Egg consumption in pregnancy and infancy: Advice has changed

› Abstract

The UK government has now revised its advice on the safety of eggs for vulnerable groups, such as pregnant women, infants and young children, confirming that they are safe to eat 'runny' or even raw, provided they are British Lion eggs. The government's Scientific Advisory Committee on Nutrition (SACN) has also re-confirmed that eggs can be introduced from around 6 months when complementary feeding begins, despite their allergenic potential. Furthermore, it suggests that deliberate exclusion or delays in introducing eggs beyond 6–12 months may increase the risk of egg allergy. This article discusses the revised recommendations in more detail and sets the SACN recommendations in the context of developing research on egg allergy. It compares advice on egg consumption for non-atopic and high-risk infants in the UK, the US and Australia, and examines the evidence on the influence of maternal diet during lactation on the risks of infant egg allergy. Finally, it provides an update on the nutritional benefits of eggs for pregnant women, infants and young children, including new research on critical but lesser known nutrients such as iodine and choline, with consideration of the suitability of eggs in baby-led weaning.

Key words

› Nutrition › Diet › Eggs › Breastfeeding › Weaning › Complementary feeding

Concerns about two key issues in relation to eggs—their potential contamination with *Salmonella* bacteria and the risks of allergy—have previously led mothers and health professionals to question the suitability of consuming eggs during pregnancy and when introducing complementary feeding; these issues were highlighted in an earlier article in this journal (Gray and Gibson, 2014). Nationally representative data from a sample of over 10000 mothers in the last Infant Feeding Survey indicated that around one in 10 (12%) of these mothers completely avoided giving eggs to their babies at 6 months when the Department of Health (DH) advised that eggs could be introduced.

Even at 8–10 months, when babies would be expected to be consuming a broad range of different foods, 73% of mothers fed them eggs less than once a week (McAndrew et al, 2012). A re-analysis of data from the UK Diet and Nutrition Survey of Infants and Young Children showed a similar picture (Gray and Gibson, 2014). This survey collected 4-day food diary and maternal interview data on 2683 babies aged 4–18 months (NatCen Social Research et al, 2013). At 6 months, only a very small proportion (9%) of infants had consumed eggs at least once. By 10 months, around a quarter (27%) had eaten eggs in the 4 days, but surprisingly, given the versatility and nutritional attributes of eggs, at 17 months less than half (40%) of the respondents reported that their children had eaten eggs during the collection period. Interestingly, in both surveys, concerns about allergies were the main reason given for avoiding eggs, with some respondents also mentioning worries about food poisoning.

Undoubtedly, allergy prevalence is increasing, as demonstrated by the reported rise in hospital admissions for food-related anaphylaxis, which have doubled from 1.2 to 2.4 cases per 100000 of the population per annum between 1998 and 2012 in the UK (Turner et al, 2015). It is estimated that 6–8% of children have proven food allergies, involving adverse immune reactions (Rona et al, 2007). Data from the EuroPrevall cohort of children studied from birth to 24 months indicated a 2.18% incidence of egg allergy in the UK, confirmed by skin-prick tests and double-blind oral challenge, the highest among nine European countries, where the mean incidence was 1.23% (Xepapadaki et al, 2016).

The highest reported global prevalence of egg allergy is in Australia, with 9% of children affected (Koplin et al, 2010). However, the deliberate exclusion of eggs from the infant diet may be exposing children to greater risk of developing egg allergy later in childhood (Scientific Advisory Committee on Nutrition (SACN), 2018), even when infants are at higher risk because of atopic family history or presence of eczema (British Society for Allergy and Clinical Immunology (BSACI)/

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British Dietetic Association (BDA), 2018a). Eggs are probably most appetising, especially to babies, when they are lightly cooked, as soft scrambled or 'dippy' boiled eggs. However, concerns about the potential *Salmonella* contamination of hens' eggs resulted in the precautionary principle being applied and from 1988, the DH advised that population groups particularly vulnerable to the effects of food-borne disease, including pregnant women, infants and young children, should only consume eggs that had been cooked until both yolks and whites were solid (Advisory Committee on the Microbiological Safety of Food (ACMSF), 1993).

