

EGGS

ARE THEY NATURE'S MULTIVITAMIN?

A report for health professionals by **Dr Carrie Ruxton**, Registered Dietitian





FOREWORD

Carrie Ruxton PhD, RD

Eggs have seen a revival in the UK since the 1990s when the Lion Scheme was brought in to control Salmonella levels in flocks. This was an unqualified success resulting in British Lion eggs ranking amongst the safest in the world, as noted just last year by an influential government committee.

In recent years, eggs have also found favour with health professionals both in the UK and USA when out-of-date advice to restrict egg consumption due to fears about cholesterol was finally overturned. This has given the green light to egg lovers to enjoy their favourite dish as often as they like.

Nowadays, the safety of British-produced eggs is taken for granted which has shifted the focus of our interest to the nutrient content and how eggs fit within a balanced diet. As recent government data show, eggs are a veritable natural pharmacy of vitamins, minerals, fatty acids and protein, putting them on par with most of today's superfoods. Yet, eggs are much more affordable and versatile.

In this report, commissioned by the **British Egg Industry Council (BEIC)**, we will not only consider the nutrient content of eggs but look in detail at the growing scientific literature which links regular egg consumption with tangible outcomes such as satiety, weight management, muscle function and vascular health. We hope this fascinating research persuades you to look anew at the humble egg!

AS RECENT GOVERNMENT DATA SHOW, EGGS ARE A VERITABLE NATURAL PHARMACY OF VITAMINS, MINERALS, FATTY ACIDS AND PROTEIN, PUTTING THEM ON PAR WITH MOST OF TODAY'S SUPERFOODS.

INTRODUCTION

Eggs have been recognised as a nutrient-rich food for thousands of years, with evidence that fowl were domesticated for their eggs and meat in Egypt and India as far back as 3200BC. The Romans found a nation of hen keepers, rather than warriors, when they arrived in England in 1400BC¹.

Recently, it has been reported that Brits consume 34 million eggs a day, either as part of a meal or as an ingredient in pre-prepared foods such as quiche or sandwiches, with more than eight in ten eggs produced here in the UK. The market has been growing steadily by around 2% annually². The National Diet and Nutrition Survey (NDNS)³ reveals that during the four day dietary assessment period, 30-60% of participants from toddlers to elderly consumed eggs.

Consumption of egg and egg dishes (grams per day)

Age range (years)	Males			Females		
	4-18	19-64	65+	4-18	19-64	65+
Including non-consumers	12	23	20	11	18	22
Consumers only	32	48	36	30	39	32

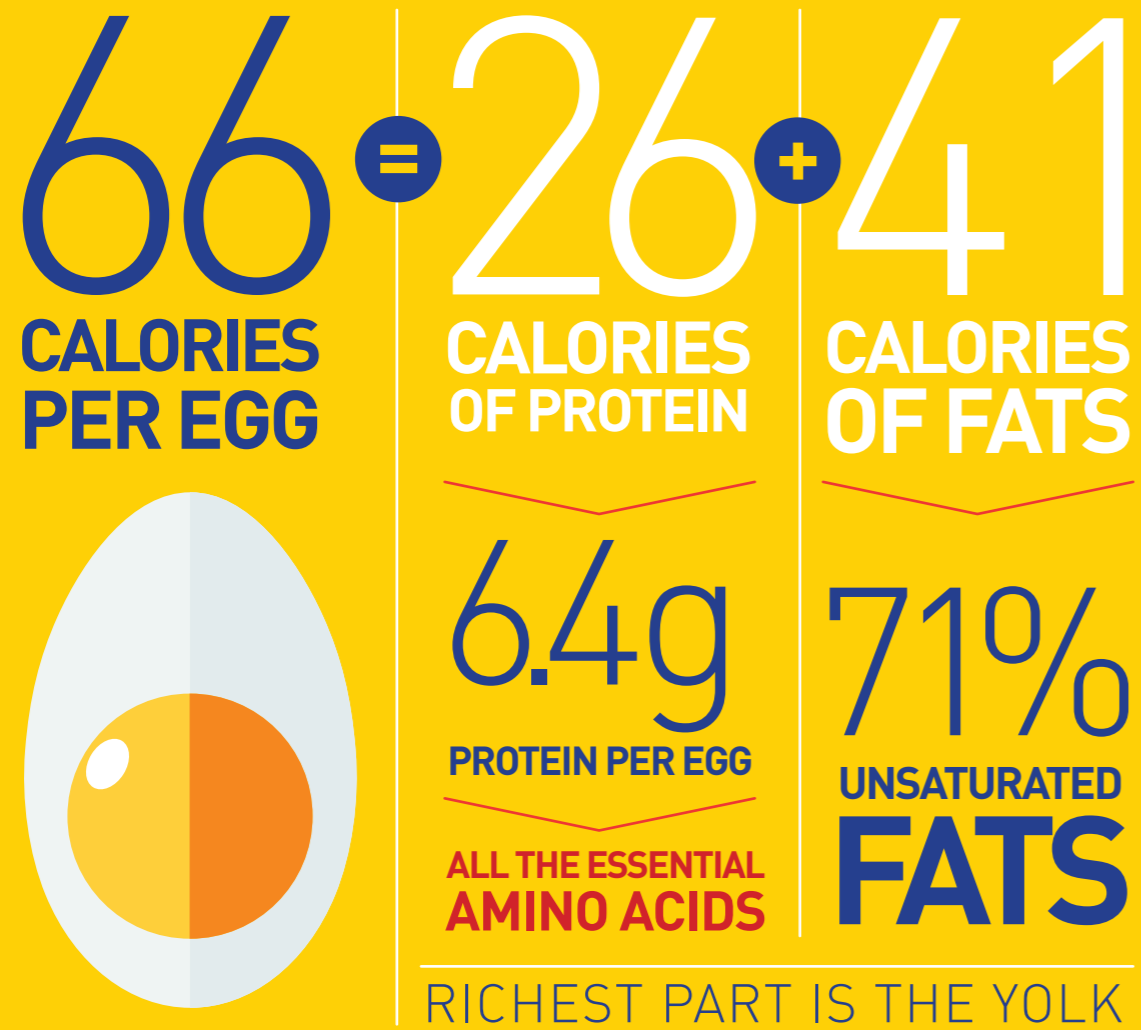
The main reasons for this success story are current high safety standards combined with recent advances in science which, around 10 years ago, resulted in a U-turn on the advice given by heart charities and government relating to eggs. Where previously, adults were asked to restrict weekly egg consumption due to fears about the cholesterol content, scientific studies have since proven that dietary cholesterol (e.g. from prawns or eggs) has no meaningful impact on blood cholesterol nor risk of heart disease⁴.

