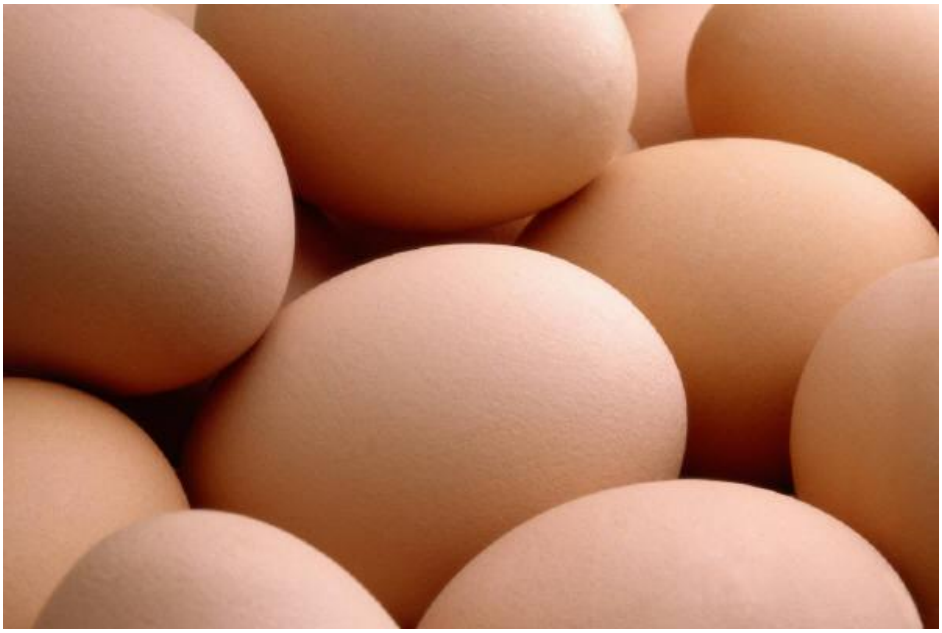
An Overview of the Nutritional Role of Eggs in the Diet



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Abbreviations

ARMD	Age Related Macular Degeneration
CHO	Carbohydrate
CVD	Cardiovascular Disease
DHA	Docosahexaenoic Acid
EFSA	European Food Safety Authority
EPA	Eicosapentaenoic Acid
EU	European Union
FA	Folic Acid
FSA	Food Standards Agency (United Kingdom)
FSAI	Food Safety Authority of Ireland
GI	Glycaemic Index
HDL	High Density Lipoprotein
IUNA	Irish Universities Nutrition Alliance
Kcal	Kilocalories
LDL	Low Density Lipoprotein
LNA	Linolenic Acid
NCFS	National Children's Food Survey
NDNS	National Diet and Nutrition Survey (UK)
NSIFCS	North South Ireland Food Consumption Survey
NTD	Neural Tube Defect
NTFS	National Teen's Food Survey
PUFA	Polyunsaturated Fatty Acid
RDA	Recommended Daily Allowance
RNI	Recommended Nutrient Intake
SD	Standard Deviation
TAG	Triacylglycerol
TG	Triglycerides
WHO	World Health Organisation

1. Nutritional 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 very popular, eggs are a highly nutritious food. One large egg provides 6.5g of protein and about half of this protein is in the egg white. Egg white is considered an ideal protein, the one by which all others are measured, because it contains all the essential amino acids in correct proportions for human nutrition (Meister, 2002). Of the total fat in eggs, over half is unsaturated fat. Eggs are also an excellent source of numerous micronutrients including iron, riboflavin, folate and many vitamins **(Table 1)**. Most of these nutrients are only found in the yolk, including the fat-soluble vitamins (A, D and E).

Data from Ireland demonstrates that eggs contributed over 15% towards the average daily intake of vitamin D and between 2-8% of folate, vitamin B12 and iron intakes (IUNA, 2001). In the USA, it was shown that eggs contributed 10-20% of the daily intake of folate and 20-30% towards the daily intakes of vitamin A, E and B12 (Song & Kerver, 2000). In the Irish food pyramid (Department of Health and Children, 2005) eggs are a 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 an ounce of meat.

2. Nutrients in Detail

2.1 Macronutrients

Energy: An average egg has an energy value of 76 kilocalories and the consumption of one egg contributes to only 3% of the average daily requirement for an adult man and to only 4% for an adult women. Due to the low calorie content of eggs and the large amount of nutrients they provide, they are often referred to as a 'nutrient dense' food. For good nutrition, most of a person's daily food intake should consist of nutrient dense foods.

Fat: Dietary fats are composed of fatty acids and glycerol and are usually called tiacylglycerols (TAGs). TAGs are primarily used as fuel for the body, so they are commonly associated with energy metabolism. Eggs contain approximately 11% fat. The

majority of fat present in eggs is contained in the yolk with only 0.05% present in the albumen. Over 60% of the fat present in eggs is unsaturated, (of this 17% is polyunsaturated fat and 44% monounsaturated fat) while 32% is composed of saturated fat.

Eggs are also a source of dietary cholesterol, with each egg containing an average of 200mg of cholesterol. Cholesterol is a fat-like substance, 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.

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. Almost 13% of the weight of the egg is protein and it is found in both the yolk and the albumen (i.e. in the white of an egg) and the protein content is higher in the albumen than in the yolk.

2.2 Micronutrients

Vitamin A: Vitamin A is a fat-soluble vitamin that is essential for vision in dim light, for the maintenance of mucous membranes and for 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 cornea and lowered resistance to infection.

Vitamin E: Vitamin E acts as an antioxidant in the body and protects cell membranes from damage by oxidation. Sources include egg yolk, vegetable oil, nuts, vegetables and cereals.

Vitamin B1: Vitamin B1 (thiamine) 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 pulses, green vegetables, pork, fruit and fortified breakfast cereals. Deficiency leads to beriberi.

Vitamin B2: Vitamin B2 (riboflavin) is involved in energy release from ingested nutrients, especially from fat and protein. Rich sources of vitamin B2 include liver, milk, cheese, yoghurts, eggs, green vegetables and yeast extracts.

Vitamin B6: Vitamin B6 (pyridoxine) is involved in the metabolism of protein. It is found in a variety of foods including beef, fish, poultry and eggs.