In the last few years, the picture for eggs has become much more positive. In 2017, revised recommendations on egg safety were issued by the Food Standards Agency (FSA) for British Lion eggs so that they can now be consumed lightly cooked or even raw by vulnerable groups (FSA, 2017); and in 2018 updated recommendations on infant feeding were published by the SACN in the *Feeding in First Year of Life* report (SACN, 2018).

These revised sets of guidance both help to confirm the suitability of eggs as a food for infants from 6 months. They are particularly relevant for health professionals as eggs contain a wide range of important nutrients, such as iodine, choline and long-chain omega-3 fatty acids that are essential to foetal and infant brain development.

British Lion eggs are safe in pregnancy and for infants

Salmonella in eggs became a major public health issue in 1988 when rates of salmonellosis linked to eggs were shown to be rising due to a new strain of the bacterium *Salmonella* enteritidis phage type 4 (SE PT4) (Gray and Gibson, 2014). Subsequently, the bacterium was found to be located in the body of the egg; this contrasted with conventional strains of *Salmonella*, which had been shown only to contaminate the egg shell (Humphrey et al, 1989). Estimated prevalence of the number of infected eggs was low, at around one in 100 eggs from infected flocks (Humphrey et al, 1989), but because of continued reports of contamination with SE PT4, the UK egg industry introduced a range of measures in the 1990s to circumvent the problem. This culminated in 1998 with the introduction of the British Lion Code of Practice (British Egg Industry Council (BEIC), 2013), which, ultimately, resulted in the decline in *Salmonella* infection associated with UK eggs; now more than 90% of UK-laid eggs are produced under this scheme (British Egg Information Service (BEIS), 2017).

The vaccination of flocks of laying hens against two strains of *Salmonella*—*Salmonella* enteritidis and *Salmonella* typhimurium—is the core element of this scheme, but the Lion Code of Practice comprises more than 700 auditable criteria, and establishes stringent controls throughout the production chain, including strict hygiene controls in egg production units, stamping of each egg with the best before date and Lion logo, and regular egg testing for *Salmonella*. It is the only egg-specific assurance scheme to meet the exacting ISO 17065 international accreditation standard (International Organisation for Standardisation, 2012).

The declining rates of salmonellosis associated with UK eggs led the FSA to ask the ACMSF to examine the issue and make recommendations. The expert group concluded that there had been a marked reduction in the presence of *Salmonella*

Table 1. Key micronutrient content of eggs and significance for pregnant women and infants

Nutrient	Per medium egg (raw)[1]	% UK RNI: pregnancy[2]	% UK RNI: infant 7–12 months[2]
Vitamin A	64 mcg	9	18
Vitamin D	1.6 mcg	16	23
Vitamin B12	1.4 mcg	93	350
Folate	24 mcg	8	48
Riboflavin	0.25 mg	18	63
Iodine	25 mcg	18	42
Selenium	12 mcg	20	120
Choline	144 mg	30[3]	90[3]

1=Average weight with shell 58 g (edible weight 50.6 g); values calculated from Department of Health (2013); 2=Reference Nutrient Intake, Department of Health (1991); 3=Adequate Intake (AI) European Food Safety Authority (2016)

Box 1. Summary of Food Standards Agency recommendations on eggs (FSA, 2017)

- Pregnant women, infants, young children and elderly people can safely eat raw or lightly cooked eggs that are produced under the British Lion Code of Practice
- Non-Lion eggs produced in the UK, eggs from outside the UK, and eggs from species other than hens should always be cooked thoroughly for vulnerable groups
- The advice does not apply to severely immunocompromised individuals, who require medically supervised diets prescribed by health professionals

Box 2. Summary of Scientific Advisory Committee on Nutrition recommendations on eggs (SACN, 2018)

