An Overview of the Nutritional Role of Eggs in the Diet

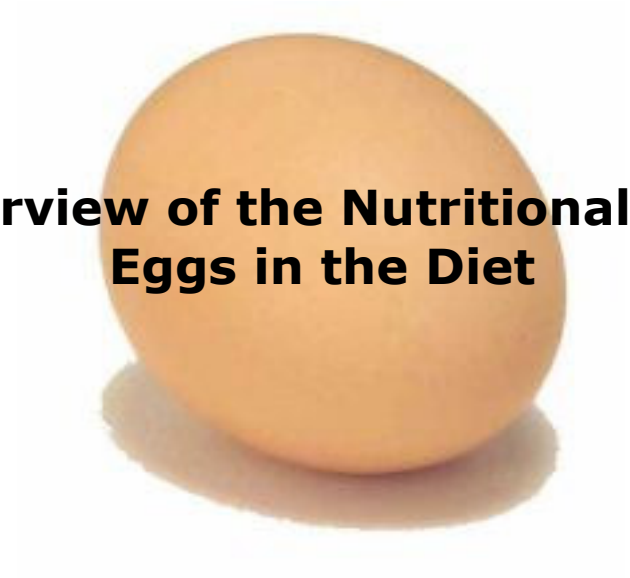

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Table of Contents

Abbreviations

CHD	Coronary Heart Disease
CHO	Carbohydrate
CVD	Cardiovascular Disease
DHA	Docosahexaenoic acid
EFSA	European Food Safety Authority
EPA	Eicosapentaenoic acid
FSA	Food Standards Agency of the United Kingdom
FSAI	Food Safety Authority of Ireland
GI	Glycaemic Index
HDL	High Density Lipoprotein
IUNA	Irish University Nutrition Alliance
kCal	Kilocalories
LDL	Low Density Lipoprotein
LNA	Linolenic Acid
NCFS	National Children's Food Survey
NDNS	National Diet and Nutrition Survey
NSIFCS	North South Ireland Food Consumption Survey
NTD	Neural Tube Defect
PCB	Polychlorinated biphenyls
PUFA	Polyunsaturated Fatty Acid
RDA	Recommended Daily Allowance
RNI	Recommended Nutrient Intake
SD	Standard Deviation
Se	Selenium

Nutrition Value of Eggs

Hen's eggs have been used as a food by human beings since antiquity. Compared with the egg, no other single food of animal origin is eaten by so many people all over the world and none is served in such a variety of ways (Surai & Sparks, 2001). As well as being highly popular, eggs are a highly nutritious food. One large egg provides 6.5g of protein; about half of this protein is in the egg white. Egg white is considered an ideal protein- the one by which all others are measures- because it contains all the essential amino acids in correct proportions for human nutrition (Meister, 2002). However, protein is found in both the white and the yolk. Of the total fat in eggs, over half is unsaturated fat. Eggs are also a significant source of iron, riboflavin, folate and vitamins B12, D and E. The iron in egg yolks, like the iron in meat, is highly bioavailable; therefore eggs may be an important source of iron in the diet of individuals who are deficient in iron and also lacto-ovo-vegetarians. Most of the nutrients found in eggs are found in the yolk. The yolk contains all the fat-soluble vitamins (A, D and E) and most of the other vitamin and minerals. About the only nutrient not found in egg is vitamin C. In a survey in the USA, it was shown that eggs contributed 10-20% of daily intake of folate and 20-30% of daily intake of vitamins A, E and B12 (Song & Kerver, 2000). Data from the NHANES III study showed that intakes of many nutrients were higher among egg eaters than among people who don't eat eggs, and that egg eaters were less likely to have diets that were inadequate in various nutrients (Song & Kerver, 2000). In the newly published food pyramid by the Health Promotion Unit of the Department of Health and Children (Health Promotion Unit, 2005) eggs are part of the protein rich food group "Meat, Fish, Eggs and Alternatives". Two portions of this food group are recommended per day. One egg is equivalent to one ounce of meat.

Table 1: Composition of an egg

Nutrient	Quantity per egg[1]	Daily Requirement[2]	% of daily requirement
Calories	76 kcals	2500kcals	3%
Total fat	4.7g		
Saturated fat	1.6g		
Cholesterol	196mg	300mg	65%
Protein	6.5g	52.5g	12%
Vitamin A	95 *u*g	700ug	14%
Vitamin D	0.9ug	0-10ug	
Vitamin E	0.56mg		
Vitamin B12	1.25ug	1.4ug	90%
Vitamin B6	0.06mg	0.79mg	8%
Folate	25ug	300ug	8%
Thiamin	0.05mg	1.1mg	5%
Riboflavin	0.24mg	1.6mg	15%
Phosphorous	100mg	550mg	18%
Zinc	0.65mg	9.5mg	7%
Iron	0.95mg	10mg	10%
Selenium	0.55ug	55ug	1%
Choline	280mg**		
Lutein	150-250mg**		
Zeaxanthin	200mg**		

[1] Average weight of egg is 50g (based on Food Portion Sizes published by the Ministry of Agriculture, Fisheries and Food, 2nd Edition 1997). The composition of an egg is based on analysis published in McCance & Widdowson's, the composition of foods, 6th edition. **No data on the content of these compounds in eggs were available in McCance and Widdowson's 2002, therefore were taken from the literature (Meister, 2002).

[2] Requirements of an adult male based on the Recommended Dietary Allowances for Ireland 1999. Food Safety Authority of Ireland.