Vitamin B12: Vitamin B12 (cobalamin) is necessary for the adequate formation of blood cells and nerve fibres. Rich sources are offal and meat, eggs and milk. Deficiency leads to pernicious anaemia.

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 haem iron (easily absorbed) and non-haem iron (not as easily absorbed). Eggs contain haem iron and therefore are an ideal haem iron source for vegetarians. The other main source of haem iron is meat. A lack of iron leads to lower iron stores in the body and eventually to iron deficiency anaemia.

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 pulses. Deficiency is rare and may cause delayed puberty and retarded growth.

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, and further it is critical for brain and memory development in utero and early life (Applegate, 2000). Specific Irish recommendations regarding choline intake during pregnancy do not exist, however Australian guidelines propose that pregnant women should ingest 450 mg/day, and breastfeeding women should ingest 550 mg/day (National Health and Medical Research Council, 2006). Two eggs, including the yolks, contain about 250mg of choline.

Lutein and Zeaxanthin: Lutein and zeaxanthin are carotenoids found in egg yolk and accumulate in the macular region of the retina in the eye. These carotenoids are strongly

implicated as being protective against age-related macular degeneration (ARMD) and cataracts (Chung *et al.*, 2004).

Although many micronutrients contained in eggs have been described in this section, probably two nutrients of particular importance in relation to public health in the Irish population are folate and vitamin D.

Folate: Folate is needed for the formation of red blood cells. It also reduces the risk of neural tube defects (NTD) in infants. Folate is known to reduce the risk of NTDs by up to 70% if taken prior to conception and up to 12 weeks after conception (UK Medical Research Council, 1991). A recent report released by the Food Safety Authority of Ireland (FSAI) reviewed folate intakes and also examined the results of a survey on the incidence of NTD's in an Irish sample during 2005-06. This report provided evidence that women of childbearing age received 30% more folate in their diet as compared to three years previous, and that this was probably due to voluntary fortification across the food sector. These findings were in conjunction with the observation of an overall reduction in the incidence of NTD's to 0.93 per 1,000 births in this period (FSAI, 2008). Therefore the continued voluntary fortification of the Irish food supply with folic acid is important in maintaining this lower incidence of NTD's. 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 lower amount

Vitamin D: Vitamin D is also a fat-soluble vitamin which promotes calcium and phosphate absorption from foods and is thus essential for healthy bone and teeth. Dietary sources of vitamin D are rather limited in comparison to other vitamins, but its main sources include egg yolk, oily fish, fortified margarine and fortified breakfast cereals. Another report issued by the FSAI identified poor vitamin D status amongst infants, adults, adolescent girls and pregnant women living in Ireland (FSAI, 2007). The FSAI recommends a government policy of vitamin D supplementation for infants aged 0-12 months living in Ireland. Deficiencies can lead to failure of bones to develop properly and to calcify, progressing to rickets in children and osteomalacia in adults with severe or chronic deficiency.

3. Eggs and the lifecycle

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

3.1 Infants

According to weaning guidelines issued by the World Health Organisation (WHO), from 4-6 months of age, babies can begin receiving appropriate complementary foods while continuing to breastfeed up to 2 years or beyond (WHO, 2004). Iron stores in breastfed infants become depleted by 6 months, and after this stores need to be topped up by consuming iron rich weaning foods such as eggs. Eggs are considered suitable for weaning infants because they are a source of haem iron, they are small in volume, and they have a soft texture suitable for weaning. A study by Makrides *et al.*, (2002) was completed to investigate whether egg yolk in the weaning diet can influence iron status. The result of this study indicated that it is possible and practical for weaning infants to consume 4 egg yolks per week without affecting the intake of other foods such as cereal and meat.

3.2 Childhood and adolescence

Eggs provide essential nutrients for growth and development during childhood and adolescence. As a result of this period of rapid growth and development, protein requirements (per kg body weight) during childhood and adolescence are higher than those during adulthood. Increased requirements for some other nutrients during this period include iron, folate, magnesium, riboflavin, vitamin A and zinc. The inclusion of eggs in the diets of growing children and adolescents would therefore help achieve these increased nutritional requirements.

Breakfast is often seen as the most important meal of the day yet it is often the most missed, especially amongst older children and adolescents (Affenito, 2007). Breakfast consumption provides a higher percentage of micronutrients than any other meal consumed during the week and is also associated with improved cognitive and psychosocial

performance (Affenito, 2007). Eggs have been shown to be a satiating breakfast choice (i.e. keep you feeling fuller for longer) in overweight adults and when eaten for breakfast, eggs can reduce the amount of energy consumed at lunch (Vander Wal *et al*., 2005). Further research is required to determine the potential beneficial effects of eggs when consumed by children and adolescents at breakfast.

3.3 Adults

As an average egg only contain 76 kilocalories, they are useful in a calorie-restricted diet due to the fact that they are a nutrient-dense low calorie food. As previously stated, evidence exists which suggests that consuming eggs may increase satiety in overweight and obese subjects. Vander Wal *et al.,* (2005) demonstrated that compared to an iso-caloric, equal weight bagel-based breakfast; an egg-based breakfast induced greater satiety and significantly reduced short-term food intake. However, the potential role of a routine egg-based breakfast in producing a sustained caloric deficit and consequent weight loss should be further investigated.

3.4 Pregnant and lactating mothers

Pregnancy and lactation increase a woman's nutritional requirements for key nutrients such as energy, protein, n-3 polyunsaturated fatty acids (PUFA) and most vitamins and minerals including vitamin D, vitamin C, calcium, iron and folate. Adequate nutrition during pregnancy is essential to optimise both maternal health and that of the developing child. As eggs are a significant source of high biological value protein and key vitamins and minerals, their inclusion in the diets of pregnant and lactating women would help achieve increased nutritional requirements. **Table 2** displays the additional nutrients required during pregnancy, and the amount provided by one serving of eggs. See also section 5.2 *Omega 3 enriched eggs.*

3.5 Elderly

Elderly people may be faced with a range of difficulties which can affect food intake including reduced appetite, poor dentition, limited access or transport to shops, reduced income and social exclusion. Eggs are a suitably high nutritious food for the elderly as they

are cheap, convenient and easy to prepare. Also the carotenoids - lutein and zeaxanthin found in eggs could help prevent age related eye problems. 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 the egg yolk, it means that eating eggs could potentially provide protection from this disease (Chung *et al.,* 2004), (see also the section 5.4: *lutein enriched eggs*).