So, eggs are no longer limited and people of all ages can enjoy them as much as they like within a healthy balanced diet. Yet, as this report will set out, the evidence is now pointing towards a specific role for eggs in health, as Nature's very own multivitamin. This may mean that health professionals could be justified in actively promoting the consumption of eggs.

PERFECT PROTEIN

Hens' eggs are known for their high quality protein and indeed are used as the reference standard against which all other foods are assessed, as well as a favoured food for sports enthusiasts. This is due to their essential amino acid profile and the high digestibility of egg protein.

In 2013, an updated nutrient composition for UK eggs was published by the Department of Health⁵, providing new data for the food tables used by academics and health professionals. Since the last analysis in the 1980s, levels of energy, fat, saturated fat and cholesterol have reduced due to changes in the size of eggs as well as poultry feeding, while protein has remained constant.⁶ An average medium-sized egg (contents 58g) now provides 66kcal, 4.6g fat, 1.3g saturates and 177mg cholesterol (previous figures were 78kcal, 5.8g, 1.7g and 202mg respectively).

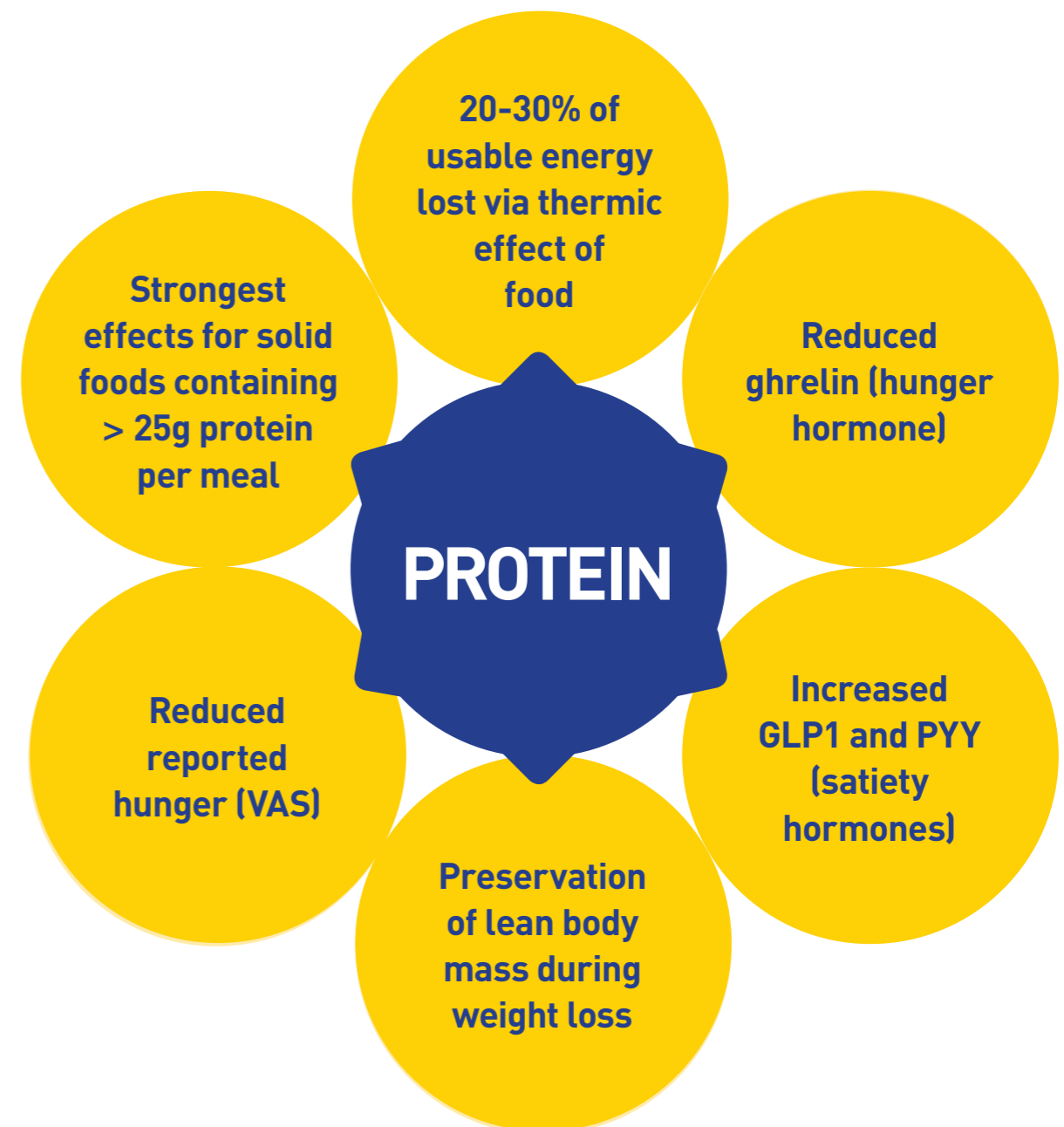


Interest in the role of protein in health has gone way beyond traditional views about how protein contributes to growth and repair. In the last couple of decades, two new areas of protein research have emerged relating to satiety and prevention of age-related muscle decline, often called sarcopenia.

SATIETY: THE POWERFUL ROLE OF PROTEIN

With rising obesity levels in Western countries, scientists have been searching for nutrients and foods that could help curb appetite and support body weight control. More than 20 years ago, protein was identified as a candidate nutrient.

Protein has several advantages – it isn't stored in the body, it boosts the thermic effect of food (energy given off after meals) and it alters the balance of hormones responsible for hunger and satiety (the feeling of fullness experienced after eating). Research⁷ suggests several ways that protein could impact positively on satiety and weight control as summarised below.



In the past 10 years, eight randomised controlled trials have examined the potential impact of eggs on satiety and weight management (see Appendix 1). The methodology of studies typically involves a test meal (e.g. breakfast or lunch) followed by visual analogue scales (VAS) which estimate hunger, satiety and desire to eat. Later on, another meal can be given to establish whether the high protein test meal promotes lower calorie consumption. Pre- and post-meal hormone levels are often measured.

