

Egg consumption and cardiovascular health

Yumurta tüketimi ve kardiyovasküler sağlık

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Egg has been accepted as a symbol of high cholesterol diet for years and its consumption has been a matter of debate for cardiovascular health. Clinical studies have yielded conflicting results, increasing the amplitude of arguments. This article reviews the current literature related to egg consumption and summarizes the merits and demerits of egg consumption on a scientific basis. Current guidelines recommend restricting dietary cholesterol consumption to 200 mg daily for cardiovascular health. Therefore, when making dietary suggestions especially for patients with cardiovascular disease, diabetes, severe risk factors and hypercholesterolemia, or a family history of premature atherosclerosis, we should keep in mind that an average egg yolk contains >200 mg cholesterol even though its negative effect on serum lipid levels is less than that of other sources of dietary cholesterol.

Key words: Cholesterol, dietary; coronary disease; diet; eggs; risk factors.

The recent increase in the “egg has been acquitted” debate in the media has been governed on a non-scientific basis. We believe that the best response to the many concerns and misconceptions created by certain remarks should be provided on a scientific basis. This article has therefore it led us to review the literature about egg consumption.

For the past 40 years, egg has been regarded as a symbol of cholesterol, that is, a dietary habit which is hazardous for heart health. This opinion should not be overlooked considering the cholesterol content of an average egg yolk (216-275 mg).^[1] As it is well known, epidemiological data indicate that increased intake of dietary cholesterol is associated with an increased risk of coronary heart disease (CHD), independently of plasma cholesterol levels.^[2] As it is shown in the Seven Countries Study, many previous studies have demonstrated that there is an association between serum cholesterol levels and CHD, and that

Yumurta, yıllardır kolesterolü yüksek beslenmenin sembolü olarak kabul edilmiş ve tüketimi kardiyovasküler sağlık açısından tartışma konusu olmuştur. Özellikle de klinik araştırmalarda çelişkili sonuçlar bildirilmesi bu tartışmaları daha da artırmıştır. Bu derlemede yumurta ile ilgili güncel literatür gözden geçirilerek, bilimsel açıdan yumurtanın yarar ve zararları özetlenmiştir. Kardiyovasküler sağlığı korumaya yönelik bir diyetle, güncel kılavuzların önerdiği şekilde kolesterol tüketiminin günde 200 mgr ile sınırlanması gerekmektedir. Bu nedenle de, başta kardiyovasküler hastalığı olanlar, diyabetik hastalar, hiperkolesterolemi ve ciddi risk faktörleri olanlar ile ailesel erken ateroskleroz öyküsü bulunan hastalara sağlıklı beslenme önerilerinde bulunurken, diğer kolesterol kaynaklarına göre kan lipid düzeylerine olumsuz etkisi daha az olsa da, bir yumurta sarısının >200 mgr kolesterol içerdiği unutulmamalıdır.

Anahtar sözcükler: Kolesterol, diyet; koroner hastalık; diyet; yumurta; risk faktörü.

the risk of CHD can be reduced by various treatments in patients with high blood cholesterol levels.^[3] Likewise, it has been shown that Japanese who consumed a diet low in cholesterol had increased blood cholesterol levels and the risk of CHD when they changed their dietary habits following their immigration to Hawaii and San Francisco.^[4] Experimental animal studies also demonstrated that a diet rich in cholesterol led to atherosclerosis.^[5]

In respect of these data, The American Heart Association (AHA) has recommended limiting average daily cholesterol intake to <300 mg in order to prevent the risk of increased blood cholesterol and thereby CHD (AHA step I diet). With respect to secondary prevention, AHA limited the average daily cholesterol intake to 200 mg in the step II diet.^[6] The public has also been warned against the consumption of egg yolk which contains a high amount of cholesterol. However, the effect of egg consumption on LDL-Cholesterol (LDC-C) level

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and cardiovascular health is being discussed widely in recent years. Inadequate methodology employed in dietary studies on egg consumption, together with lack of clarity on the subject has led to several misconceptions and misinterpretations.