4. Legislation for eggs: EU and National Legislation

Legislation surrounding egg production and marketing in Ireland refers to the European Communities (Welfare of Laying Hens) Regulations 2002 (S.I. No. 98 of 2002). This is in line with the EU Council Directive 99/74/EC, which details the minimum standards for the protection of laying hens. It distinguishes three types of rearing systems for laying hens: 'enriched cages', 'non-enriched cage systems' and 'non-cage systems'. The rearing of hens in 'non-enriched' cage systems is prohibited with effect from 1st January 2012. In addition, since the 1st January 2003 such cages may not be built or brought into service for the first time. The Directive also provides that all egg production units must be registered with the competent authorities in Member States. They must each have a distinguishing number which will be used to trace eggs back to the farm where they were produced. More recently, Directive 2002/4/EC sets out rules on the registration of establishments keeping laying hens. It also requires the use of the following codes for the farming methods defined in Commission Regulation (EC) No 589/2008:

1 = 'Free range eggs'

2 = 'Barn eggs'

3 = 'Eggs from caged hens'

There is additional legislation to cover specific issues such as marketing, hygiene, marking of eggs, record keeping and egg products.

4.1 Marketing

Marketing of eggs is covered by the European Communities (Marketing Standards for Eggs) Regulations 2009 (S.I. No. 140 of 2009) and under Council Regulation (EC) No. 1234/2007 which sets out the framework marketing standards for eggs of hens of the Gallus gallus species. More recently, a further Commission Regulation (EC) No 589/2008 was developed which defines 'eggs' as: *"meaning eggs in shell — other than broken, incubated or cooked eggs — that are produced by hens of the species Gallus gallus and are fit for direct human consumption or for the preparation of egg products"*

4.2 Hygiene

This is covered under European Communities (Food and Feed Hygiene) Regulations 2005 (S.I. No. 910 of 2005), plus amendments and under Regulation (EC) 853/2004. The Regulation requires that at the producer's premises, and until sale to the consumer, eggs must be kept clean, dry, and free of extraneous odour, effectively protected from shocks and out of direct sunshine. Eggs must be stored and transported at a temperature that is best suited to assure optimal conservation of their hygiene properties. Eggs must be delivered to the consumer within a maximum limit of 21 days of laying.

4.3 Marking of eggs

The marking of eggs in Ireland is covered under the Commission Regulation (EC) No 589/2008, which requires that eggs must be graded by quality as follows: Class A or Class B. Class A eggs must also be graded by weight as follows:

- XL - very large: weight = 73 g
- L - large: weight = 63 g and <73 g
- M - medium: weight = 53 g and <63 g
- S - small: weight <53 g

Class B eggs must only be delivered to the food and non-food industry.

The label on egg packs must comply with Directive 2000/13/EC on the labelling, presentation and advertising of foodstuffs. Eggs must be graded, marked and packed within 10 days of laying. However, eggs marketed as "Extra" or "Extra Fresh" must be

graded, marked and packed within 4 days of laying. Packs containing Class A eggs shall bear on the outer surface in easily visible and clearly legible type:

1. The packing centre code
2. The quality grading
3. The weight grading
4. The date of minimum durability, which is fixed at ≤28 days after laying.
5. The wording 'washed eggs' in accordance with Article 3 of Commission Regulation (EC) No 589/2008
6. An indication advising consumers to keep eggs chilled after purchase in accordance with Article 3(1)(6) of Directive 2000/13/EC

In addition to these requirements, packs containing Class A eggs must bear the farming method on the outer surface in easily visible and clearly legible type. For this identification only the following terms shall be used:

1. For conventional farming, the terms set out in Part A of Annex I of Commission Regulation (EC) No 589/2008
2. For organic production, the terms set out in Council Regulation (EC) No 834/2007) from 31st December 2008

Packs containing Class B eggs shall bear on the outer surface in easily visible and clearly legible type: The packing centre code, the quality grading and the packing date

4.4 Records to be kept by producers

Producers must record information on the farming methods, specifying for each farming method used:

1. The date of placing, age at placing and number of laying hens
2. The date of culling and the number of hens culled
3. Daily egg production
4. The number and/or weight of eggs sold per day or delivered daily
5. The names and addresses of purchasers

4.5 Egg products

'Egg products' are defined in Regulation (EC)853/2004 as *" processed products resulting from the processing of eggs, or of various components or mixtures of eggs, or from the further processing of such processed products".* Food business operators must ensure that establishments for the manufacture of egg products are constructed, laid out and equipped so as to ensure separation of the following operations:

1. Washing, drying and disinfecting dirty eggs
2. Breaking eggs, collecting their contents and removing parts of shells and membranes; and
3. Operations other than those referred to in points 1 and 2

Food business operators must ensure that all operations are carried out in such a way as to avoid any contamination during production, handling and storage of egg products Food business operators must ensure that raw materials used to manufacture egg products comply with the following requirements.

1. The shells of eggs used in the manufacture of egg products must be fully developed and contain no breaks. However, cracked eggs may be used for the manufacture of egg products if the establishment delivers them directly to a processing establishment, where they must be broken as soon as possible.
2. Liquid egg must be obtained in accordance with the requirements of Regulation (EC) 853/2004 i.e. Special hygiene requirements for the manufacture of egg products

5. Future of eggs and nutrition

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

future of eggs has been in relation to investigating both their relationship with cholesterol levels and in their use as a functional food, both of which will be discussed in the following sections.

5.1 Eggs and cholesterol

5.1.1 Introduction to cholesterol: Cholesterol is a soft, wax-like substance which is found in every cell in our body. Cholesterol does not dissolve in the blood and thus it is bound to special proteins called apoproteins which keep the cholesterol soluble. The complex of fats, cholesterol and apoproteins is called a lipoprotein. There are many different lipoprotein particles in the blood stream which differ in their size and composition of fats and proteins. The largest lipoprotein is called a chylomicron which is produced in the intestinal cells. These lipoproteins help to deliver dietary fat to the liver. The liver then in turn produces very low density lipoproteins (VLDL) which are gradually broken down to form low-density lipoproteins (LDL). During this breakdown process fragments are released which join other apoproteins produced in the liver to form high density lipoproteins (HDL) (www.irishheart.ie). Whereas VLDL and LDL deliver cholesterol and fat to all our cells, HDL is thought to be responsible for transporting cholesterol back from our cells to the liver where it is sent into the intestine for excretion. LDL cholesterol is an independent risk factor for the progression of CVD (Griffin & Cunnane, 2009).