- Exclusive breastfeeding for around the first 6 months of life and continued for at least the first 12 months; infant formula based on cows' or goats' milk is the only suitable alternative; however, goats' milk is not a suitable substitute for infants with cows' milk allergy as the proteins in both milks are very similar (NHS Choices, 2018)
- First complementary foods should be encouraged from around 6 months; alongside continued breastfeeding (advice is unchanged from previous recommendations)
- Allergenic foods, including those containing hens' egg (and peanut), should not be differentiated from other solid foods
- Deliberate exclusion or delayed introduction of eggs or peanuts beyond 6–12 months may increase the risk of allergy to these foods later in childhood
- Once eggs (or other allergenic proteins) are introduced at around 6 months and are tolerated, they should be part of the infant's diet; if exposure to the protein is not continued, this may increase the risks of sensitisation and food allergy

bacteria in UK shell eggs produced under the British Lion Code of Practice, demonstrating a very low risk of contracting *Salmonella* from UK produced eggs (ACMSF, 2016). Accordingly, FSA revised its advice for population groups vulnerable to infection, including infants, young children and pregnant women, who can now consume lightly cooked or even raw eggs (FSA, 2017). The advice is summarised in *Box 1*. Importantly, the revised advice only applies to eggs produced in the UK under the British Lion scheme. Advice for vulnerable groups is unchanged in relation to other (non-Lion) eggs produced in the UK, eggs produced outside the UK, and eggs from other species, such as ducks (FSA, 2017).

Despite the change in government advice, recent omnibus survey data suggest that pregnant women and mothers of young babies are still uncertain about the safety of eating lightly cooked eggs (Intrinsic Insight, 2018). In a survey of 900 mothers, carried out on behalf of the British Egg Industry Council, 44% of those who were pregnant compared with 19% of those with children under 1 year of age said that it was safe to eat 'runny' eggs, reflecting the change in advice in the last year. However, most of the pregnant women (74%) and mothers with young babies (89%) still believed that eggs fed to babies should be thoroughly cooked. These results suggest that health professionals still need to help reassure women that UK (Lion-marked) eggs are a safe and nutritious food to eat when pregnant and in complementary feeding, even when lightly cooked.

Recent studies on egg allergy

It has been hypothesised that there might be a 'critical window'; an optimum period to introduce potentially allergenic proteins into the infant diet to minimise risk of subsequent allergy and indeed to induce tolerance to those proteins, which might be around or before 6 months (Lack 2012; Gray and Gibson, 2014). This hypothesis was tested in two landmark studies: Learning Early about Peanut Allergy (LEAP) and Enquiring About Tolerance (EAT) (Du Toit et al, 2015; Perkin et al, 2016). The outcomes of these studies have provided good evidence to support the idea that earlier introduction of allergenic foods into the infant diet can reduce the risk of allergy to those foods later in childhood.

The LEAP study was a randomised controlled trial (RCT) among 640 infants aged 4–11 months at high risk of developing peanut allergy because of severe eczema, pre-existing egg allergy, or both. It showed a significant reduction in prevalence of peanut allergy in babies exposed to peanut early on (Du Toit et al, 2015). The EAT study, another RCT, randomly assigned 1303 exclusively breastfed infants, this time drawn from the general population and not necessarily at risk of food allergy, to a standard introduction group (breastfeeding until around 6 months) or to an early introduction group (Perkin et al, 2016). In the early introduction group, six foods commonly associated with IgE-mediated food allergy (cows' milk, peanut, egg, sesame, white fish (cod), and wheat) were introduced randomly from around 3 months, with cows' milk first and wheat last. To fulfil the study protocol, the infants had to consume at least 75% of a specific

amount of each protein every week for at least 5 weeks between 3 and 6 months of age; the recommended amount of egg was 4 g per week (equivalent to 2 g egg white protein), so 3 g met the study protocol. The primary outcome of the study was food allergy to one or more of the foods, determined by a positive reaction to food challenge between 12 months and 3 years of age (Perkin et al, 2016).

