition news in the 90s has been extremely positive addressing both the dietary cholesterol - heart disease issue and the valuable contributions of eggs in the diet (2). Both clinical and epidemiological studies continue to show that eggs have little effect on plasma cholesterol levels and are unrelated to heart disease risk. The findings that dietary cholesterol raises both LDL and HDL cholesterol levels with no negative effects on the LDL:HDL ratio fits with the findings from epidemiological trials showing that egg consumption does not alter heart disease risk. The data fully support the view that "an egg or two a day really is okay." Even the American Heart Association has taken notice of the evidence that cholesterol from eggs is not a risk for heart disease and accordingly the American Heart Association's new 2000 dietary guidelines now permit an egg a day, rather than only three a week (20).

As the dietary cholesterol question becomes less of an issue, emphasis can now shift towards the valuable role eggs play in a nutritious and healthful diet. Studies defining the contributions eggs make to the nutrient value of the diet in low-income families, the elderly, and socioeconomic sub-sets of the population become increasingly important (21). As new studies document the value of eggs in the diet, the cholesterol argument against eggs becomes less important. The finding that egg yolk carotenoids can potentially be an effective preventive strategy against age-related macular degeneration adds an important health benefit to other nutritional benefits of eggs. Nutrition research continues to change attitudes about the role of eggs in a healthy diet. Eggs are beginning to lose their status as the visual icon of too much fat, too much cholesterol in the diet and moving towards its earlier image as an important dietary constituent with quality, affordability, and nutrient value.

[For more information and details, visit the Egg Nutrition Center web site at [www.enc-online.org](http://www.enc-online.org).]

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