5.1.2 Dietary cholesterol: The potential link between dietary cholesterol and CVD has elicited scientific interest for many years. However, extensive research has failed to provide an explicit link between dietary cholesterol and the progression of CVD. A review by McNamara (2000) examined the perceived relationship between dietary cholesterol, plasma cholesterol and atherosclerosis. McNamara (2000) demonstrated that the extrapolation of data from animal studies to human health is extremely complicated due to the high variability in animal responses to dietary cholesterol while epidemiological studies demonstrating a significant positive correlation between dietary cholesterol levels and CVD have statistical flaws associated with them. Studies often fail to take account for the presence of two confounding factors; a high saturated fat diet resulting in elevated plasma cholesterol levels and a dietary pattern low in fruits, grains and vegetables resulting in

lower intakes of B vitamins, antioxidants and dietary fibre which can contribute to an increased risk of CVD. In conclusion, studies have demonstrated that the effects of dietary cholesterol on serum cholesterol are small and clinically insignificant when compared to the greater influence of saturated fat on levels of circulating LDL cholesterol and on risk for CVD (Gray & Griffin, 2009).

5.1.3 Egg consumption and cholesterol studies: Eggs represent the richest source of dietary cholesterol in Westernised diets, with a single egg yolk containing approximately 200mg of cholesterol. Therefore they have often been used as a vehicle for the delivery of dietary cholesterol in human interventions and as a marker of dietary cholesterol intake in prospective cohort studies (Lee & Griffin, 2006). However as previously stated, many prospective studies are confounded by the fact that dietary cholesterol and saturated fat occur together in the diet so that their levels are highly correlated.

A plethora of studies exist which attempt to find some plausible relationship between eggs and CVD risk. **Table 5** displays more recent studies which have investigated potential links between the two. The association between egg consumption and total cholesterol concentration was examined in a study of 90,735 individuals who took part in the Japan Public Health Centre-based prospective study (Nakamura *et al.*, 2006). This large prospective study found that frequent consumption of eggs, up to almost daily, was not associated with any consistent adverse effect on CVD incidence. In fact, an inverse association between egg consumption and mean total cholesterol concentrations was found. Alongside this an inverse association between egg consumption with the frequency of subjects with hypercholesterolemia was observed.

A nationally representative cohort study of 9,734 adults aged 25 to 74 years in the US also examined the relationship between regular egg consumption and risk of stroke and CVD (Qureshi *et al.*, 2007). After adjusting for differences in age, gender and CVD risk factors such as serum cholesterol and cigarette smoking, no significant differences were observed between those who consumed >6 eggs/week compared to those who consumed none or <1 egg/week in relation to stroke or coronary artery disease. However among diabetics, consumption of >6 eggs per week was associated with an increased risk of CVD.

Conflicting results were however seen in a prospective cohort study of 21,327 participants from the Physicians Health Study (Djousse & Gazziano, 2008). Infrequent egg consumption (<6 eggs/week) was not associated with CVD, while the consumption of >7 eggs/week was associated with modest but significantly higher risk of mortality in this population. This association was even stronger among diabetic patients. A number of limitations exist however, such as the lack of consideration for confounding or residual factors including the effects of saturated fat, markers of insulin resistance, lipids and other relevant nutrients or biomarkers on the observed association.

A small randomised, controlled dietary intervention study investigated the combined effects of increased dietary cholesterol and weight loss on plasma LDL cholesterol and lipoproteins (Harman *et al.,* 2008). The study concluded that no increase in total plasma or LDL cholesterol was identified in subjects when accompanied by moderate weight loss. A further randomised dietary intervention study of 28 overweight or obese subjects demonstrated that consuming a carbohydrate-restricted diet (CRD) (10–15% of energy from carbohydrates), in addition to 3 eggs/day, increased plasma HDL cholesterol. Plasma triglycerides (TG) concentrations were reduced in the intervention group while no change occurred in LDL-cholesterol concentrations or in the LDL: HDL ratio (Mutungi *et al.,* 2008).

Ratliff *et al.,* (2008) also examined the inflammatory response of a CRD in subjects who also consumed an additional 640mg/day of cholesterol provided by eggs. The study concluded that eggs make a significant contribution to the anti-inflammatory effects of a CRD, possibly due to the presence of lutein; a potent antioxidant present in eggs.

Kritchevsky & Kritchevsky (2000) reviewed epidemiological evidence relating dietary cholesterol and egg intake to increased risk of CVD. The review showed that inconsistent evidence in relation to egg consumption and CVD risk exists. 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). This review concluded that when a full range of

confounding factors was considered, the association between cholesterol intake and heart disease risk was small (Kritchevsky & Kritchevsky, 2000).

5.1.4 Conclusion – cholesterol and eggs: Based on the studies presented in **Table 5,** it is clearly evident that, although dietary cholesterol may impact serum cholesterol levels, the presence of confounding factors including a high saturated fat diet and dietary patterns low in fruits, grains and vegetables may have a greater effect. In a review of eggs and dietary cholesterol, Lee & Griffin (2006) concluded that evidence from prospective cohort studies suggests that the relatively small increase in circulating cholesterol does not correspond with an increase in CVD risk. Furthermore, the numerous prospective studies undertaken in the last 30 years provide no consistent evidence that egg consumption has an independent association with risk of heart disease (Gray & Griffin, 2009).

5.2 Functional egg

A functional food is defined as one that encompasses potentially healthy products providing health 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 foods, functional foods can also include 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 effect on serum cholesterol levels. However, eggs are an excellent dietary source of many essential (e.g. 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 ARMD (Moeller *et al.,* 2000). The lutein and zeaxanthin in eggs may be particularly valuable because they are highly bioavailable (Handelman *et al.,* 1999).