Unfortunately, due to issues with study protocol adherence and, therefore, failure to meet statistical criteria, the outcomes of the EAT study were less clear than those of LEAP (Perkin et al, 2016). The main issue was consumption of the required weekly quantity of protein in the early introduction group. This was difficult to achieve in such young babies, with egg being the most problematic, perhaps unsurprisingly as it was presented in well-cooked (hard-boiled) form. Nevertheless, the study demonstrated that early introduction of the potentially allergenic foods between 3 and 6 months, while maintaining breastfeeding, was safe and in the infants who managed to consume the recommended quantity of the foods (the per protocol analysis) there was a statistically significant reduction in prevalence of food allergy in the early introduction group compared with the standard introduction group. This was particularly evident for egg (1.4% vs 5.5%) and peanut (0% vs 2.4%). Overall, this represented a significant 67% lower relative risk of food allergy in the early introduction group. However, applying the intention-to-treat analysis (when each participant was analysed irrespective of study protocol adherence) the 20% relative risk reduction of food allergy in the early introduction group did not achieve statistical significance (Perkin et al, 2016). Despite the statistical issues with the study, the important finding was that consuming 2 g egg-white protein (or peanut) each week was associated with a significantly lower prevalence of allergies to these proteins later in childhood compared with less consumption (Perkin et al, 2016).

Evidence on the merits of appropriately timed introduction of eggs continues to accumulate, but there is a lack of consistency in study design, particularly in the form in which the eggs are presented, leading to some conflicting results (Ierodiakonou et al, 2016). Results from the Prevention of Egg Allergy with Tiny Amount InTake trial (PETIT), a Japanese RCT of high-risk infants with severe eczema, indicate that a stepwise approach to cooked egg introduction may reduce subsequent allergic risk (Natsume et al, 2017). Infants in the egg group were initially given a small amount (50 mg) of heated whole egg powder daily between 6 and 9 months; this was increased to 250 mg daily from 9–12 months. Oral food challenge at 12 months showed a significant difference in allergic response to egg, with 38% in the placebo group reacting compared with only 8% in the egg group (Natsume et al, 2017).

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There is also epidemiological evidence supporting the concept (Koplin et al, 2010; Peters et al, 2017; Tran et al, 2017). Data from the ongoing Australian longitudinal HealthNuts study, a cohort of over 5300 children recruited from the general population in Melbourne, where there is an extremely high prevalence of childhood egg allergy, and followed from 12 months to 10 years, demonstrated that the introduction of egg into the diet later (at 10–12 months) was associated with higher rates of egg allergy compared with those infants who were exposed to eggs early (between 4 and 6 months) (Koplin et al, 2010).

The Canadian Healthy Infant Longitudinal Development (CHILD) birth cohort study gathered dietary intake data by questionnaire at 3, 6, 12, 18 and 24 months from 2124 children and observed correlations with the results of skin-prick tests to three allergens (egg, peanut and cows' milk) at 12 months (Tran et al, 2017). Delayed introduction and, specifically, avoidance of egg and peanut in the first year of life was associated

with a significantly increased risk of sensitisation to these proteins (Tran et al, 2017).

Advice on eggs and complementary feeding—same but different?

For many years, the DH has recommended exclusive breastfeeding or using a suitable infant formula for the first 6 months of infant life and beginning complementary feeding at around 6 months while continuing breast- or formula feeding (Gray and Gibson, 2014). The DH also advised that all babies could begin to eat potentially allergenic foods such as eggs, nuts in a suitable form, fish, and wheat, when complementary feeding begins at around 6 months; this was a change from advice in the 1990s, when it was recommended that these foods be delayed until 10–11 months in infants with atopic family history (Gray and Gibson, 2014). The SACN has now reviewed feeding advice for infants and young children up to 5 years of age for the first time since the 1994 COMA report (DH, 1994); the first SACN report covers the period from 0–12 months (SACN, 2018).

The SACN considered the question of food allergy in the context of the recent studies discussed above and to inform the review, the DH asked the Committee on Toxicity of Chemicals in Food, Consumer Products and the Environment (COT) to evaluate the effects of duration of total/exclusive breastfeeding, timing of introduction of complementary feeding, and early exposure to food antigens on the development of allergic responses and immune tolerance and autoimmune disease (COT, 2016; SACN, 2018). In order to specifically examine the effects of timing of introduction of certain allergenic foods (cows' milk, hen's egg, peanut, tree nuts, fish, wheat, soya) and future risk of sensitisation and allergy, a systematic review and meta-analysis of the evidence up to March 2016 was commissioned (Ierodiakonou et al, 2016). This was one of several commissioned systematic reviews (SACN, 2018).