Nutrients in detail

1. Macronutrients

Calories

An average egg has an energy value of 76 kilocalories and the consumption of one egg daily would contribute only 3% of the average requirement of an adult man and only 4% for an adult woman. Due to the low calorie content of eggs and the large amount of nutrients they provide they are often referred to as nutrient dense foods. A nutrient dense food is one that provides a relatively high proportion of a person's daily need of essential nutrients while supplying only a small proportion of the daily need for calories. For good nutrition, most of a person's daily food intake should consist of nutrient dense foods. Although eggs are not an unusually rich source of any one nutrient they provide substantial amounts of a range of nutrients and therefore can be termed a nutrient dense food.

Cholesterol

Cholesterol and lecithin are fat-like substances and are essential to the structure and function of all cells in the body. Cholesterol helps to maintain the flexibility and permeability of cell membranes and is also a raw material for the fatty lubricants that help to keep the skin supple. Cholesterol is essential for the production of sex hormones, cortisol, vitamin D and bile salts. Lecithin is involved in general lipid transportation in the blood and in the metabolism of cholesterol

Protein

Eggs are an excellent source of protein. Egg protein is of high biological value as it contains all the essential amino acids needed by the human body (www.nutritionandeggs.co.uk). Eggs therefore complement other food proteins of lower biological value by providing the amino acids that are in short supply in those foods. 12.5% of the weight of the egg is protein and it is found in both the yolk and the albumen. Although protein is more concentrated around the yolk, there is in fact more protein in the albumen.

2. Micronutrients

Vitamin A

Vitamin A is essential for vision in dim light, for maintenance of mucous membranes and for skin and growth. It sources include egg yolk, fortified margarine, butter, milk, liver and fatty fish. Deficiency can lead to reduced night vision, loss of sight through gradual damage to the comea and lowered resistance to infection. As vitamin A is fat-soluble and not excreted in the urine excess is stored in the liver and toxicity can occur (www.nutritionandeggs.co.uk).

Vitamin D

Vitamin D promotes calcium and phosphate absorption from food and is thus essential for bones and teeth. Sources include egg yolk, sunshine, oily fish, fortified margarine and breakfast cereals. Deficiency can lead to failure of bones to grow and calcify leading to rickets in children and osteomalacia in adults.

Again vitamin D is fat-soluble and excess can be toxic (www.nutritionandeggs.co.uk).

Vitamin E

Vitamin E acts as an antioxidant in the body and protects cell membranes from damage by oxidation. Sources include egg yolk, vegetable oils, nuts, vegetables and cereals. Deficiency can occur in premature infants or due to malabsorption. Excess effects are unknown (www.nutritionandeggs.co.uk).

Vitamin B12

Vitamin B12 is necessary for the proper formation of blood cells and nerve fibres. Rich sources are offal and meat, egg and milk. Deficiency leads to pernicious anaemia. There are no toxic effects from excess known (www.nutritionandeggs.co.uk).

Vitamin B6

Also known as pyridoxine, vitamin B6 is involved in the metabolism of protein. It is found in a variety of foods including beef, fish, poultry and eggs. Deficiency may occur as a complication of disease and drug effects (www.nutritionandeggs.co.uk).

Thiamin

Thiamin or vitamin B1 is involved in the release of energy from carbohydrates. It is important for the brain and nerves, which use glucose as their energy source. Along with eggs, sources include cereals, nuts and pluses, green vegetables, pork, fruit

and fortified cereals. Deficiency leads to beriberi. Alcoholics can develop this deficiency. (www.nutritionandeggs.co.uk)

Folate

Folate is needed for the formation of red blood cells. It also reduces the risk of neural tube defects (NTD) in infants. Pregnant mothers should have adequate levels during the first trimester of pregnancy to reduce the risk of NTD's, UK Medical Research Council Vitamin Study, 1991). Deficiency in the general population can lead to megaloblastic anaemia. Rich sources of folate include liver, orange juice, dark green vegetables, while eggs contain a lesser amount.

Riboflavin

Riboflavin also known as B2 is involved in energy release, especially from fat and protein. Rich sources are liver, milk, cheese, yoghurts, eggs, green vegetables and yeast extracts. Deficiency includes changes in the mucous membrane and skin around the mouth and nose. The body excretes excess riboflavin and no adverse effects are presently known (www.nutritionandeggs.co.uk).

Iron

Iron is required for the formation of haemoglobin in red blood cells, which transport oxygen around the body. There are two forms of iron namely, haeme-iron (easily absorbed) and nonhaeme-iron (not as easily absorbed). Eggs contain haeme iron. The other main source of haeme iron is meat. A lack of

iron leads to lower iron stores in the body and eventually to iron deficiency anaemia (www.nutritionandeggs.co.uk).

Selenium

Selenium acts as an antioxidant in the body and protects against oxidative damage. There is increased research in selenium due to its hypothesized role in the prevention of certain degenerative diseases such as cancer and cardiovascular disease (Reilly, 1998). One egg can provide 55 µg of Selenium.

