# Baked Milk and Egg Diets for Milk and Egg Allergy Management

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**KEYWORDS**

• Cow's milk allergy • Hen's egg allergy • Baked milk • Baked egg
• Extensively heated milk • Extensively heated egg • Milk allergy • Egg allergy

**KEY POINTS**

- Baked milk and egg are well tolerated in the diets of a majority of milk- and egg-allergic children.
- Inclusion of baked milk and egg in the diet of children who are tolerant of these baked forms may accelerate the resolution of milk and egg allergy.
- Clinical factors and biomarkers for predicting baked milk and egg tolerability or reactivity are lacking, and further research is needed.
- Tolerance to baked milk and egg may be a marker of a milder and transient milk and egg allergy.
- Anaphylaxis to baked milk and egg can occur, thus physician-supervised introduction is recommended.

## INTRODUCTION

Cow's milk (CM) and egg allergies are some of the most common food allergies in young children. It is estimated that up to 3.8% and 2% of children less than 5 years of age have CM and egg allergy, respectively.[1] CM and egg are a large part of diets in many cultures. These allergens are commonly found in baked goods and are an important source of protein and calories, particularly in young children. Strict elimination of all CM and egg products may put children at risk for nutritional deficiencies as well as have a psychosocial impact. Studies show that the baked form of CM and egg is less allergenic and tolerated by a majority of CM- and egg-allergic children. The

The authors have nothing to disclose.

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Immunol Allergy Clin N Am 36 (2016) 147–159
http://dx.doi.org/10.1016/j.iac.2015.08.013 **immunology.theclinics.com**
0889-8561/16/$ – see front matter 

ability to add baked CM and egg products to the diets of CM- and egg-allergic children can improve the nutritional content of their diet and increase quality of life. In addition, data suggest that including baked CM and egg in the diet may accelerate resolution of CM and egg allergy. The goal of this review is to examine our current understanding of the effects of baked CM and egg in the management of CM and egg allergy.

## PREVALENCE OF BAKED MILK AND EGG TOLERANCE

A CM allergy natural history study in a multi-site US population by Wood and colleagues,[2] which followed 293 infants, found that 21% (32 of 155) of subjects with CM allergy at the 5-year time point tolerated some baked milk products. An egg allergy natural history study in the same population by Sicherer and colleagues,[3] which followed 213 infants, found that 38% (43 of 113) of subjects with egg allergy at the 6-year time point tolerated some baked egg products. Percentages are typically higher in studies in which baked CM and egg tolerance are proactively evaluated with oral food challenges. For example, in a large population study in Australia by Peters and colleagues[4] in which baked egg challenges were offered at age 1 and 2 years of age to challenge-proven raw egg–reactive children, 80% (n = 126 of 157) of subjects tolerated baked egg at baseline.

Overall, studies show that between 69% and 83% of CM-allergic children can tolerate baked CM, and between 63% and 83% of egg-allergic children can tolerated baked egg, as detailed in **Tables 1** and **2**, **Box 1**. The studies that were reviewed used similar methods for baking CM and egg. In baked CM studies, a serving size was the equivalent of 0.5 to 2.6 g of CM protein in a muffin or cupcake baked at 350°F (180°C) for 20 to 30 minutes.[5–8] In baked egg studies, a serving size was the equivalent of 1 to 3 g egg protein in a muffin or cupcake baked at 350°F to 375°F (180°C–190°C) for 20 to 30 minutes.[9–16]

Not many studies have examined the tolerance of baked milk or egg in patients with eosinophilic esophagitis (EoE). One study examined 15 patients with EoE who were electively ingesting baked milk. Eleven patients (73%) showed tolerance of baked CM ingestion, and 4 patients showed a relapse of EoE disease on esophageal biopsy ($\geq$10 eosinophils per high-power field).[17] This small study suggests that baked milk and egg proteins may be tolerated most patients with EoE and warrant further investigation.

## FOOD PROCESSING

Proteins possess both sequential and conformational epitopes that immunoglobulin E (IgE) antibodies may recognize and bind to. Heating alters conformational epitopes and induces other protein structural changes so that IgE antibodies may no longer bind.[18] Interaction of food proteins with one another (such as CM and egg with a wheat matrix) may also alter allergenicity.[19]

Casein makes up 80% of CM protein and is immunodominant, whereas whey makes up 20% and consists primarily of $\alpha$-lactalbumin and $\beta$-lactoglobulin.[20] Casein and $\alpha$-lactalbumin are more heat stable than $\beta$-lactoglobulin.[18] In one study, most children older than 9 years with persistent CM allergy had IgE binding to sequential (linear) casein epitopes as compared with patients younger than 3 years who are likely to outgrow CM allergy.[21]

Ovalbumin makes up 54% of egg white (EW) protein, however, ovomucoid (OM), which makes up 11%, is considered the immunodominant protein.[22] Compared with ovalbumin, OM is stable to both heat and digestive enzymes.[23] Children with persistent egg allergy have had higher levels of OM-specific IgE, specifically to sequential (linear) OM epitopes.[22,24]