In studies of less than four days duration, egg consumption at a test meal appears to influence levels of appetite hormones and reported hunger and fullness. However, energy intake at a subsequent meal is not typically affected, except in studies involving normal weight men. This could be because lean men are better at responding to hunger and satiety cues. In longer term studies, the short-term

impact of egg consumption on appetite control appears to influence calorie intake since one study found differences in evening snacking⁸, while another reported statistically significant reductions in body weight and fat loss⁹.

ONE STUDY SHOWED THAT EGG PROTEINS WERE BROKEN DOWN AND METABOLISED MORE SLOWLY THAN COMPARABLE PROTEINS, SUGGESTING UNIQUE EFFECTS ON APPETITE HORMONE PRODUCTION.

It is clear in these studies that consumption of eggs – a high protein food with the complete range of amino acids – is consistently influencing hunger and satiety as well as appetite hormones. While eggs are not unique in providing high quality protein, the specific balance of amino acids in eggs could make them particularly suitable for weight control. In a trial which compared eggs with cottage cheese¹⁰, both containing similar amounts of total protein, the amino acids in eggs were broken down and metabolised more slowly, potentially influencing which hormones are activated at specific time points after eating a meal.



PROTEIN FOR HEALTHY AGEING

Sarcopenia (muscle loss) is a common disorder in older people leading to falls and loss of mobility. Inflammation¹¹ and reduced muscle protein synthesis are key causes of this condition.

Evidence suggests that a high protein diet – particularly one containing high biological value protein – can stem the age-related decline in muscle tissue. The effects are strongest when protein consumption is combined with resistance training exercise. A meta-analysis¹² found that the amino acid, leucine, was 8% more likely to stimulate muscle protein synthesis compared with other amino acids. Eggs are one of the richest sources of leucine. Indeed, a recent review¹³ concluded that eggs could play an important role in boosting the protein content and nutritional value of older people's diets. This will be studied further during a BEIC-funded PhD

study at Bournemouth University which will look at nutritional benefits when elderly people are encouraged to eat more eggs. The results of this study are eagerly awaited as it is the first time that the impact of regular egg consumption on markers of sarcopenia has been tested.