Zinc

Zinc is essential for growth, and sexual maturation. It is also involved in enzyme activity and wound healing and fighting infection. It is found in milk, cheese, meat, eggs, fish, and wholegrain cereals and pluses. Deficiency is rare and may cause delayed puberty and retarded growth. Excess can interfere with copper metabolism. (www.nutritionandeggs.co.uk)

Choline

Choline is a dietary component essential for normal functioning of all cells. It assures the structural integrity and signalling functions of the cell membrane; it is the major source of methyl-groups in the diet and it directly affects nerve signalling, cell signalling and lipid transportation/metabolism. Choline is a compound that is critical for brain and memory development in utero and early life (Applegate, 2000). In 1998, the National Academy of Sciences USA issued a report identifying choline as a required nutrient for humans. Eggs are an excellent source of choline (Zeisel, 2000).

Lutein and Zeaxanthin

Lutein and zeaxanthin are carotenoids found in egg yolk and accumulate in the macular region of the retina in the eye, where they may affect visual function (see section on the elderly) (Handleman et al., 1999).

Eggs and the lifestages

The nutrient density of eggs makes them a valuable contributor to the overall nutritional balance of the diet and an economical source of high quality protein. Eggs are an important component in the diets of the elderly, low income families, growing children and people limiting calories for weight loss purposes.

Infants:

Weaning of both breast-fed and formula-fed infants is usually recommended from 4-6 months of age. Although it is common to introduce iron-fortified cereals as a first food, this contrasts with more traditional weaning practices in which egg yolks and brains were used as first foods (Simopoulos & Salem, 1992). Iron stores in breast-fed infants become depleted by 6 months. Because breast milk is not a good source of iron, therefore iron rich weaning foods are considered important to avoid iron deficiency. Like meat, egg yolks contain both haeme and nonhaeme iron. Haeme iron is absorbed more efficiently than nonhaeme iron. Egg yolk is considered suitable for weaning infants because it contains some haeme iron, is small in volume, and has a soft texture suitable for weaning. A study was completed to investigate whether egg yolk in the weaning diet can influence iron status. The results of their trial indicated that it is possible and practical for weaning infants to consume 4 egg yolks / week without

affecting the intake of other foods such as cereals and meats. The egg yolk intervention resulted in modest improvements in iron status that may be most beneficial to infants who are iron deplete (Makrides et al., 2002).

In the same study infants were fed 4 egg yolks/week enriched with n-3 fatty acids which include docosahexaenoic acid (DHA) (Makrides et al., 2002). DHA has been shown to lead to short term improvements in visual and neural development of pre-term infants and biochemical data indicate that breast-fed infants accumulate DHA in the brain until >12 months and at a greater rate than infants formula fed without DHA. They concluded that n-3 fatty acid enriched eggs might provide a means of increasing dietary DHA during the second 6 months of life.

Childhood

The most commonly cited reason for delaying the introduction of whole eggs to infants is to avoid sensitising infants to egg white proteins and hence the development of egg-related allergies (Simopoulos & Salem, 1992). Like most food allergies, egg allergy is more common in childhood and about half the children who have it will grow out of it by the age of three (FSA, 2005). The main causes of egg allergy are three proteins in the white of eggs, ovomucoid, ovalbumin and conalbumin. Cooking can destroy some of these allergens, but not all, which means that some people may react to raw eggs and not cooked eggs. It is recommended that in atopic families (families in which one or more first-degree relative suffers from confirmed atopic disease such as asthma, rhinitis, eczema, urticaria or hay fever), breast-feeding should be encouraged and the introduction of complementary

foods, in particular allergenic foods (e.g. eggs, cow's milk), delayed (FSAI, 1999). Although there are few published controlled studies on the delayed introduction of selected foods the limited data suggest that a delay in introduction of allergenic foods (including eggs) would help in reducing the incidence of allergy (Chandra, 2002).

Adults

As eggs only contain 76 kilocalories per average egg they are useful in a calorie-restricted diet. As previously stated the consumption of one egg daily would contribute only 3% of the average requirement of an adult man and only 4% for an adult woman. Therefore they are a useful example of a low calorie food that provides large amounts of other nutrients. A lot of media attention has recently focused on the GI diet. The GI stands for the glycaemic index, which is a measure of the type or quality of carbohydrates in a particular food, and how fast 50 grams of this carbohydrate raises blood glucose levels, (and consequent insulin secretion and effects produced by the pancreas) as it is digested. As eggs contain no carbohydrates, they do not have a glycaemic index and are therefore useful in a low GI diet.

Pregnant Mothers

Pregnancy may be a time when dietary supplies of choline are especially limiting. During pregnancy large amounts of choline are delivered to the foetus across the placenta and this depletes maternal stores of choline. Two eggs per day contain approximately the dietary requirement for choline, and until more foods are analysed, pregnant women might want to include eggs in their diet (Zeisel, 2000).

Nursing Mothers

One study has shown that n-3 poly unsaturated fatty acids (PUFA) content can be increased in breast milk without altering the plasma content of cholesterol or triglycerides, when n-3 PUFA eggs are consumed. N-3 PUFA, especially DHA, is important in the developing nervous system of newborns and influences structural and functional parameters during rapid brain growth. The mothers in this study consumed 2 eggs/day enriched with n-3 PUFA (Cherian & Sim, 1996).