Another real value for improvement of the human diet is by 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 in eggs are n-3 PUFA, folate and carotenoids. 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, somewhat less sophisticated means have been used to modify their content – namely feeding hens modified foods. In a review paper by Surai & Sparks (2001), it was concluded that eggs ideally fit the requirements of a functional food. The levels of certain nutrients (such as n-3 PUFA) could be increased in the egg to such an extent that consumption of a single egg could deliver these nutrients in amounts comparable to or higher than daily requirements. **Table 3** provides detail of recent and relevant studies outlining the functional roles of eggs and a description of these studies is provided in the following paragraphs.

5.2.1 Omega-3 enriched eggs: The beneficial effects of long chain fatty acids such as omega-3 polyunsaturated fatty acids (n-3 PUFA) are well documented and include a reduced risk of CVD, rheumatoid arthritis and various mental illnesses including dementia (Riediger *et al.,* 2009). The two key n-3 PUFA are eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA), with current UK recommendations for adults being 450mg EPA and DHA/day (Scientific Advisory Committee on Nutrition/Committee on Toxicity, 2004). There is also a high requirement for DHA in the last trimester of pregnancy and in the first 3 months of life. N-3 PUFA, especially DHA, is important in the developing nervous system of newborns and influences structural and functional parameters during rapid brain growth (Cherain & Sim, 1996). Research has shown that the regular inclusion of n-3 PUFA enriched eggs in the diets of breastfeeding mothers can significantly improve the n-3 PUFA status of the infants.

Commercial eggs contain a high proportion of n-6 PUFA but are a poor source of n-3 PUFA. Marine foods, in particular oily fish, are the main source of these fatty acids, but in many parts of Europe intakes are below recommendations (EFSA, 2009). In view of the low levels of fish consumption in Ireland (only 66% of adults are consumers of fish with a mean intake of 25g/day (IUNA, 2001)); fortified eggs could provide a potential cheap and

easily accessible source of n-3 PUFA. Very recently, the European Food Safety Authority (EFSA) proposed 250mg/d as the labelling reference intake value for the long chain n-3 PUFAs EPA and DHA, which is in agreement with the most recent evidence on the relationship between the intake of these fatty acids and CVD (EFSA, 2009). EFSA have also advised that for a food to claim it is a source of n-3 PUFA then it must contain at least 15% of the RNI of n-3 PUFA concerned, and if a product claims that it is high in n-3 PUFA then it must contain >30% of the RNI of the n-3 PUFA per 100g/ml/kcal of food (EFSA, 2005).

A randomised controlled trial by Shapira *et al.,* (2008) which involved feeding n-3 PUFA-fortified feed versus a standard feed to laying hens showed that fortified eggs yielded a 3.8-fold increase in total n-3 PUFA and a 2.4-fold increase in DHA (**Table 3**).

Gillingham *et al.,* (2005) examined 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 and demonstrated that the consumption of two DHA-enriched eggs for 21 consecutive days was found to significantly increase the overall n-3 PUFA status without significantly altering circulating cholesterol levels.

A study by Sindelar *et al.,* (2004) found that the addition of one n-3 PUFA enriched egg per day, significantly increased dietary intake of DHA. However, the consumption of one n-3 PUFA enriched egg resulted in higher serum triglycerides levels in physically active adults compared to the 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. However despite the increase observed, serum triglycerides remained within the desirable recommendation (Sindelar *et al.,* 2004).

5.2.2 Folic acid enriched eggs: As outlined in **table 3**, studies have been successful in feeding folic acid (FA) to hens to increase levels of folate in eggs (House *et al.,* 2002; Herbert *et al.,* 2005; Roth Meir & Bohmer, 2007; Hoey *et al.,* 2009). Recent studies have demonstrated that by enriching the FA content of a hen's feed, the folate content of an average-sized egg can more than double from 32 to 75 µg (Roth Meir & Bohmer, 2007; Hoey *et al.,* 2009). In addition, FA-enriched eggs also provide a cost-effective option for increasing folate intakes.

5.2.3 Lutein enriched eggs: Recent intervention studies have demonstrated that increasing egg consumption (up to 1 egg per day) can increase serum lutein and zeaxanthin concentrations (**Table 3**) (Chung *et al.,* 2004; Goodrow *et al.,* 2006; Wenzel *et al.,* 2006). An intervention study by Chung *et al.,* (2004) compared the bioavailability of lutein from various sources including lutein supplements, spinach and lutein-enriched eggs (containing 5 times the amount of lutein in conventional eggs). Findings from the study showed that the serum lutein response was highest after enriched egg consumption compared to other treatments in the study. The cholesterol content of the egg yolk may enhance the bioavailability of lutein from egg yolks, however further studies are warranted to fully understand the mechanism for increased lutein bioavailability in eggs.

6. Patterns of egg consumption

The level of egg consumption in Ireland is relatively low. National food consumption surveys carried out by the Irish Universities Nutrition Alliance (IUNA) have examined 7-day food intakes in Irish adults (North/South Ireland Food Consumption Survey, NSIFCS), (IUNA, 2001), in children (National Children's Food Survey, NCFS), (IUNA, 2005) and in teenagers (National Teen's Food Survey, NTFS), (IUNA, 2007). These surveys have shown that egg and egg dish consumption corresponds to less than the intake of one egg per day.

Table 4 presents egg consumption data from these food surveys. The mean daily egg consumption by all children (5-12 years) and teenagers (13–17 years) was, for both groups, 8g/day. Only 41% and 42% of teenagers and children consumed eggs, respectively. Among teenage consumers of eggs, intake was greater among boys (22g/day) compared to girls (18g/day). Among children, the intake of eggs and the proportion of the sample consuming eggs did not vary greatly between boys and girls or change within age group. When high consumers of eggs were examined (i.e. at the 95^{th} percentile of egg intake), consumption ranged from 47g/day in children to 54g/day in teenagers, which corresponds to approximately one egg per day.

Intakes of eggs among Irish adults are greater than intakes of teenagers and children. Mean daily intake of eggs for the total population was 17g/day. Sixty-one percent of adults consumed eggs with a mean daily intake of 25g/day among these consumers. More men than women were egg consumers, and the proportion of consumers increased

with increasing age. Similarly, men consumed a higher amount of eggs. When the 95th percentile of egg intake for all adults was examined, this only approximated one egg per day (i.e. 54g). Taking vegetarians as a separate group (n=23), mean daily egg intake was lower than in the general adult population at 15g/day ($\pm$11g).