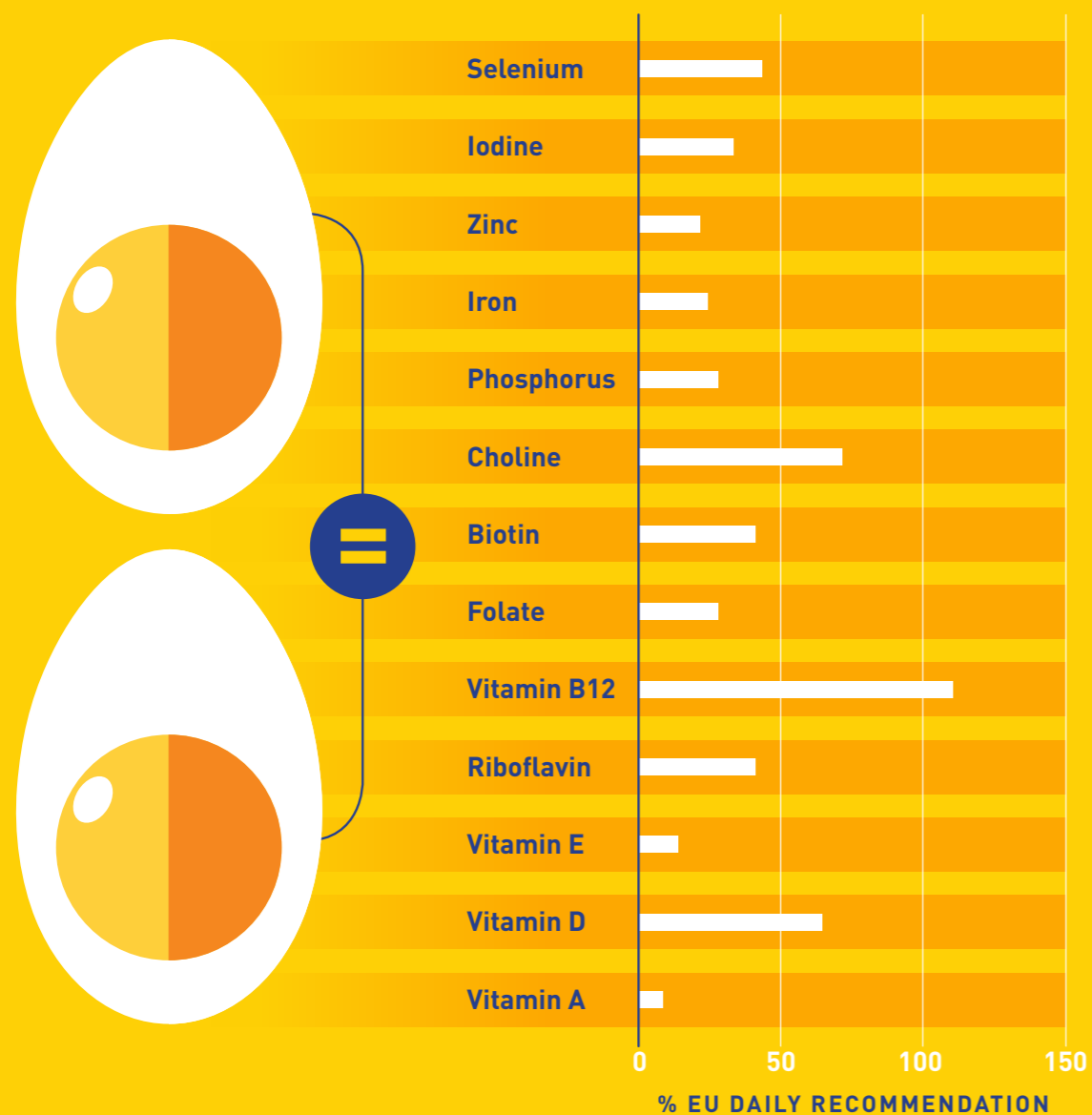
Eggs could also play a role in supporting brain and cognitive function during ageing. In an observational study of 2497 dementia-free middle-aged men¹⁴, egg intake was statistically associated with better performance on neuropsychological tests of the frontal lobe and executive functioning. The mechanism may relate to choline and, indeed, this was an ingredient in a medical nutrition product which slowed cognitive decline in patients with early stage Alzheimer's¹⁵. Choline is also used in drugs for treating cognitive disturbances in the elderly.

A META-ANALYSIS¹² FOUND THAT THE AMINO ACID, LEUCINE, WAS 8% MORE LIKELY TO STIMULATE MUSCLE PROTEIN SYNTHESIS COMPARED WITH OTHER AMINO ACIDS.



VITAMINS, MINERALS AND MORE

While the protein content of eggs is well known, this isn't the case for the vitamins, minerals and fatty acids. Yet, eggs are a very rich source of specific nutrients as shown below, e.g. **a portion of two eggs provides 100% of the European Nutrient Reference Value (NRV) for vitamin B12 and over 60% of the NRV for vitamin D** (although in the UK this would be 32% as the recommendation has recently increased to 10 micrograms).