Elderly

Elderly people are reported to suffer from monotonous and poor diets and thus are often at risk of poor nutrition and health status. This can be attributed to changes in emotional and socio-economic status, decrease physical activity and decreased appetite and food intake, among others. Eggs may be a suitable highly nutritious food for the elderly as they are cheap, convenient and easy to prepare.. In the 'Nutrition Recommendations for Older People' produced by the Food Safety Authority of Ireland in 2000, there was no mention of including eggs as part of a healthy balanced diet. In contrast the Food Standards Agency in the UK has a specific section on nutrition for older people, which has plenty of references to eggs (www.eatwell.gov.uk/agesandstages/olderpeople). Also the carotenoids lutein and zeaxanthin found in eggs could help or even reverse the age related eye problem 'macular degeneration'. Macular degeneration is one of the leading causes of blindness in the western world, and occurs naturally as a consequence of the aging process. The macular portion of the eye is primarily made up of powerful

antioxidants, lutein and zeaxanthin. The disease occurs when the macular portion of the eye, which provides protection for the light sensitive retina, is destroyed. Research shows that by providing lutein and zeaxanthin in the diet, the density of the macular portion can be increased, thus affording protection for the eyes. As lutein and zeaxanthin are abundant in egg yolk it means that eating eggs could help provide protection for the eyes (Chung et al., 2004).

Future of nutrition and eggs

For years, eggs have been held up as a powerhouse of nutrition. The reputation has been due to eggs' exceptional nutrition profile as a nutrient dense food containing high quality protein and a substantial amount of many essential vitamins and minerals. Unfortunately their position on the nutrition pedestal fell with the discovery that they are also a source of dietary cholesterol. The most recent scientific research not only returns eggs to their golden position of the past, but also elevates their position as a functional food and ultimately provides more reasons than ever to consume eggs.

Functional Eggs

The concept of functional foods has become popular in recent years. The concept came from Japan in the 1970s with the term functional food appearing in 1984 (Harris, 2000). The Food and Nutrition Board of the National Academy of Sciences defines functional food as one that encompasses potentially healthy products providing health benefits beyond that of the traditional nutrients it contains (Milner, 2000). The interest in functional foods has resulted in a number of new foods in the market place designed to address specific health concerns, particularly regarding chronic diseases of aging. In addition

to new food specifically designed to enhance health, functional foods can also include those traditional, familiar foods for which recent research findings have highlighted new health benefits or dispelled old dogma about potential adverse effects. The egg is an excellent example of this. Eggs have not traditionally been regarded as a functional food, primarily due to concerns about their adverse effect on serum cholesterol levels. However, eggs are an excellent dietary source of many essential (protein and choline) and non–essential (e.g. lutein and zeaxanthin) components. Eggs can be considered potential "functional foods" because they contain components that may have benefits that go beyond basic nutrition, such as the carotenoids lutein and zeaxanthin, which may help to protect against age related eye diseases, including cataract and macular degeneration (Hasler, 2000; Moeller et al. 2000). The lutein and zeaxanthin in eggs may be particularly valuable because they are highly bioavailable (Handelman et al., 1999).

Designer eggs

Many of the nutrients in eggs can be manipulated by dietary means, therefore a real value for improvement of the human diet is the manipulation of only those nutrients which are usually in short supply in other products or have a positive effect on human health when consumed in excess. Among these nutrients which can be manipulated are n-3 fatty acids; vitamin E, carotenoids and selenium. Studies have been completed to improve the level of these nutrients in eggs. Functional foods normally have been modified through biotechnology to enhance their quality or nutritional value. In the case of eggs a somewhat less sophisticated means have been used to modify their content- namely feeding the hens different types of food.

Omega 3-enriched eggs

Commercial eggs contain a high proportion of n-6 polyunsaturated fatty acids (PUFA) but are a poor source of polyunsaturated n-3 fatty acids. Epidemiological evidence has indicated that increased consumption of fish, rich in long chain n-3 polyunsaturated fatty acids (n-3 PUFA), especially eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) is associated with a reduced risk of cardiovascular disease (CVD) all-cause mortality (Din et al., 2004; Lee & Lip, 2003) and other chronic diseases (Table 2). It has been reported that higher blood EPA plus DHA levels was associated with a 70% lower risk of fatal ischaemic heart disease in older adults (Lemaitre et al., 2003). In view of very low levels of fish consumption in the population (only 66% of Irish adults are consumers of fish with a mean intake of 35g/day), there is an interest in producing n-3 PUFA eggs via altered feeding. Such eggs can potentially enhance the intake of n-3 PUFA, particularly DHA. In one recent study that looked at the effects of consuming DHA enriched eggs (108mg DHA per 50g egg) on serum lipids and fatty acid compositions in statin-treated hypercholesterolaemic male patients positive results were reported (Gillingham et al., 2005). They concluded that consumption of two DHA enriched eggs was found to significantly increase the overall n-3 PUFA status without significantly altering circulating cholesterol levels. Another study found that the addition of one n-3 PUFA enriched egg per day significantly increased dietary intake of the n-3 PUFA, LNA and DHA (Sindelar et al., 2004). However in this study the consumption of one n-3 PUFA enriched egg resulted in higher serum triglycerides in physically active adults than did daily consumption of one conventional egg. This finding was in contrast to other studies completed by this group, which have shown a reduction or no effect of dietary n-3 PUFA

on triglycerides. Despite the increase, serum triglycerides remained within the recommended desirable serum triglycerides concentration.

Attempts to produce eggs n-3 PUFA can be divided into two groups.

1. Produce an egg enriched in linolenic acid, which is a precursor of DHA and is also considered to have protective effect against fatal ischaemic heart disease (Hu et al., 1999a). For this purpose the hen's diet is usually relatively rich in flaxseeds, linseeds, or their corresponding oils; as a result the egg's yolk is enriched with linolenic acid and the level of DHA is also increased (Ferrier et al., 1995).