Data from the UK National Diet and Nutrition Survey (NDNS, 2004) found similar egg intakes to those observed in the Irish population. In the NDNS, men consumed 23g/day of eggs, while lower intakes of 16g/day were consumed by women. Approximately 60% of women and nearly 70% of men consumed eggs with intakes in this group of consumers at approximately 36g/day and 40g/day, respectively. A greater proportion of the older men and women were egg consumers compared to the younger age groups.

7. Current guidelines concerning egg consumption

In more recent years, recommendations regarding egg consumption are moving away from the more stringent guidelines previously published due to the lack of evidence for these recommendations. At present, the Irish Department of Health & Children does not provide specific guidelines regarding egg consumption for the general population, but an update of the Irish Food pyramid is expected in the coming year. However, recent guidelines from the Irish Heart Foundation confirm that a healthy individual can have up to seven eggs a week and those on a cholesterol lowering diet can have four to six eggs a week (Irish Heart Foundation, 2008).

The Heart Foundation in Australia has based their recommendations on the recognition that the saturated and trans fat content of the diet is more influential on serum cholesterol levels than dietary cholesterol and therefore advises that *"A healthy balanced diet can include a serving of eggs (two eggs) in two to three meals a week"* (Heart Foundation (Australia), 2008). The American Heart Association guidelines recommend consuming less than 300mg of cholesterol per day however no specific guidelines regarding egg consumption are provided (American Heart Association, 2008). Similarly, in the UK, no specific guidelines regarding eggs are made; instead the emphasis is placed on a reduction of saturated fat intake (British Heart Foundation, 2008).

8. Eggs as a healthy alternative in the diet

Recent qualitative work in Ireland attempted to investigate the attitudes of G.P.s towards eggs and beef (Bord Bia, 2008). Key findings from the survey suggested that G.P.s continue to recommend limiting egg consumption to 2-3 eggs per week due to their opinions on the "saturated fat and cholesterol content of eggs". Roughly over half were aware of recent guidelines to suggest up to 7 eggs per week. However, among those who were aware of these guidelines, only a small proportion was actively encouraging patients to adopt them. There is concern that while an egg in itself may have a reasonably positive nutritional profile, the cooking method is likely to negate this, for example "eggs scrambled with lots of butter and buttery toast". Indeed the cooking method applied can significantly alter the energy and fat content of egg dishes as displayed in **Table 6**. From analysis of foods consumed in combination at the meal level in the NSIFCS, it was found that eggs were commonly consumed with white bread (in 56% of the meals where eggs were consumed, white bread was also consumed), bacon & ham (36%), wholemeal bread (26%) and sausages (24%). Therefore, recommendations on the cooking method and the concomitant intake of other foods should also be provided to the general population.

9. Recommendations & Conclusions

Due to recent scientific evidence on the link between egg intake and health, policies regarding placing a restriction on egg consumption in recent years have relaxed. However, additional studies are warranted to confirm the limited, independent effects of egg consumption on CVD progression. Such evidence would undoubtedly reduce concerns raised by health professionals and consumers in Ireland regarding acceptable egg consumption levels. Before national policies can be relaxed, bodies such as the Irish Heart Foundation will continue to provide specific guidelines regarding egg consumption. Such guidelines in many countries now emphasise a reduction in saturated fat intake due to the undeniable fact that changes in dietary saturated fat have a significant influence on circulating LDL cholesterol to a much greater extent than the dietary cholesterol in foods (Gray & Griffin, 2009). Therefore, it appears that the consumption of 1 egg a day is safe provided it is part of a balanced healthy diet that is overall low in fat (<35% of total energy

from fat) and low in saturated fat (<10% of total energy from saturated fat), high in fibre (i.e. 24g per day) and high in fruit and vegetables (at least 5 portions per day).

In conclusion, eggs are a low-cost, nutrient-dense food and a source of high quality biological value protein and micronutrients. 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.

10. Some Useful websites

www.aecl.org
www.britegg.co.uk
www.eggs.ie
www.eggs.org.nz
www.enag.org.au
www.food.gov.uk
www.incredibleegg.org
www.irishheart.ie
www.nutritionandeggs.co.uk

11. Tables

Table 1: Composition of an egg

Nutrient	Quantity per egg[1]	RDA[2]	% of RDA
Calories	76 kcals	2500 kcals	3%
Total fat*	4.7 g		
Saturated fat*	1.6 g		
Cholesterol	196 mg	300 mg	65%
Protein	6.5 g	52.5 g	12%
Vitamin A	95 µg	700µg	14%
Vitamin D	0.9 µg	0-10µg	
Vitamin E*	0.56 mg		
Vitamin B6	0.06 mg	0.79 mg	8%
Vitamin B12	1.25µg	1.4µg	90%
DHA/ EPA[3]	118 mg	450 mg	26%
Folate	25 µg	300 µg	8%
Thiamin	0.05 mg	1.1 mg	5%
Riboflavin	0.24 mg	1.6 mg	15%
Phosphorous	100 mg	550 mg	18%
Zinc	0.65 mg	9.5 mg	7%
Iron	0.95 mg	10 mg	10%
Selenium	0.55µg	55 µg	1%
Choline*	280 mg*		
Lutein*	150-250 mg**		
Zeaxanthin*	200mg **		

[1]The composition of an egg is based on analysis published in McCance & Widdowson's, the composition of foods, 6th edition (2002).
[2]Requirements of an adult male based on the RDA's for Ireland 1999. Food Safety Authority of Ireland.
[3]Givens D.I. & Gibbs R.A. (2008) Symposium on "How can the n-3 content of the diet be improved?" Current intakes of EPA and DHA in European populations and the potential of animal-derived foods to increase them. Proceedings of the Nutrition Society. **67,** 273-280.
* There are no Irish RDA's available for total fat, saturated fat, vitamin E, choline, lutein and zeaxanthin.
**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).
RDA: Recommended Daily Allowance