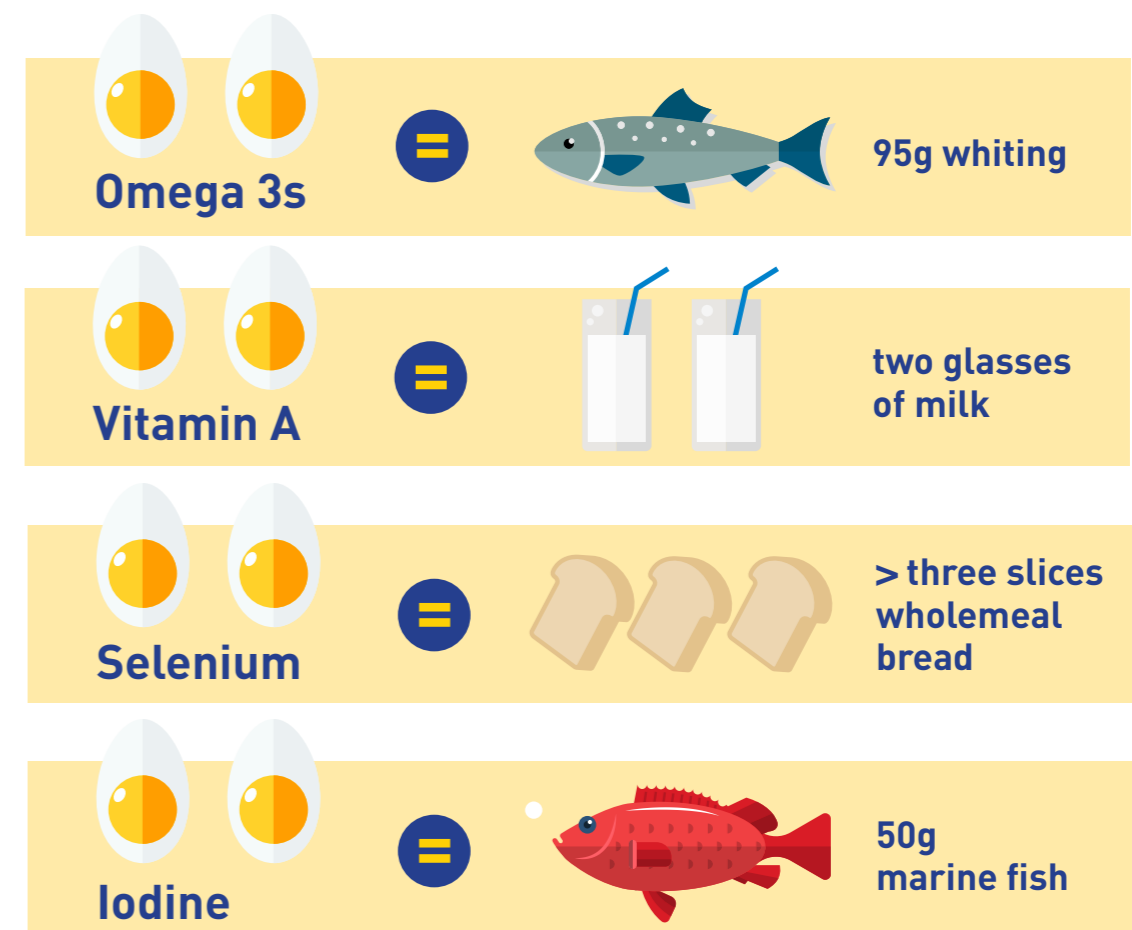


B VITAMINS

B vitamins support normal energy release, psychological/nervous function and reduce tiredness and fatigue¹⁶. In addition, riboflavin supports skin and eye health and is an antioxidant, while both vitamin B12 and folate support normal immune function. Folate contributes to maternal tissue growth during pregnancy and normal cell division, underpinning its role in preventing foetal neural tube disorders¹⁷.

Intakes of B vitamins are within recommended levels for the majority of people in the UK, although folate intake and status are low in girls and women of childbearing age. Eggs are one of the few protein-rich foods that also supply a recognised source of folate.

Two eggs provide:



VITAMIN D

This contributes to the absorption/utilisation of calcium and phosphorus, helping to support normal bone development in children and maintain normal bones and teeth throughout life. Vitamin D is also important for normal muscle function and immune function and can help reduce the risk of falls in the elderly¹⁸. Year-round supplementation with vitamin D is advised during pregnancy, lactation, early life and old age due to these health requirements. Given the low vitamin D status across the UK population (up to 20% insufficiency in summer rising to 40% in winter/spring), there is a need for everyone to consume more vitamin D¹⁹. After oily fish, eggs are the richest natural source of this vitamin, and contain the more bioavailable form of D3.

CHOLINE

Choline is a vitamin-like compound used to synthesise phospholipids, a component of cell walls, and the neurotransmitter acetylcholine, both of which play a vital role in brain activity and development. Choline donates methyl groups to DNA, helping to silence genes that may be detrimental to health.

While the benefits of choline are not fully understood, there is evidence that experimental depletion of choline leads to liver damage²⁰, while high choline intakes are associated with a reduction in inflammation, homocysteine levels (a risk for heart disease), and breast cancer risk²¹. An observational study in 1391 older adults found that higher choline intakes were related to better cognitive performance²². Adequate intakes for choline were set in 2016 for adults (400mg), pregnancy (480mg) and lactation (520mg)²³. The higher levels in pregnancy and lactation reflect increased requirements for foetal brain development and breast milk production. Two eggs provide 72% of the adult recommendation, with eggs and liver representing the best dietary sources.

Few interventions with choline have been done. One randomised controlled trial²⁴ supplemented 99 pregnant women with 750mg phosphatidylcholine daily from 18 weeks gestation until 90 days after delivery. While the choline content of breast milk improved, no effects were seen on infant memory or language development, perhaps because women in the study were already consuming 80% of the choline requirement for pregnancy. Another study in older people with early stage dementia reported significant improvements in cognitive function following supplementation with 400mg choline alfoscerate for 180 days²⁵.

**A STUDY FOUND
PROVED COGNITIVE
FUNCTION IN OLDER
PEOPLE WITH EARLY
STAGE DEMENTIA
FOLLOWING CHOLINE
SUPPLEMENTATION.**

SELENIUM

Selenium is vital for normal hair, nails, and immune function. It is also a powerful antioxidant. Around half of women and girls, and a quarter of men, have intakes of selenium below the Lower Reference Nutrient Intake (LRNI)²⁶, a level that indicates a risk of deficiency. Selenium intakes in the UK are affected by low soil levels which restrict the selenium in grains and meat/milk. The implications of this are unclear since data on selenium status suggest that current intakes are consistent with normal health. However, observational studies have reported associations between a poor selenium status and an increased risk of cancer and heart disease²⁷. Two eggs provide 44% of the selenium NRV.