The effect of egg consumption on blood lipid levels

One of the starting points of these debates is based on the extent of the effect of egg consumption on serum cholesterol levels. An average of 100 mg daily increase in dietary cholesterol intake leads to a 2-3 mg increase in total cholesterol level, with a 70% fraction consisting of LDL-C.^[7] Given the fact that the cholesterol content of an average egg yolk is approximately 220 mg, it can simply be estimated that consumption of an egg yolk would lead to a 4.4 to 6.6 mg increase in total cholesterol level and a 3 to 4.6 mg increase in LDL-C. In addition, controlled metabolic studies has shown that cholesterol intake by consuming an egg yolk or the whole egg increases blood LDL-C level.^[8,9] However, the only difference between the groups in most of these studies has been the amount of cholesterol when comparison was made between the subjects who consumed and those who did not consume eggs in terms of consumption of other nutritional components including fatty acids, carbohydrates and protein. As a result, it is not possible for these studies to evaluate the effect of egg consumption on blood fats in real life.

In addition, varied effects of dietary cholesterol intake on blood cholesterol levels may be observed depending on the individual subject (there are data suggesting that one third of communities have a genetically high response rate to dietary cholesterol), and these effects may be attenuated under higher levels of dietary cholesterol intake.^[1,10] For instance, addition of egg to the American diet which is higher in cholesterol and saturated fat may not affect the blood cholesterol level, whereas it may affect the blood cholesterol level in the Mediterranean diet or vegetarian diet which are lower in cholesterol and saturated fat. In a randomized study, the daily addition of an egg to the standard lactovegetarian diet with a very low cholesterol intake (97 mg/day) increased the LDL-C level to 12% ($p < 0.05$).^[11] A meta-analysis of controlled metabolic studies found an association between pre-study cholesterol intake and cholesterol intake added to diets in terms of serum cholesterol response.^[9] In other words, the higher the amount of dietary cholesterol intake, the less the blood cholesterol level is affected by addition of cholesterol with diet.

Another characteristic of egg is its relatively low content of saturated fatty acids. As it is well-known, dietary cholesterol intake added to the diet increases the blood LDL-C less than saturated fats. Therefore the effect of foods such as eggs, shrimps, and mussel with a high cholesterol content which are relatively low in saturated fats, on LDL-C level is lower than the effect foods such as meat, butter, etc. which are high in saturated fats and cholesterol.^[12]

On the other hand, the simultaneous increase in the effect of eggs on HDL-Cholesterol (HDL-C) level is also well known and its augmentation effect on blood cholesterol is thought to balance its effect on HDL-C. However, a meta-analysis of 17 studies (556 subjects) conducted on eggs between 1974-1999 demonstrated that a 100 mg increase in daily dietary cholesterol intake led to 0.020 units increase in the total cholesterol/HDL cholesterol ratio (95% CI: 0.010-0.030); a 2.2 mg/dL increase in total cholesterol concentration (95% CI 1.8-2.5 mg/dL) and a 0.008 units 0.3 mg/dL increase in HDL-cholesterol levels (95% CI: 0.2-0.4 mg/dL).^[13] Increased dietary cholesterol has an adverse effect on lipid profile since it leads to an increase in total cholesterol/HDL cholesterol ratio. Similarly, a study investigating the effect of the addition of eggs to a basal low-fat diet on lipid profile in normolipidemic subjects showed that a 581-calorie cholesterol diet consisting of a twice-daily-egg program increased both LDL-C and HDL-C levels; however, the LDL-C/HDL-C ratio increased since there was a higher increase in LDL-C level compared to HDL-C level (7.6% vs. 10.2%, $p = 0.0001$).^[12] As a result, investigators concluded that the concept suggesting limiting the consumption of foods rich in cholesterol including eggs was still valid. Indeed, the quality of the HDL-C is also as important as the quantity in determining cardiovascular risks. It is therefore also important to increase immature (small) HDL-C particles as well as HDL-C level. Likewise, IDEAL and EPIC-Norfolk studies showed that high HDL-C levels did not have any protective effect on cardiac health and that they might constitute additional risk when apoA-I and apoB levels were corrected.^[14] Changes in HDL-C have been markedly evaluated and investigated in studies on eggs. Therefore, the possibility that increases in HDL-C levels with egg consumption may be beneficial in heart protection, is questionable.