Table 2: Additional nutrients required during pregnancy

Nutrient	Additional Requirement During Pregnancy[1]	% Additional RDA Provided by 1 Serving of Egg
Protein	+ 10 g	65%
Iron	+ 1 mg	95%
Folate	+ 200 µg	12.5%
Vitamin B12	+ 0.2 µg	> 100%
Vitamin A	+ 100 µg	95%
Vitamin D	+10 µg	9%

[1]Requirements of a pregnant female (second half of pregnancy) based on the Recommended Dietary Allowances for Ireland 1999. Food Safety Authority of Ireland.
RDA = Recommended Daily Allowance

Table 3: A summary of studies that have examined the functional role of enriched-eggs

Study	Aim	Subjects	Methods and Results
Omega 3 Enriched Eggs			
Riediger *et al.,* 2009 Journal of the American Dietetic Association	A systematic review of the roles of n-3 PUFA in health and disease	Review	Clinical benefits of n-3 PUFA enriched eggs has been shown in individuals with hypertriglyceridemia (high triglyceride levels in blood) as well as healthy individuals. Absorption, distribution & metabolism of the n-3 PUFA remains the same.
Shapira *et al.,* 2008 Israel Medical Association Journal	To evaluate the dietary contribution of 'field fortification' of eggs by adding n-3 PUFA to high n-6 PUFA hen feed and to assess consumer preferences	3,500 laying hens. Randomised control trial	Laying hens fed n-3 PUFA fortified feed or control feed for 5 weeks. Fortified eggs yielded a 3.8 fold increase in total n-3 PUFA. Sensory evaluations were not significantly different between control and fortified eggs. Egg costs increased by 1.5 – 3.0%.
Gillingham *et al.,* 2005 Food Research International	To determine the effects of consuming DHA-enriched eggs on serum lipids and fatty acid compositions in statin-treated hypercholesterolemic male patients	15 subjects Double-blind cross over design	The novel egg group exhibited a significant rise in EPA plus DHA levels in serum phospholipids (by 23%) which can be related to a reduced risk for fatal ischemic heart disease.
Sindelar *et al.,* 2004 Nutrition Research	To compare the effects of the consumption of one n-3 PUFA enriched egg or one conventional egg on serum lipids in physically active adults	12 adults randomly assigned to treatment groups	Dietary intake of α-linolenic acid, DHA and serum α-linolenic acid were higher during the n-3 PUFA–enriched egg treatment than during the conventional egg treatment ($P< 0.05$). Serum triglycerides were higher ($P< 0.05$) with n-3 PUFA–enriched eggs than with conventional eggs.
Lutein Enriched Eggs			
Goodrow *et al.,* 2006 Journal of Nutrition	To investigate the effect of consuming one egg/day for 5 weeks on serum concentrations of lutein and zeaxanthin in adults >60yrs	Randomised cross-over, n=33, intervention	The 18-wk intervention included one run-in and one washout period of no eggs prior to and between two 5-week interventions of either consuming 1 egg or egg substitute/d. Serum lutein and zeaxanthin levels increased by 26% and 38% respectively in the intervention group. Serum total cholesterol, LDL cholesterol, HDL cholesterol and triglycerides were not affected.
Wenzel *et al.,* 2006 Journal of Nutrition	To identify whether a 12-week egg intervention increases serum zeaxanthin and macular pigment optical	24 females, aged 24-59 years.	Subjects were assigned to 1 of 3 groups. Group 1= PILL (sugar-filled capsule). Group 2 = EGG 1 (6 eggs/week with 331µg of lutein & zeaxanthin per egg yolk). Group 3 = EGG 2 (6 eggs/week with 964µg of lutein & zeaxanthin per egg yolk). Serum zeaxanthin, but not serum lutein, increased in both the EGG 1

	density in women		(P <0.04) and EGG 2 (P <0.01) groups
Chung *et al.*, 2004 Journal of Nutrition	To compare the bioavailability of lutein from various sources such as supplements, lutein-enriched eggs & spinach	Healthy men, n=10 intervention cross-over design, 9d study	Subjects were administered 1 of 4 lutein doses: lutein supplement, lutein ester supplement, spinach or lutein-enriched egg. Results showed that serum lutein responses were significantly higher after the lutein-enriched egg compared to any other form. There was no significant difference in triacylglycerol rich lipoproteins levels between all forms.
Folate Enriched Eggs			
Hoey *et al.*, 2009 British Journal of Nutrition	To develop eggs with an enriched natural folate content and minimal unmetabolised folic acid	48 laying hens randomised, 12 weeks	Hens were randomised to receive the basal feed to which had been added one of the following folic acid (FA) levels (0, 2, 4, 8, 16, 32 mg/kg feed). The maximal egg folate content was achieved by adding 16mg FA/kg feed. The folate enrichment of eggs resulted in the folate content of an average-sized egg ranging from 32 to 75 µg.
Roth Maier & Bohmer 2007 International Journal of Vitamin and Nutrient Research	To evaluate the fortification of eggs with folic acid as a possible contribution to enhance the folic acid status of populations	72 hens	Hens were assigned to 1of 5 dietary groups and supplemented with 0, 0.5, 1.0, 2.0, and 4.0 mg folic acid/kg feed during an 8-week period. The availability of folate in eggs increased by 68%. One folate-enriched egg could provide up to 76 µg of folate.
Herbert *et al.*, 2005 Poultry Science	To determine the effects of folic acid supplementation on egg folate content and the performance of folate status on two strains of laying hens	Hyline W36 and W98 hens (n=6 per diet)	Supplementation of FA in laying hens led to an increase in egg folate content and plasma folate levels and decreased homocysteine concentrations. The higher egg mass producing strain, Hyline W98, benefited from increased folic acid through a reduction in plasma homocysteine concentrations, suggesting that this strain has a higher requirement for folate than the W36 strain.
House *et al.*, 2002 Poultry Science	To assess the enrichment of eggs with folic acid through supplementation of the laying hen's diet	140 Hyline W36 laying hens, 25 to 28 weeks old at peak levels of production	The study consisted of 3 experiment groups. Group 1: Hens received feed with 0-10mg/kg crystalline FA. Group 2: Hens divided into 7 treatment groups and feed was fortified with 0, 1, 2,4,8,16,32 mg folic acid/kg diet. Group 3: Hens received a barley based feed with or without 4 mg folic acid/kg diet. Results: Group 1: A 10mg/kg inclusion of folic acid increased folic acid incorporation into the egg over that of an un-supplemented egg. Group 2: The response of egg folate to dietary folic acid supplementation was saturable, with 90% of maximal egg folate levels established at approximately 4mg FA/kg diet. Group 3: Folate levels were stable, in control and fortified eggs, during 28d of storage at 4 C.