2. Include pre-formed DHA in the hen's diet usually in the form of fish (menhaden, herring or tuna) oil (Leskanich & Noble, 1997).

Table 2. Health benefits of omega-3 enriched eggs

Health benefits if n-3 fatty acids for human in the prevention and management of human diseases
Coronary Heart Disease
Hypertension
Thrombosis
Type 2 Diabetes
Renal Disease
Rheumatoid arthritis
Ulcerative colitis
Crohn's disease
Depression
Embolism
Allergic problems
Chronic obstructive pulmonary disease
Prostate and breast cancer
Immunological functions
Autoimmune disease
Foetal brain and visual development
Improvements in learning ability
Positive effects on longevity

Selenium enriched eggs- Results from Surai's group have showed that the inclusion of organic selenium in the chicken diet could substantially increase the accumulation of this trace element in the egg (Surai, 2000a; Surai, 200b). The production of Se-fortified eggs is achieved by feeding birds a Se supplemented diet at a level of

0.4mg/kg in the form of Se-enriched yeast, an egg would contain approximately 30ug of Se which is about 50% of the daily requirement. This could be used to improve the population Se status in many countries including Scotland where the selenium content of the diet meets only 50% of the requirement (Rayman, 2000).

Lutein enriched eggs-yolk lutein content can be increased, although further studies are needed to investigate the major decline in transfer efficiency seen with higher levels of dietary supplementation (Lesson & Caston, 2004).

Folic acid enriched eggs- Studies have been successful in feeding increase levels of folate to hens to increase levels of folate in eggs. In terms of nutritional value, one large egg collected from a folic-acid supplemented hen provided approximately 15% of the recommended dietary allowance for adult males (RDA= 300ug) (House et al., 2002).

Vitamin D- Vitamin D supplements can be successfully fed to laying hens to increase the vitamin D content of eggs (Mattila et al., 2003, 2004).

In a review paper by Surai & Sparks (2001) they concluded that eggs ideally fit the requirements of a functional food. For example the levels of certain nutrients (vitamin E and DHA could be increased in the egg to such an extent that consumption of a single egg could deliver these nutrients in amounts comparable or higher than daily requirements. They also stated that the ability of the egg to be used as a functional food has been established; now what is required is education of the consumer as to its potential benefits (Surai & Sparks,

2001). The European Food Safety Authority (EFSA) has proposed that for a food to claim it is a source of n-3 fatty acids then it must contain 15% of the Recommended Nutritional Intake (with the RNI set at 2g/day for an adult male) for an adult male of the omega 3 fatty acids concerned per 100g or 100 ml or 100 kcal (EFSA, 2005).

Other Interesting facts about eggs

Dioxins

Foods high in animal fats, such as milk, meat, fish and eggs (and food produced with them) are the main sources of dioxins and polychlorinated biphenols (PCB) although al foods contain at least low levels of these chemicals. The risk to health comes with high levels of dioxins and PCB over a long period. They have been shown to cause a wide range of effects in certain animals, including cancer and damage to the immune and reproductive systems, although it appears that people may be less sensitive (FSA, 2005).

Cholesterol content of different eggs

One study concluded that there is no significant difference in cholesterol levels of large, white and dark-shelled eggs. Although slightly lower, the cholesterol concentration of small, white shelled eggs was also not significantly different in terms of mg/g of yolk. No significant difference was seen between the cholesterol levels of raw and cooked eggs. The overall average of cholesterol content of chicken eggs was 12.0mg/g yolk and that of the quail egg was 12.1mg/g yolk. (Bragagnolo & Rodriguez-Amaya, 2003). However it should be noted that the average weight of a large chicken egg in this

study was 64g with a yolk weight of 19g while the average weight of a quail egg was 9.8g with a yolk weight of 3.2g. Therefore if a person ate a quail egg their cholesterol intake would be 39mg as opposed to a chicken egg, which would lead to a cholesterol intake of 233mg.

Patterns of Egg Consumption

The present level of egg consumption in Ireland is relatively low. National food survey studies carried out by the Irish Universities Nutrition Alliance, examining seven day food intake in Irish adults (North/South Ireland Food Consumption Survey NSIFCS, IUNA, 2001) and children (National Children's Food Survey, NCFS IUNA, 2005) have shown that egg and egg dish consumption corresponds to less than one egg per day.

Table 3 presents egg consumption data from these food surveys. The mean daily egg consumption in children aged 5-12 years is 18 grams per day with only 42% of this group consuming eggs. The intake of eggs and proportion of the sample consuming eggs does not vary greatly between boys and girls or change with age group. When the highest consumers of eggs are examined (95^{th} percentile, i.e. the top 5% of consumers), consumption ranges from 41-47 grams per day, which corresponds to less than 1 egg per day.

A greater proportion of adults consume eggs compared to children. Sixty-one percent of adults consume eggs with a mean daily intake of 25 grams. The proportion of consumers is higher for men than women and increases with increasing age for both. Similarly, men consume a

higher amount of eggs. When the top 5% percent of consumers of all the adults are examined, consumption of eggs only approximates 1 per day

Intake of eggs appears to have decreased in Ireland in the past fifteen years. In 1990, the Irish National Nutrition Survey reported that daily egg intake was approximately 40g in men and 30 grams in women. In children aged 8-12 years egg consumption was higher in girls at 27 grams per day compared to 21g per day in boys.