The systematic review found that for both egg and peanut there was moderate-quality evidence that introduction early in the weaning process—at 4–6 months for egg and at 4–11 months for peanut—was associated with a lower risk of developing allergies to those foods later in childhood (Ierodiakonou et al, 2016). However, there was considerable heterogeneity in the studies, particularly those investigating egg, with studies in both high and low allergic risk populations. There was also inconsistency in the form of egg protein used, which included pasteurised or heated whole egg, pasteurised egg white powder, or whole cooked egg. Cooking or heating eggs influences the conformation and the potential allergenicity of egg proteins. The authors concluded that limitations in the studies allowed only cautious interpretation of the results (Ierodiakonou et al, 2016).

COT went on to conclude that early introduction of egg and peanut reduced subsequent development of allergy to those foods, based on six studies for egg and two studies for peanut, but recommended further work before advice to government could be made (COT, 2016). Accordingly, a joint SACN/COT working group was convened to consider both the COT assessment (COT, 2016) and to evaluate the health outcomes associated with possible reduction in exclusive breastfeeding for 6 months (SACN/COT, 2017). On the basis of a formal benefit–risk assessment, the joint SACN/COT working group concluded that:

- There was evidence that deliberate exclusion of egg and peanut beyond 6–12 months may put the infant at increased risk of developing allergies to those foods
- The idea of a 'critical window' for introducing egg (or peanut) before 6 months was not supported by adequate evidence
- Data suggesting that introducing eggs before 6 months might be of benefit was limited and drawn from RCTs where the infant population studied was not representative of the general population
- There was insufficient evidence to show that introducing egg (or peanut) between 4 and 6 months of age would reduce subsequent allergy to a greater extent than introducing those foods at 6 months.

These conclusions formed the basis of the SACN recommendations to government concerning introduction of allergenic foods into the infant diet (SACN, 2018). They are summarised in relation to eggs in *Box 2*. The SACN recommended that first complementary foods should be encouraged from around 6 months alongside continued breastfeeding and this advice is unchanged from previous recommendations. Allergenic foods, including those containing egg (and peanut), should not be differentiated from other solid foods. Crucially, the SACN stated that there was enough evidence to show that the deliberate exclusion or delayed introduction of eggs or peanuts beyond 6–12 months might increase the risk of allergy to these foods later in childhood (SACN, 2018).

Of equal importance is the recommendation that once eggs (or other allergenic proteins) are introduced at around 6 months and are tolerated,

they should continue to be included in the infant's diet on a regular basis (for example, at least once per week) because if exposure to the protein is not maintained, this may increase the risks of sensitisation and later development of allergy (SACN, 2018). The SACN also expressed concern that beginning complementary feeding much before 6 months, if foods such as egg or peanut were introduced early, could displace breast milk with potential adverse nutritional consequences not outweighed by the potential immunological benefits (SACN, 2018).

Advice for high-risk infants

The SACN suggested that infants at higher risk of developing food allergies because of the presence of early onset eczema might be advised to seek medical advice before introducing potentially allergenic foods such as egg and peanut (SACN, 2018). The BSACI Paediatric Allergy Group and BDA Food Allergy Specialist Group have published two new sets of guidance on prevention of food allergy in higher risk infants: one for health professionals and one for parents (BSACI/BDA, 2018a; 2018b).

The guidance states that for infants at high allergic risk because of early onset eczema (in the first 3 months of life), or presence of moderate–severe eczema, or who already have a food allergy (for example, to cows' milk), may benefit from earlier exposure to foods containing egg and peanut and suggests that health professionals/parents should consider starting complementary feeding from 4 months. Once the infant is accepting solids, such as puréed vegetables and fruits, cooked egg (and peanut in suitable form, such as sugar-free, salt-free peanut butter) should be introduced, followed by other foods known to cause allergies (BSACI/BDA, 2018a).