Other benefits of the egg

Egg is a rich source of high quality protein which contains all essential amino acids for the human body as

well as vitamin B complex, folic acid and fat soluble vitamins (A, D and E). It is also a rich source of minerals such as iodine, zinc, calcium and iron. As a result, it is an important nutrient for children in the rapid growth and developmental stage of life. In addition, it is also important in meeting the protein requirement for pregnant and breastfeeding women. Egg is also considered to be preventive against cataract and age-related macular degeneration due to its high content of two carotenoids (lutein and zeaxanthin).^[15] Another important characteristic of an egg is its low carbohydrate content; there are approximately 55 calories in an egg and it has the capacity of preventing hunger for a long time. Consequently, egg is an indispensable part of a slimming diets which is applied for balanced weight loss.^[16] Considering all these characteristics, the harmful effects of the cholesterol content of an egg are considered to be balanced by the beneficial effects of its other beneficial contents, leading dieticians to recommend egg consumption in place of other cholesterol sources. Being cheap also leads to increased consumption. Despite its cholesterol-increasing effect it is also considered to be protective against atherosclerosis due to the high content of antioxidant vitamins.

Egg and cardiovascular risk

The understanding that egg consumption did not increase blood LDL-C level as expected led to misinterpretation by many of our colleagues suggesting that egg was not harmful, that it insignificantly increased blood cholesterol level, and that patients with heart diseases might consume eggs as desired. This can be explained by the updated version of NCEP ATP III Guidelines published in 2004 where it was stated that a 30 mg increase in LDL-C level led to 30% increase in the risk of CHD.^[17] Given the fact that LDL-C level can be increased 3-5 mg by an egg, it can be estimated that daily egg consumption may increase the CHD risk to up to 3% to 5%.

On the other hand, it is suggested that the increased rate of CHD risk increases with an increase in the level of blood cholesterol. For instance, CHD risk increased from grade I to grade II (one grade) when total cholesterol level increased from 200 mg/dL to 250 mg/dL, while the risk increased from grade II to grade IV (2 grades = 2-fold) when total cholesterol level increased from 250 mg/dL to 300 mg/dL.^[18] This indicates that diet becomes of more importance when cholesterol levels increase.

Despite these data on dietary cholesterol and LDL-C levels, the effect of egg consumption on the development of cardiovascular events has not been adequately

demonstrated. This may be explained by insufficient number of studies in this area and the ineffective methodologies used. In particular, it is not possible to standardize consumption of the other dietary sources of cholesterol and saturated/unsaturated fatty acids, carbohydrates and antioxidant vitamins between the groups based only on comparison of egg consumption. As a result, this reality should be taken into consideration when interpreting the results of these studies.

No association was found between egg consumption and CHD incidence in the Framingham study.^[19] Another case-control study involving female patients in Italy also showed no association between egg consumption and CHD risk.^[20] On the other hand, a study conducted in California (the Seventh Day Adventists) found that increased egg consumption was associated with increased risk of fatal CHD. This result, however, was not obtained in the second longer term analysis.^[21] No association was found between egg consumption and CHD incidence in the joint analysis of the Nurses' Health Study with a 14-year follow-up period and the Health Professionals Follow-up Study involving 117,933 cases conducted in USA.^[22] Depending on the frequency of egg consumption (<1/week, 1/week, 2-4/week, 5-6/week and >1/day), the CHD risk was established as 1.0, 1.06, 1.12, 0.90 and 1.08 ($p < 0.75$) respectively for men, and 1.0, 0.82, 0.99, 0.95 and 0.82 ($p < 0.95$) respectively for women, in the analysis. Lack of any association between egg consumption and CHD risk in these studies led to an impression suggesting that there was generally no link between egg consumption and heart diseases. However, dietary habits were evaluated based only on the questionnaire without any standardization for the dietary components, although these are prospective studies. Nevertheless, ≥ 1 daily egg consumption was associated with increased risk of cardiovascular diseases in patients who developed diabetes during the follow-up in both studies.