Data from the National Diet and Nutrition Survey (NDNS) in the UK, found that men consume 23 grams of eggs per day, while lower intakes of 16 grams is consumed by women. Approximately 60% of women and nearly 70% of men consume eggs with intakes in this group of consumers at approximately 36 and 40 grams per day respectively. A greater proportion of the older men and women were egg consumers compared to the younger age groups (NDNS, 2004 Vol. 1). While intakes in this population are similar to Ireland, the actual proportion of consumers is lower.

Egg consumption is also less than one egg per day at approximately 40 grams per day in Spain. However these intakes are still higher than intakes in Ireland. In Spain egg consumption has also decreased from 300 eggs per person in 1987 to 223 eggs per person in 2000 (www.institutohuevo.com).

Considering the high nutrient quality of eggs there is definitely scope to increase both the amount of eggs consumed and also the proportion of consumers in the Irish population of children and adults.

Table 3 Mean, SD, median and percentile intakes of eggs and egg dishes (gram/day) in Irish adults and children by sex and age group

Food group	Total Sample						Consumers only						
					Percentiles							Percentiles	
	n	Mean	SD	Median	5th	95th	*n*	%	Mean	SD	Median	5th	95th
All Children (5-12 years)	594	8	13	0	0	36	251	42	18	14	15	4	47
All Boys 5-12 years	293	8	13	0	0	36	119	41	19	13	17	4	43
Boys 5-8	145	8	13	0	0	33	59	41	19	13	19	4	41
Boys 9-12	148	7	13	0	0	38	60	41	18	14	15	4	46
All Girls 5-12 years	301	8	13	0	0	37	132	44	18	14	14	4	51
Girls 5-8	151	7	13	0	0	33	65	43	17	15	13	3	53
Girls 9-12	150	8	13	0	0	40	67	45	18	14	15	4	49
All Adults (18-64 years)	1379	17	21	11	0	54	944	68	25	22	17	7	61
All Men (18-64 years)	662	21	23	17	0	61	489	74	28	23	23	7	70
Men18-35	253	19	22	14	0	60	178	70	26	21	22	4	66
Men 36-50	236	21	23	17	0	66	178	75	28	23	23	8	72
Men 51-64	173	24	26	17	0	66	133	77	31	26	26	6	82
All Women (18-64 years)	717	14	19	9	0	45	455	63	22	19	17	6	54
Women18-35	269	13	21	8	0	45	161	60	22	23	17	7	49
Women 36-50	286	14	17	9	0	45	186	65	21	17	17	6	55
Women 51-64	162	15	17	9	0	54	108	67	22	16	17	5	57

Eggs as a healthy alternative in the diet.

Eggs are a highly nutritious food and can play an important role as a part of a healthy diet. In the table below, it is clearly demonstrated how egg dishes can be a very healthy alternative food source and incorporated into everyday meals

Table 4: Healthy alternative meals using eggs, illustrating differences in energy intake and macronutrients

Breakfast	**kCals**	**Fat (g)**	**CHO (g)**	**Protein(g)**
Option 1				
Juice, poached egg & toast*	260	9	35	12
Option 2				
Juice, fried egg & toast*	287	12	35	12
Breakfast: Even if the fried egg in option 2 is replaced with a poached egg a saving of 27 kcals and 3 grams of fat can be made.				
Lunch	**kCals**	**Fat (g)**	**CHO (g)**	**Protein(g)**
Option 1				
Baguette, with ham cheese & coleslaw*	935	50	93	35
Option 2				
'What's in the fridge' omelette**	336	21	18	19
Lunch, an omelette can provide a healthy alternative to a filled baguette with a saving of nearly 600 kcals and 29 grams of fat. 600kcals would take a very long time in the gym to burn, while the omelette can be prepared in 15 minutes				
Dinner	**kCals**	**Fat (g)**	**CHO (g)**	**Protein(g)**
Option 1				
Bun Burger, chips & beans*	820	42	82	34
Option 2				
Poached egg & home fries**	281	14	22	17
Poached egg and home fires is a healthy and tasty alternative to burger and chips with a saving of over 500 calories and 28 grams of fat.				

* Analyses using McCance and Widdowson's Composition of Foods, 6th Ed..

** Analyses taken from Bord Bía eggs easy as 1, 2, 3 leaflet

Eggs and Cholesterol

History of Cholesterol

The existence of cholesterol has been known for about 250 years. The associations between cholesterol and aortic plaques dates back to Vogel's work in 1843 (Human Nutrition, 2001 p81). The French chemist M.E. Chevreul is credited with the initial discovery of cholesterol in 1815 (Vance & Van Den Bosch, 2000). He found it as a component of human gallstones and named it cholesterine (chole for bile and stereos for solid). The associations between cholesterol and aortic plaques dates back to Vogel's work in 1843 (Human Nutrition, 2001). The link between the levels of plasma cholesterol and atherosclerosis was experimentally demonstrated in rabbits in 1913 by Anitschkow and Chalatow (Vance & Van Den Bosch, 2000). Since that time, numerous studies have demonstrated that high levels of plasma cholesterol are correlated with atherosclerosis. The issue is more complicated than was suspected by Anitschkow and Chalatow in 1913. When examining plama cholesterol, there are many types including low density lipoprotein (LDL), high density lipoprotein (HDL), very low density lipoprotein (VLDL) and triglycerides. High levels of HDL are protective against atherosclerosis and cardiovascular disease. The theory, with much experimental evidence to support it, suggests that HDL functions to remove cholesterol from body tissues and delivers it to the liver where the cholesterol is degraded to bile acids and excreted from the body (Vance & Van Den Bosch, 2000).