Recommendations in other countries

Other international bodies have issued advice concerning earlier introduction of eggs in complementary feeding. The European Society for Paediatric Gastroenterology, Hepatology, and Nutrition (ESPGHAN) guidance for low-risk infants is in line with the SACN recommendations (Fewtrell et al, 2017). It recommends exclusive or full breastfeeding for the first 4 months (17 weeks) and exclusive or predominant breastfeeding for approximately 6 months (26 weeks); the introduction of complementary foods should not be delayed beyond 6 months but should not begin before 4 months. This position paper recommends that potentially allergenic foods, such as eggs, can be introduced at any time after 4 months (Fewtrell et al, 2017). Similarly, the Australian Society of Clinical Immunology and Allergy (ASCIA) recommends breastfeeding for at least 6 months and suggests that solids, including common food allergens such as eggs, can be introduced between 4 and 6 months if the child is developmentally ready, with a caveat concerning infants with severe eczema or known food allergies (ASCIA, 2016).

Guidelines have also been issued in the US, which state that foods containing cows' milk, eggs, peanut, tree nuts, soy, wheat, fish and shellfish can be introduced in age-appropriate forms between 4 and 6 months and that their delayed introduction may increase the child's subsequent risk of developing allergies (AAAAI, 2015). Again, various caveats are included such as the seeking medical advice in infants with moderate/severe eczema, or previous adverse reactions to foods. All these guidelines emphasise the acceptability of introducing egg into an infant's diet from 17 weeks.

Hard or runny—how should eggs be cooked for allergy prevention?

In terms of microbiological safety, we have already established that if they are British Lion eggs they can be eaten lightly cooked (or raw), even by infants (FSA, 2017). However, from the perspective of allergy, some clarification may be required. The SACN makes no recommendations on the form in which egg is first presented to infants at around 6 months (SACN, 2018).

Infants who have no known risks of food allergy—those who do not have early onset eczema or a family history of atopic disease—can be introduced to egg in an easily consumed, soft form when complementary feeding begins from around 6 months. For example, softly scrambled egg, puréed if necessary, is easy to eat from a spoon. If baby-led weaning (BLW) is the preferred approach (Rapley, 2018; SACN, 2018), toast soldiers dipped into a lightly boiled egg can be given to the baby to hold if they are developmentally ready.

Advice for infants at higher risk of food allergy because of early onset or moderate–severe eczema or existing food allergy may be slightly different (BSACI/BDA, 2018a; 2018b). The studies on egg allergy, including some of those undertaken in high-risk infants, have used egg in various forms (Ierodiakonou et al, 2016). Whereas the UK EAT study used fully-cooked (hard-boiled) egg, various others have used pasteurised/heated egg white powder and heated whole egg powder (Ierodiakonou et al, 2016) and this will influence potential allergenicity. The guidance from BSACI/

BDA (2018) points out that the form in which egg is presented is important, noting reports that raw egg powder caused significant adverse reactions in high-risk infants (Palmer et al, 2013; Bellach et al, 2017) and that cooked egg is better tolerated. Children who exhibit reactions to lightly cooked egg may often be able tolerate extensively heated egg in baked goods (such as small muffins) and in time this may be associated with tolerance of less well cooked egg (Upton and Nowak-Wegrzyn, 2018); this approach may be used to manage egg allergy (Leonard et al, 2015).

Overall, for high-risk infants, it would be best to seek specialist medical advice before introducing egg. In any case, potentially allergenic foods such as eggs, should be introduced one at a time, starting in small amounts and gradually increased over a few days; once established the food should be given regularly, or at least once per week (BSACI/BDA, 2018b).

Influence of maternal diet during pregnancy and breastfeeding on childhood food allergy

A review of the limited evidence in this area (Gray and Gibson, 2014) noted that, despite suggestions during the 1980s and 1990s that reduced maternal exposure to dietary antigens such as cows' milk and eggs might reduce food allergic disease in the infant (Fälth-Magnusson and Kjellman, 1992), subsequent studies and a Cochrane review of five trials of maternal antigen avoidance did not support this idea (Zeigler, 2003; Kramer and Kakuma, 2012).