Table 4: Mean, SD, Median and Percentile Intakes of Eggs and Egg Dishes (gram/day) in Irish Adults and Children by Sex and Age Group

Population Group	Total Sample					Consumers Only					
				Percentile						Percentile	
	n	mean	SD	5th	95th	n	%	mean	SD	5th	95th
All Adults (18-64 years)	1379	17	21	0	54	944	68	25	22	7	61
All Men (18-64 years)	662	21	23	0	61	489	74	28	23	7	70
Men (18-35 years)	253	19	22	0	60	178	70	26	21	4	66
Men (36-50 years)	236	21	23	0	66	178	75	28	23	8	72
Men (51 - 64 years)	173	24	26	0	66	133	77	31	26	6	82
All Women (18-64 years)	717	14	19	0	45	455	63	22	19	6	54
Women (18-35 years)	269	13	21	0	45	161	60	22	23	7	49
Women (36-50 years)	286	14	17	0	45	186	65	21	17	6	55
Women (51-64 years)	162	15	17	0	54	108	67	22	16	5	57
All Teens (13-17 years)	441.0	8	14	0	38	181	41	20	16	7	54
All Boys (13-17 years)	220.0	11	17	0	50	111	50	22	18	7	58
Boys (13-14 years)	93.0	12	20	0	58	47	51	25	22	7	82
Boys (15-17 years)	127.0	10	14	0	41	64	50	20	14	6	51
All girls (13-17 years)	212.0	6	11	0	34	70	33	18	13	7	44
Girls (13-14 years)	91.0	5	8	0	22	31	34	13	8	6	34
Girls (15-17 years)	121.0	7	12	0	42	39	32	21	15	7	51
All Children (5-12 years)	594	8	13	0	36	251	42	18	14	4	47
All Boys (5-12 years)	293	8	13	0	36	119	41	19	13	4	43
Boys (5-8 years)	145	8	13	0	33	59	41	19	13	4	41
Boys (9-12 years)	148	7	13	0	38	60	41	18	14	4	46
All Girls (5-12 years)	301	8	13	0	37	132	44	18	14	4	51
Girls (5-8 years)	151	7	13	0	33	65	43	17	15	3	53
Girls (9-12 years)	150	8	13	0	40	67	45	18	14	4	49

SD: Standard deviation

Table 5: Egg consumption and cholesterol studies

Study	Aim of study	Subjects	Results & Conclusions
Gray & Griffin, 2009. Nutrition Bulletin.	Review of the link between eggs and dietary cholesterol	Review	There is no consistent evidence in the last 30 years of prospective studies that egg consumption has an independent association with increased risk of heart disease. The relatively small increase in circulating cholesterol associated with egg consumption does not correspond with CVD risk
Djousse & Gaziano 2008. American Journal of Clinical Nutrition	To examine the association between egg consumption and risk of CVD and mortality	Prospective cohort study of 21,327 male subjects Physicians Health Study 1	Infrequent egg consumption (<6 eggs/week) was not associated with CVD. However >7 eggs /week was associated with modest but significantly higher risk of mortality. There was a greater risk of CVD with egg consumption among diabetics. However numerous limitations exist in this study including a failure to exclude confounding factors
Harman *et al.*, 2008. European Journal of Nutrition	To determine the combined effects of increased dietary cholesterol and weight loss produced by energy restriction on plasma LDL cholesterol and lipoproteins	45 subjects randomised controlled parallel study, energy restricted diet 12 weeks	An increased intake of dietary cholesterol from 2 eggs/day did not increase total plasma or LDL cholesterol when accompanied by energy restriction and moderate weight loss
Ratliff *et al.*, 2008 Nutrition & Metabolism.	To examine the effects of eggs on adiponectin (marker of insulin sensitivity) and on inflammatory markers in the context of CVD	28 US overweight men aged 40-70years.	A CRD with daily intake of eggs decreased plasma CRP and increased plasma adiponectin compared to a CRD without eggs
Qureshi *et al.*, 2007 Medical Science Monitor.	To examine the association between egg consumption and risk of CVD and mortality	9734 adults 25-74 years, NHANES-1 study (1971-75)	No increased risk of stroke or CVD with consumption of >6 eggs per week or $\geq$1 egg per day. However, there was an increased risk of CVD associated with higher egg consumption in diabetics
Lee & Griffin, 2006. Nutrition Bulletin.	Review of dietary cholesterol, eggs and CVD risk	Review	Epidemiological studies have found no independent relationship between dietary cholesterol or egg consumption and CVD risk. A moderate consumption of eggs (1-2 per day) should be encouraged as part of an energy-restricted weight-losing dietary regimen
Nakamura *et al.*, 2006. British Journal of Nutrition	Examined the association between egg consumption and total cholesterol concentration with the risk of CVD	90,735 subjects, 40-69 years, Japan health centre-based prospective study	Egg consumption was not associated with the risk of CVD. There was also an inverse correlation between egg consumption and mean total cholesterol concentration

CVD = Cardiovascular Disease Risk; LDL = Low Density Lipoprotein; CRP = C-reactive protein; CRD = Carbohydrate Restricted Diet

Table 6: Energy and fat composition of common egg dishes

Egg Dish[1]	Average Portion (g)	Energy (Kcals)	Total Fat (g)	Saturated Fat (g)	Cholesterol (mg)
Hard boiled egg	50g	74	5.4	1.6	193
Poached Egg	50	74	5.4	1.6	193
Egg fried in vegetable oil	60	107	8.3	2.4	261
Scrambled egg with milk & butter	134	412	39.7	21.2	463
Omelette with cheese	120	324	27.6	14.6	322
Quiche Lorraine	140	501	35.7	14.8	162

[1]Average weight of egg dishes obtained from Food Standards Agency, Food Portion Sizes 3rd Edition (2002) London TSO, pp38. The composition of an egg is based on analysis published in McCance & Widdowson's, the composition of foods, 6th edition, 2002

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