In 2008, an unfavorable data was added to this controversial topic. a total of 1084 patients were observed to develop heart failure during a 20-year follow-up in the Physicians Health Study including a cohort of 21,275 subjects.^[23] In the analysis of the dietary questionnaire in respect to the relationship between egg consumption and heart failure (HF), no association between egg consumption of up to 6 weekly and the development of HF was found. However, it was shown that the risk of HF increased by 28% and 64% in individuals who consumed one and ≥ 2 eggs daily, respectively. Similar results from the relationship between egg consumption and HF were also obtained in individuals with previous myocardial infarction (MI). Another

study involving 514 Western Australian Aborigines who were followed over 14 years demonstrated that the risk of CHD increased 2.6-fold in individuals who consumed ≥ 2 eggs weekly compared to those who consumed < 2 eggs weekly.^[24] In addition, data obtained from the Health Professionals Follow-up Study involving 37,851 diabetic men showed that the risk of CHD increased 2-fold in individuals who consumed ≥ 1 egg daily after adjusting many factors having the potential to affect the risk.^[22] These data suggest that the risk of HF may increase due to the risk of CHD which is associated with egg consumption. Likewise, plasma LDL-C level has also an effect on the development of hypertension and myocardial infarction which are the major risk factors for HF.

The extensive Japan Public Health Study on egg consumption which included 90,735 subjects (cohort I: 19,856 men, 21,408 women and age range 40-59; cohort II: 23,463 men, 26,008 women and age range 40-69) demonstrated no association between egg consumption and CHD, although there was a link between total cholesterol level and the development of CHD in the follow-up period from 1990-1994 to 2001.^[25] However, individuals with hypercholesterolemia were observed to refrain from egg consumption. The NIPPON DATA80 study also conducted in Japan including 5186 women and 4077 men within a 14-year follow-up period found that the levels of total cholesterol was directly proportional to egg consumption. Although significant results were not obtained from the male subjects in the study, mortality rate due to ischemic heart disease and all-cause mortality rate were observed to increase with egg consumption in the female subjects: Based on egg consumption, assessment of mortality due to heart diseases was divided into 5 groups including > 2 /day, 1/day, 1/2 day, 1-2/week and rarely. Mortality rate due to heart disease was 1.1, 0.5, 0.4, 0.5 and 2.0/1000 person-years, respectively ($p=0.008$), and the all-cause mortality rate was 14.8, 8.0, 7.5, 7.5 and 14.4/1000 person-years, respectively ($p<0.0001$).^[26]

In consideration of all results of the studies on the association between egg and CHD, the American Heart Association and NCEP Guidelines recommend limiting average daily dietary cholesterol intake to less than 200 mg/dL, although no specific recommendations are made on egg consumption for cardiovascular prevention. The situation would clearly be understood given the fact that an average egg yolk also contains at least 200 mg/dL of cholesterol. Indeed, any physician who is informed about this fact has probably not forbidden any body from egg consumption. However, it is reasonable to recommend limiting average daily dietary cholesterol intake to less than 200 mg/dL for individuals at high

risk of cardiovascular disease or family history, patients with diabetes and hypercholesterolemia.

In conclusion, there is no objection by any person concerning egg consumption for those in the growth and developmental stage of life and adults who do not have any cardiovascular diseases and major risk factors. However, based on current guidelines, it is recommended limiting average daily dietary cholesterol intake to less than 200 mg/dL for individuals with cardiovascular diseases, diabetes, hypercholesterolemia, family history of premature atherosclerosis, and major risk factors. Hence, when making dietary recommendations, it should be kept in mind that an average egg yolk contains > 200 mg/dL of cholesterol although its negative effect on serum lipid levels is less than that of other sources of dietary cholesterol.

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