IODINE

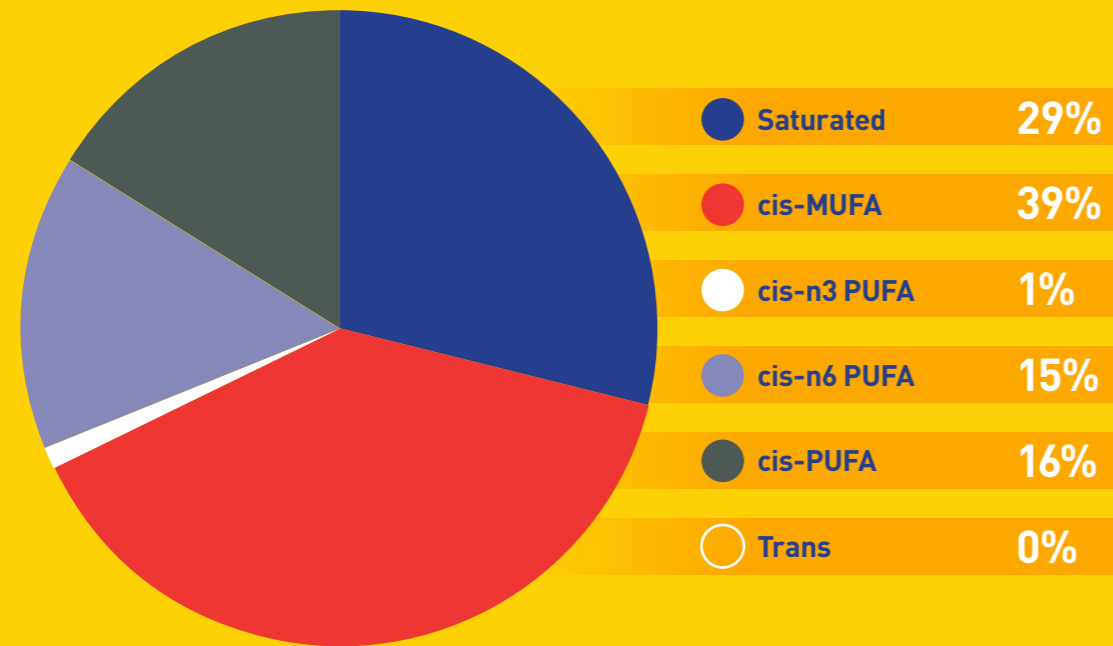
Iodine contributes to cognitive function and thyroid function. Around 20% of teenage girls and 9% of women have intakes of iodine that fail to meet the LRNI. In addition, low iodine status has been identified as an issue in the UK and may impact on child cognition. Iodine deficiency has been found in up to 40% of pregnant women in some UK studies, and may be associated with low birth weight and delays in infant neurological and behavioural development²⁸. Two eggs provide a third of the NRV for iodine.

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FATTY ACID BALANCE

Nearly two thirds of the calories in eggs come from fats but these are mostly the healthy unsaturated fats, polyunsaturated fatty acids (similar to those in vegetable oil) and monounsaturated fatty acids (similar to those in olive oil). Less than a third of the fats in eggs are saturated as shown in the chart below.



**EGGS CONTAIN
130MG OF OMEGA-3
FATTY ACIDS PER 100G
OF EDIBLE WEIGHT.
THE PRIMARY OMEGA-3
FATTY ACIDS IN EGGS IS
DOCOSAHEXAENOIC ACID
AND IS OF A SUFFICIENT
LEVEL TO QUALIFY
AS A 'SOURCE' IN
EU LAW.**



EU HEALTH CLAIMS

According to European Nutrition and Health Claims regulations, eggs are officially 'high' in protein, 'a source' of vitamin A, folate, choline and phosphorus, and 'rich in' vitamin D, riboflavin, vitamin B12, biotin, selenium and iodine.

Meeting the minimum criteria for a source of these nutrients allows eggs to make a series of authorised health claims which are summarised in the table below.

Nutrient	Authorised health claim
Protein	Growth and maintenance of muscle mass Maintenance of normal bones
Docosahexaenoic acid (DHA)	Maintenance of brain function Normal brain development of the foetus & breastfed infants
Choline	Normal liver function & blood lipid metabolism
Vitamin A	Normal skin, vision and immune function
Riboflavin	Normal energy metabolism, psychological function, skin, vision & red blood cells Protects cells from oxidative stress
Biotin	Normal energy metabolism, psychological function, skin & hair
Folate	Contributes to blood cell formation, tissue growth during pregnancy, normal immune function & psychological function Helps reduce tiredness & fatigue
Vitamin B12	Normal energy metabolism, psychological function, nervous function & immune function Helps reduce tiredness & fatigue
Vitamin D	Maintenance of normal bones, muscle function & immune function Boosts calcium and phosphorus absorption & utilisation Helps prevent falls in older people
Iodine	Normal cognitive function, nervous function & skin
Phosphorus	Normal bones & teeth
Selenium	Normal hair, nails, spermatogenesis, immune function & thyroid function Protects cells from oxidative stress (antioxidant)

SAFETY OF EGGS

From time to time, concerns have been expressed about the safety of egg consumption in certain vulnerable groups, e.g. pregnant women, infants and the elderly. In the case of British Lion eggs, which benefit from strict microbiological control, these fears are misplaced. Previous views on allergy risk in young children are also now being challenged while new data on the lack of association between dietary cholesterol and chronic heart disease risk suggest that eggs are safe for everyone. These aspects will now be considered.