To inform the COT considerations of the effect of infant diet on atopic disease and the SACN review of infant feeding, the FSA commissioned a second systematic review to examine the effect of diet during pregnancy and lactation, as well as in infancy, on risk of childhood allergic disease (Garcia-Larsen et al, 2018). There was only limited evidence, mainly from observational studies, for an effect of maternal diet during either pregnancy or lactation on subsequent experience of childhood food allergy (Garcia-Larsen et al, 2018).

However, evidence from animal studies suggests that exposure to food allergens through breast milk can induce oral tolerance to allergens in the offspring (Bernard et al, 2014). The influence of maternal egg consumption during breastfeeding on the development of immune tolerance to eggs in infants has been investigated in an Australian RCT (Metcalfe et al, 2016). Mothers were randomised during the first 6 weeks of lactation to one of three groups: 'high' egg intake (>4 eggs per week); 'low' intake (1–3 eggs per week); or an egg-free diet. There were positive correlations between egg intake and breast milk ovalbumin concentrations in the mother and between maternal egg consumption and plasma egg-specific IgG4 levels in the infant. The presence of IgG4 antibodies to specific foods is associated with immune tolerance to those foods (Caubet et al, 2012). The authors concluded that exposing mothers to higher levels of egg protein during lactation may encourage the development of oral tolerance to eggs in the infant (Metcalfe et al, 2016). Further work in this area is required.

Nutritional contribution of eggs in pregnancy and for babies

Eggs can make an important nutritional contribution to pregnant and lactating women, and infants and young children (Gray and Gibson, 2014; Woodward, 2018) (*Table 1*). They provide many nutrients essential to foetal and infant growth and development, including high-quality protein, vitamin D, vitamin B12, folate, choline, iodine, selenium, and long chain omega-3 fatty acids. In fact, they are one of the few dietary sources of vitamin D, iodine and choline. They also contribute important amounts of other B vitamins and minerals, including some iron and zinc.

Iodine is a nutrient that gets little attention, but according to the World Health Organization, the UK is classified as mildly iodine insufficient (Combet et al, 2015) and it has been suggested that iodine is a nutrient of concern for pregnant women (Rayman and Bath, 2015). Iodine is essential for adequate maternal thyroid function, which is critical for neurodevelopment of the foetus and infant (Zimmerman, 2009). Evidence from various studies, including the UK Avon Longitudinal Study of Parents and Children (ALSPAC) and the Australian Gestational Iodine Cohort Study, suggests that even mild iodine deficiency is associated with delays in neurocognition later in childhood (Bath et al, 2013; Hynes et al, 2013). In the ALSPAC study, children born to mothers with low maternal iodine status in pregnancy had about a 60% greater risk of falling into the bottom quartile of scores for verbal intelligence quotient, reading accuracy and comprehension at age 8/9 years (Rayman and Bath, 2015). Low dietary iodine intake and low iodine status in pregnant women appear to be common in the UK (Bath et al, 2014; 2015; Combet et al, 2015). Two medium-sized eggs provide 50 mcg iodine, representing 36% of the pregnancy reference nutrient intake (RNI), so can contribute important amounts of this much-needed nutrient

both in pregnancy and to the developing infant brain during complementary feeding.

Choline, a vitamin-like compound used to make phospholipids and therefore cell membranes, is another lesser known nutrient of importance in pregnancy. Although much of the work has been carried out in animal models, there is evidence that choline is important for human foetal development, particularly for the brain (Caudill, 2010). The European Food Safety Authority (EFSA) has set adequate intake levels (AI) of 480 mg/day in pregnancy and 520 mg/day in lactation (compared to an AI of 400 mg for healthy adults) and an AI of 160 mg/day for infants aged 7–11 months (EFSA, 2016).

To date, a limited number of studies have investigated the influence of maternal choline status/supplementation on infant/childhood neurocognition and the results have been inconsistent (Caudill et al, 2018). However, the results of a recent small but well controlled RCT suggest that choline intake in pregnancy may have cognitive effects in the offspring, with supplementation in the third trimester of pregnancy having a positive effect on infant processing speeds at 13 months (Caudill et al, 2018). Eggs are particularly rich in choline and one of the few food sources of this nutrient, with two medium eggs contributing almost two thirds of the AI for pregnant women.