Role of cholesterol in the Diet

Cholesterol is a key nutrient in the diets of humans. It is the main sterol of importance in the diet and has many roles including

1. Vital component of biological membranes.

   Cholesterol is essential for the formation of cell membranes and maintenance of their integrity.

2. Precursor to bile salts used in fat digestion.

   One of the most important derivatives of cholesterol is bile acids. These originate in the liver and play a major role in the digestion of fats.

3. Precursor to steroid hormones.

   Cholesterol is a precursor to a wide diversity of steroid hormone including male and female sex hormones and provitamin D3.

Dietary Cholesterol

There appears to be a popular misconception that dietary cholesterol is directly correlated with serum cholesterol. However, within a normal range of cholesterol intake of 100-400mg/day there is very little impact on serum cholesterol. This misconception can be easily abolished considering that the body has many compensatory mechanisms to deal with increasing dietary load of cholesterol. Essentially, the amount absorbed in the gut is diminished and this mechanism abolishes any dose response relationship between dietary cholesterol and serum cholesterol, over a realistic range of intakes. A meta-analyses study undertaken by the WHO to examine dietary influences on dietary cholesterol and serum cholesterol in relation to CHD, found that dietary modification could only achieve a 4-5% reduction in serum cholesterol (Human Nutrition, 2001).

Recent studies have cast further doubt on the relationship between dietary cholesterol and heart disease. Kritchevsky & Kritchevsky (2000) reviewed recent epidemiological studies relating dietary factors to incidence of heart disease. They noted that a significant independent relationship between dietary cholesterol and LDL or total serum cholesterol levels, incidence of heart disease or heart disease deaths did not necessarily occur in various studies reviewed.

Over the past quarter century studies investigating the relationship between dietary cholesterol and atherosclerosis have raised questions regarding the contribution of dietary cholesterol to heart disease risk and the validity of dietary cholesterol restrictions for the prevention of disease risk. In a review of studies by McNamara (2000) examining dietary cholesterol and atherosclerosis, it was reported that analysis of the available epidemiological and clinical data indicated that for the general population, dietary cholesterol made no significant contribution to atherosclerosis and risk of cardiovascular disease.

Additional work by McNamara also reported that in clinical feeding studies, the average change in plasma total cholesterol was 2.2 mg/dL per 100 mg/day change in dietary cholesterol, with plasma lipoprotein cholesterol responses to the same 100 mg/day change averaged 1.9 mg/dL for LDL and 0.4 mg/dL for HDL cholesterol, with little or no effect on the LDL:HDL cholesterol ratio.

Egg consumption & cholesterol

Cholesterol is present in all foods of animal origin, but eggs are the most common food that is rich in cholesterol. Cholesterol is absent in

foods of plant origin. Apart from the cholesterol content, eggs provide many key essential nutrients in the diet. The only reason controversy exists regarding egg consumption is purely because of its cholesterol content.

In Table 5, taken from Kritchevsky & Kritchevsky (2000), summary data of the Epidemiologic Evidence Relating Egg Consumption to Coronary Heart Disease Risk are presented. The results vary from study to study with some reporting an increased relative risk for the consumption of 1 egg per week compared to 7 per week (Oxford Vegetarian Study) while other studies found little or no association. In the studies reviewed, dietary cholesterol intake was associated with a modest increase in the risk of coronary events. The true magnitude of the association however is difficult to determine due to the failure to account for potential confounding effects of other aspects such as lifestyle factors (smoking, alcohol, physical activity) and dietary factors (fat and saturated fat, fruit and vegetables and fibre) . When a full-range of confounding factors was considered, the association between cholesterol intake and heart disease risk was small. Several studies have examined egg intake and its relationship with coronary outcomes. All but one failed to consider the role of other potentially confounding dietary factors. When dietary confounders were considered, no association was seen between egg consumption at levels up to one or more eggs per day and coronary heart disease in non-diabetic men and women (Kritchevsky & Kritchevsky,2000).

Table 5 Summary data of the Epidemiologic Evidence Relating Egg Consumption to Coronary Heart Disease Risk (taken from Kritchevsky & Kritchevsky, 2000)

Study Population (Ref)	Egg Consumption Levels Compared (per week)	Relative Risk	Adjustment Factors
Framingham [19]	Men		None
	<2.5 *versus* ≥ 7	1.3	
	Women		
	<1.5 *versus* ≥ 5*	1.3	
Italian Women 22–69 years of age [20]	< 1 *versus* > 2	0.8	Age
Finnish Men and Women 30 to 69 years of age [21]	Not Applicable (Average Consumption of Coronary Deaths Compared to Survivors)	Difference in Intake Men 1 g/day Women 0 g/day	Age
Seventh-Day Adventists [22,23]	<1 *versus* ≥ 3	1.01	None
Oxford Vegetarian Study [24]	<1 *versus* ≥ 6	2.68**	Age, gender, smoking, social class
Nurses Health Study and Male Health Professionals Study [25]	<1 *versus* ≥ 7		Age, body mass index, cigarette smoking, parental history of MI, vitamin supplement use, alcohol consumption, history of hypertension, physical activity, total energy intake, bacon consumption and, in women, menopausal status and post-menopausal hormone use
	Men	0.93	
	Women	0.78	

* Values represent highest and lowest tertiles of egg consumption. Values for women are derived from a graphical display and are therefore approximate.