MICROBIOLOGICAL CONCERNS

Previous NHS and Food Standards Agency (FSA) advice to vulnerable consumers was that eggs should be consumed fully cooked to ensure that any risk of microbiological contamination was minimised. This meant no runny yolks for those who loved them. However, on-going surveillance in the past decade has revealed an absence of harmful bacteria in British Lion eggs, thanks to a comprehensive programme of hen vaccination and farm controls.

The most recent report from the influential Advisory Committee on the Microbiological Safety of Foods in 2016²⁹ noted the following:

- **There has been a major reduction in the risk from salmonella in UK hens' eggs since 2001**
- **This is especially the case for eggs produced under the Lion Code, or equivalent schemes**
- **It is recommended that these eggs could be served raw or lightly cooked to both those in good health and those in more vulnerable groups.**

The ACMSF report is now being considered by the Food Standards Agency and an announcement on the revised consumer advice is expected during 2017.



ALLERGY CONCERNS

Egg allergy affects a small percentage of young children (<2%) and even fewer adults (<0.1%). Despite this, misconceptions about allergy often mean that parents are reluctant to introduce eggs into the weaning diet as shown by a 2013 poll of 500 mums and by data from the Diet and Nutrition Survey of Infants and Young Children. A secondary analysis of this showed that less than 10% of babies were consuming egg at 6 months and only 40% of mums were regularly feeding their babies eggs at 17 months, citing allergy/fear of allergy as the main reason for avoidance³⁰.

Challenge to this view has come from the *Enquiring About Tolerance (EAT)* study which was a randomised controlled trial involving 1300 infants³¹. The aim was to examine the prevalence of food allergy following the introduction of common allergens either after six months of age as currently recommended, or between four and six months. The results revealed an overall trend that introducing cooked egg and peanut butter between four and six months reduced the risk of allergy to these foods. However, there was no impact on risk of allergy when wheat, dairy foods, sesame or fish were introduced prior to six months. The EAT study supports the findings from a previous Australian study of 2589 infants³² which found additionally that duration of breastfeeding and age at weaning had no impact on the risk of egg allergy. These results are being considered in an update of government weaning policy by the Scientific Advisory Committee on Nutrition.

A POLL OF 500 MUMS FOUND THAT ONLY 16% WOULD INCLUDE EGGS AS A WEANING FOOD, WHILE 30% SAID THEY WOULD FEED EGGS AFTER THEIR BABY REACHED 12 MONTHS.



CHOLESTEROL CONCERNS

Like prawns and liver, eggs are high in cholesterol, although levels per 100g have reduced slightly since 1990. In the 1970s, it was believed that dietary cholesterol could push up blood cholesterol levels, creating a risk for cardiovascular health. However, new evidence in the past 15 years reveals that this is not the case for most people – the exception being the small proportion of individuals with a genetic condition called familial hypercholesterolaemia.

Instead, certain types of saturated fatty acids are thought to negatively affect blood cholesterol.

So, what does this mean for eggs? A review of egg intervention studies found that giving a cholesterol challenge, using high amounts of eggs, for up to

6 weeks, either had no impact on blood cholesterol or vascular function, or for the few people who responded, increased both 'bad' LDL cholesterol and 'good' HDL cholesterol at the same time which preserved the proper ratio between these lipoproteins³³. The growing data suggesting no effect from eggs has filtered through to public health advice in the US and the UK which both dropped their advice to limit egg consumption around 2008. Nowadays, in these countries, there are no limits to how many eggs can be eaten³⁴, and recognition given to the positive role of eggs in reduced fat, heart health diets.

Another area of controversy for cholesterol is type 2 diabetes. This was prompted by several observational studies reporting statistical associations between high egg consumption and risk of type 2 diabetes³⁵, as well as risk of cardiovascular mortality in people with

diabetes³⁶. However, other observational studies have found no associations with egg consumption, for example a European study of 15,956 healthy adults followed for 7 years found similar rates of subsequent type 2 diabetes when consumption of >4 eggs a week was compared with <1 egg a week³⁷. It is worth noting that observational studies are uncontrolled and can't be used to determine cause and effect, therefore it is possible that the association with eggs is due to other factors, e.g. fried foods traditionally eaten alongside eggs.

Turning to the potential risk of egg consumption in people with pre-existing type 2 diabetes, the underlying theory is that these patients respond differently to dietary cholesterol. This may not be the case according to a study which argued that people with insulin resistance who were given eggs appeared to be resistant to the effects of dietary cholesterol³⁸.