Similarly, eggs are one of the few rich dietary sources of vitamin D in its most bioavailable form—D3. It is recognised that low vitamin D status prevails across the UK population, especially in the winter months, largely because of limited exposure to UV light in the northern hemisphere (SACN, 2016). Consequently, vitamin D supplementation is advised during pregnancy and lactation for infants from birth to 1 year who are breastfed or receiving less than 500 ml formula daily, and for young children up to 4 years of age (NHS Choices, 2017). However, increasing dietary intake of vitamin D is also important and two medium eggs would provide about one third of the RNI for pregnant or lactating women and one medium egg would provide 1.6 mcg, around 23% of the RNI for children of 6 months to 3 years.

Eggs are also a significant source of long-chain omega-3 fatty acids, principally in the form of docosahexaenoic acid (DHA), another nutrient that is essential for foetal and infant brain development and function (Lauritzen et al, 2016). One medium egg contains about 70 mg DHA and the adult daily intake recommended by the SACN is 450 mg (SACN, 2004).

Key points

- The government has revised its precautionary advice to vulnerable groups including pregnant women and infants and young children; it is now safe for these groups to consume raw or lightly cooked 'runny' eggs, provided they are British Lion eggs
- Eggs provide many nutrients, including some that are found in a limited number of other foods and which are particularly important for foetal and infant development
- The report of the Scientific Advisory Committee, *Nutrition Feeding in the First Year of Life*, recommends that eggs can be introduced into the infant diet at around 6 months when complementary feeding begins
- The delayed introduction or deliberate exclusion of eggs beyond 6–12 months may increase the risk of egg allergy
- Once eggs are introduced into the infant's diet and are tolerated, they should continue to be offered regularly; discontinuation after initial exposure may increase the likelihood of sensitisation

BLW, where the infant self-feeds from the beginning, has emerged as a distinct approach to the transition from milk feeds to family food in recent years, although not without controversy (Rapley, 2018). The evidence base for this is limited, with the results of only one RCT available to date; however, in the recent *Feeding in the First Year of Life* report, the SACN acknowledged that this single trial reported earlier self-feeding alongside less food fussiness and greater food enjoyment in infants fed using BLW (SACN, 2018). If this approach is fully or partially adopted, eggs provide an ideal vehicle for a nutritious early food in the form of slices of omelette, toast or bread dipped into yolk, or small pancakes or egg muffins.

Conclusions

The two new sets of advice reviewed here (FSA, 2017; SACN, 2018), which both confirm the suitability of eggs, even when lightly cooked, for feeding young babies and pregnant women should be reassuring for health professionals, parents and carers. The importance of introducing potentially allergenic proteins such as eggs early on in complementary feeding, between 6 and 12 months, is underlined by the recommendations of the SACN, as is the need to maintain regular intake once eggs are introduced and tolerated (SACN, 2018). Similar guidance has been issued in the US, Australia and Europe (AAAAI, 2015; ASCIA, 2016; Fewtrell et al, 2017).

These messages need to be conveyed to parents and carers, as there still seems to be doubt concerning eggs in pregnancy and for infants, especially in relation to allergy (Gray and Gibson, 2014; Intrinsic Insight, 2018). Whereas the SACN recommendations focus on infants who are not

at risk of allergy, guidelines for infants with early onset or moderate-to-severe eczema, considered to be at high food allergic risk, have been issued by the BSACI/BDA. They suggest that overall it may be appropriate to introduce eggs from 4 months but that health professionals must help parents make informed decisions about introducing potential food allergens in the knowledge that delayed introduction may increase allergic risk but that this must be balanced against the availability of specialist allergy testing in the local medical service, which might lead to delays in introduction (BSACI/BDA, 2018a).

Eggs provide a wide range of nutrients, many of which are especially valuable in pregnancy, infancy and early childhood when demands for growth and development are especially high. These include nutrients that recent research has emphasised are crucial to brain and neurological development: iodine, choline and DHA. For most pregnant women and babies, there is no reason why eggs should not be eaten frequently to provide nutrient-dense meals as part of a healthy balanced diet. There is a need for health professionals to pass on this information to women who are pregnant or who have young babies. JHV

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