** Statistically Significant (p <0.05)

Dawber et al., (2000) addressed the effect of egg consumption on dietary cholesterol intake and on serum cholesterol level and on the incidence of CHD in a free living US population from Framingham, USA. The Framingham Study has been investigating various host and environmental factors which may contribute to differences in the risk of development of atherosclerotic disease. In men the average egg consumption was 5.9/wk compared to 3.8/wk for women. Egg consumption was grouped into low medium and high for men and women, with the high group accounting for 7 eggs or more per week in men and 5 eggs or more per week in women. Cholesterol intake was examined across increasing tertiles of egg consumption and while dietary cholesterol intake increased, the same increase was not seen for serum cholesterol. Essentially there was no change in serum cholesterol with increasing tertiles of egg consumption with no evidence of any significant association of egg consumption with the incidence of death from all causes, total CHD, myocardial infarction, or angina pectoris. The researchers concluded that within the range of egg consumption in the Framingham study, merely avoiding eggs in the diet will have little or no effect on blood cholesterol level.

Based on the results of a meta-analysis by Clarke et al., (1997), the average effects of adding an egg a day to the diet on plasma LDL cholesterol, HDL cholesterol and the LDL:HDL ratio can be estimated. As shown in Table 6, addition of an egg a day to the diet increases plasma LDL by 4.1 mg/dL and HDL by 0.9 mg/dL with changes in the LDL:HDL ratio ranging from 0.03 in the low LDL model to 0.01 in the high LDL model. These modest changes in the LDL:HDL cholesterol ratio with addition of an egg a day to the diet are consistent with the epidemiological study reports that egg consumption is not related to CHD incidence. Based on the

available data, egg restrictions would be predicted to have little effect on plasma cholesterol levels or on CHD risk.

Table 6. Theoretical changes in plasma lipoprotein cholesterol levels and LDL:HDL cholesterol ratio with addition of 1 egg per day to the diet (Taken from Clarke et al., 1997),

	Cholesterol (mg/dL)		LDL:HDL Ratio	
	LDL	HDL	LDL:HDL	% Change
Baseline	130	50	2.60	
+ 1 egg/day	134	51	2.63	1.2%
Baseline	150	50	3.00	
+ 1 egg/day	154	51	3.02	0.7&
Baseline	170	50	3.40	
+ 1 egg/day	174	51	3.41	0.3%

Hu et al., (1999b) found no evidence of an association between egg consumption and risk of CHD or stroke in either men or women. However, a risk was found in diabetic patients. The findings from this paper concluded that consumption of up to 1 egg per day was unlikely to have an effect in healthy men and women.

However, not all research is supportive of the 'one egg a day is ok' school of thought. Nakamura et al., (2004) examined 5 egg consumption groups ranging from >2 per day to seldom. Age adjusted total cholesterol was related to increasing egg consumption in women only and not in men. All cause mortality was lower in the 1-2 eggs per week group compared to the 1 egg per day group. However, some of the limitations of this study were the use of a food frequency questionnaire which results in limited

information on amount of foods consumed and the intake of other fats and foods were not examined in conjunction with egg consumption. Other studies examining patterns of food intake with risk of cardiovascular disease have also found that a 'western type pattern' which included eggs, meats (fresh and processed) and dairy products was associated with an increased risk for cardiovascular disease (Hu et al., 2000, Kerver et al., 2003).

In a meta-analysis examining dietary cholesterol from eggs and the effect on cholesterol and HDL in humans, Weggemans et al., (2001) concluded that dietary cholesterol raised the ratio of total cholesterol to HDL cholesterol, adversely affecting the cholesterol profile. The authors concluded that the advice to limit cholesterol intake by reducing consumption of cholesterol rich foods such as eggs may still be valid.

It is evident from this review that consensus in the scientific community has not been reached regarding egg consumption and serum cholesterol. However, the studies in the literature supporting egg consumption appear to be more numerous than those not supporting egg consumption. Studies that have shown negative findings frequently have not controlled for confounding influences of other aspects of the diet or lifestyle, which may have a more detrimental effect on health outcomes than consumption of the humble egg. Similarly eggs have been shown to have a negative effect when consumed in a western type diet. However, a prudent diet is not necessarily devoid of eggs. The finding from this review would therefore support the hypothesis that 'an egg a day is ok' however, this should be as a part of a health balanced diet.

Recommendations & Conclusions

Eggs have become a symbol of the negative aspects of the diet, and fear among consumers regarding eggs may be resulting from a lack of consensus in the scientific community and the widespread marketing of low cholesterol foods and diets.

It appears that consumption of 1 egg a day is safe provided it is a part of a balance healthy diet that is overall low in fat (at least <35% energy from fat) and low in saturated fat (less than 11% of total energy intake from saturated fat) high in fibre (24g per day) and high in fruit and vegetables (a least 5 portions a day)

From this literature review it can be confirmed that current science promotes the consumption of an egg a day. Analysis on the intake of eggs in the Irish population highlights the fact that currently Irish people do not consume an egg a day and therefore there is an opportunity to promote an egg a day to the Irish population. Examination of the literature also confirms eggs as a very valuable source of numerous nutrients that are easily digested and absorbed. Along with their traditional nutritional benefits, eggs will play a role in the functional food arena with the potential to incorporate essential nutrients into eggs so that higher consumption levels of these nutrients can be achieved in the general population.

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