The issue has been considered by two randomised controlled trials which tested the impact of high egg diets on cardiovascular risk in diabetic populations. In the first³⁹, 140 people with type 2 diabetes were randomised to consume a high egg (>12/week) or a low egg (<2/week) diet for 3 months. No differences were found in lipid profile or glycaemic control at the end of the intervention. Interestingly, people in the high egg group reported less hunger and greater satiety post-breakfast. In the second trial⁴⁰, 65 participants with type 2 diabetes or impaired glucose tolerance consumed 14 eggs/week or 100g lean animal protein for 12 weeks. While both groups showed improved glycaemic and lipid profiles, blood pressure and Apo-B, results were better for the high egg diet.

In contrast to the epidemiology, these studies suggest that eggs have a positive impact on health in people with type 2 diabetes.

IN CONTRAST TO THE EPIDEMIOLOGY, RANDOMISED CONTROLLED TRIALS SUGGEST THAT EGGS HAVE A POSITIVE IMPACT ON HEALTH IN PEOPLE WITH TYPE 2 DIABETES.

WHERE NEXT FOR EGGS?

Eggs will continue to be of interest to scientists and, given their rich nutritional profile, it is possible that studies will reveal new benefits for regular egg consumption. Two recent studies give us a flavour of future evidence.

In an observational study published in 2017, researchers tracked the diets and health of 2,497 healthy middle-aged men⁴¹. Egg intake was statistically associated with better performance on neuropsychological tests of the frontal lobe and executive functioning. While again it should be recognised that observational trials can't prove cause and effect, the findings are interesting because of what we know about the impact of choline on brain health, particularly in relation to prevention of dementia. Choline is already used in therapeutic interventions for cognitive function support in the elderly.

A meta-analysis⁴² was published at the end of 2016, which pulled together

prospective cohort studies which tracked diets and disease risk over time. Seven studies were located for which data on eggs were available. These suggested that daily egg consumption was linked with a 12% reduction in the risk of stroke, while no significant associations were seen for heart disease risk. This backs up an earlier review⁴³ of experiments which showed that high egg diets had no impact on cholesterol or vascular function in humans.

As the evidence on food safety and allergy continues to develop, it is likely that future advice to parents will include the promotion of eggs as a nutritious weaning food, to be offered from six months onwards. Following the safety report by the Advisory Committee on the Microbiological Safety of Foods in 2016⁴⁴, it is highly likely that official recommendations on partially cooked eggs for vulnerable groups will change to enable parents to offer runny eggs to their babies and young children.

CONCLUSION

This report has reviewed the evidence on eggs, showing clearly how eggs can contribute to nutrient intakes, as well as impact positively on health. Eggs are a low cost, yet high quality protein source, and should be recommended as a suitable and beneficial food for people of all ages – perhaps as Nature's unique multivitamin. Certainly, when compared with other so-called superfoods, eggs provide a unique combination of protein, vitamins, minerals and fatty acids – at a lower cost to the consumer.



Appendix 1: Randomised controlled trials on eggs, satiety and weight management

Reference	Intervention	Significant findings
Liu	RCS; n=28 children; 1d; eggs vs. bagel at BK	PYY ↑ after eggs but no differences in hunger, satiety or EI at lunch
Marsset-Baglieri	RCS; n=30 adults; 1d; eggs vs. cottage cheese as snack (matched for kcal and macronutrients)	Slower amino acid release and timing of satiety hormones after eggs but no differences in satiety or EI at later meal
Pombo-Rodrigues	RCS; n=31 adults; 1d; eggs vs. jacket potato vs. chicken sandwich at lunch following standard BK	Eggs lunch ↑ satiety vs. potato lunch but no differences in EI at evening meal
Ratliff	RCS; n=20 men; 1d; eggs vs. bagel at BK	Eggs BK ↑ satiety ↓ hunger ↓ EI at lunch compared with bagel BK
Fallaize	RCS; n=30 men; 3d; eggs vs. cereal vs. croissant at BK	Eggs ↑ satiety ↓ hunger ↓ desire to eat ↓ EI at lunch
Leidy	RCS; n=20 girls; 7d; isoenergetic high protein BK (eggs/beef) vs. low protein BK (cereal) vs. no BK	BK better than no BK for appetite control. High protein performed best for satiety, control of evening snacking and reward signals as measured by fMRI
Bayham	RCS; n=20 overweight/obese adults; 7d; eggs vs. cereal at BK	↑ fullness after eggs but no impact on EI at lunch. Ghrelin ↓ (day 1) PYY ↑ (day 1, day 7)
Vander Wal	RCT; n=152 overweight/obese adults, 3 months. Half randomised to lower kcal diet (eggs vs. bagel for BK on 5d of week); half followed eggs or bagel <i>ad libitum</i> diet	When kcal restricted, eggs diet performed better for weight loss (1kg difference over study), waist circumference, % body fat. No differences in ad libitum eggs vs. bagel BK. No differences in blood lipids

Key: BK, breakfast; d, days; EI, energy intake; fMRI, functional magnetic resonance imaging (to test for reward signals in the brain); kcal, kilocalorie; RCS, randomised crossover study; RCT, randomised controlled trial.

Note: ghrelin and PYY are hunger and satiety hormones respectively.

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ABOUT THE BRITISH EGG INDUSTRY COUNCIL

The BEIC was set up in 1986 to represent the UK egg industry. Its members are the 11 major organisations concerned with the egg industry. It is funded by subscriptions from egg packers and producers who produce more than 90% of the UK's eggs. BEIC subscribers market Lion Quality eggs.

For more information visit www.egginfo.co.uk or call the British Egg Information Service on **0207 052 8899**.

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