

Unintended allergens in precautionary labelled and unlabelled products pose significant risks to UK allergic consumers

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Abstract

Background: Allergens in food may pose a risk to allergic consumers. While there is EU regulation for allergens present as an ingredient, this is not the case for unintended allergen presence (UAP). Food companies use precautionary allergen labels to inform allergic individuals of a potential risk from UAPs. This study investigates the risk of an allergic reaction within the milk-, wheat-, hazelnut- and peanut-allergic populations when ingesting UK foods across multiple product categories with and without precautionary allergen labelling.

Methods: Allergen risk assessment using probabilistic techniques enables the estimation of the residual risk after the consumption of a product that unintentionally contains an allergen.

Results: Within this selection of UK products, the majority that tested positive for an allergen contained a concentration of allergen predicted to cause a reaction in >1% of the allergic population. The concentrations of allergens measured were greater than the VITAL[®] 2.0 action levels and would trigger precautionary allergen labelling. This was found for products both with and without precautionary allergen labelling.

Conclusions: The results highlight the need for the food industry and regulators to adopt a transparent, risk-based approach for the communication of the risk associated with potential cross-contact that could occur in the processing facility or production chain.

Food allergies are a global issue and possibly increasing in prevalence and severity (1, 2). Currently, no cure exists for food allergies; allergen avoidance is the best management for food-allergic individuals. Most developed countries require labelling of the commonly allergenic foods when present as ingredients, but no regulations exist, specifically addressing precautionary allergen labelling (PAL) (3). Manufacturers make frequent use of PAL where equipment or facilities are shared between formulations that do and do not contain allergens. The intent of PAL is to relay to consumers that there may potentially be inadvertent presence of allergen residue in the product despite their best efforts to avoid cross-contact in the production facility. Surveys have found over 50% of foods in specific product categories contain PAL (4, 5). The widespread use of PAL limits allergic consumer food choices. Additionally, the inconsistent application of PAL and a wide variety of PAL statements throughout the

industry have led to confusion and contradicting dietary advice regarding avoidance of these prepackaged food products within the medical and consumer communities (6, 7). Also, an increase in risk-taking behaviour is seen as some allergic consumers may ignore PAL statements (8, 9). However, no consistent differences were observed in the concentration of allergen based on the type of PAL (9–13). There is a clear need for harmonization in PAL statements to decrease the burden felt by a food-allergic consumer (14, 15).

Internationally, many qualitative guidelines exist for PAL application. The sole exception is the quantitative (nonregulatory) guideline for PAL – Voluntary Incidental Trace Allergen Labelling (or VITAL[®]) – which was developed in 2007 by the Allergen Bureau of Australia and New Zealand. VITAL[®] is a quantitative risk management system developed to support food processors in assessing the impact of the unintended allergen presence in a food-manufacturing

environment. The overall system was updated in 2011/2012 (VITAL[®] 2.0) using scientific evidence supporting a reference dose grid established by international allergen experts from TNO, the Food Allergy and Resource Program (FARRP), Unilever and clinicians and consultants from Australia (16, 17). The International Life Sciences Institute's (ILSI) European Food Allergy Expert Group: From Thresholds to Action Levels positively reviewed the applicability of VITAL[®] 2.0 within Europe and has recently accepted the approaches and science used to develop the VITAL[®] 2.0 guideline (18–20). Still, there is a need for clinically and regularly accepted levels of risk and allergen reference doses with regard to PAL to increase the quality of life for a food-allergic consumer (14).

Based on a case study regarding undeclared hazelnut proteins in chocolate spread, TNO in the Netherlands introduced the probabilistic risk assessment concept for food allergens (21). Additional research around the world has shown the robust capabilities of the probabilistic models and assessed the risk of different cross-contamination scenarios with milk, peanut and soy flour (22–25). However, these studies focused on undeclared allergens and did not investigate the risk of consuming products with PAL. Recent studies have investigated the clinical risk to the allergic consumer population when consuming precautionary allergen-labelled products in the US, Ireland and France (10, 11, 26). Still, the three studies focus on peanut and, with the exception of Rimbaud et al. (26), assess the risk in a single product category.

To date, probabilistic risk assessment of food allergens based on UK packaged food products has not been conducted. This study investigates the risk of an allergic reaction within the milk-, wheat-, hazelnut- and peanut-allergic populations when ingesting UK foods across multiple product categories with and without PAL. To the best of our knowledge, this is the first study to focus on risk assessment of products after a stratified product search involving multiple products and allergens, which should provide a more representative risk assessment for the packaged food sector. Additionally, it is the first probabilistic study to include wheat. Products in this study are compared to the VITAL[®] 2.0 guidelines for their respective product categories. Specific attention is paid to the potential clinical implications of the consumer from the tested products.

Methods

Data

Concentration

The concentration of allergen (in ppm total protein of allergenic food) was determined in two samples for each of the food products that tested positive in the UK Food Standards Agency (FSA) Survey of Allergen precautionary allergen Labelling (27). Where necessary, conversion factors were applied to adjust for total allergenic protein content. The conversion factors used were as follows: whole peanuts are approximately 25% protein (28) (USDA National Nutrient

Database for Standard Reference), and gluten protein accounts for approximately 80% of the total protein in wheat (29). The conservative assumption was made that all of the detectable gluten protein found in the products analysed by Reading, United Kingdom was derived from wheat rather than barley or rye as the analytical method used to detect gluten residue does not distinguish among gluten sources. The assumption was also made that the remaining 20% of the wheat protein would be present in the products that were analysed. It is important to note that no commercial ELISA method is currently available to test specifically for the remaining wheat proteins, so the risk assessment must rely on these conservative assumptions. No conversion factors were used for milk or hazelnut residues as the ELISA methods used for the analysis reported the results in units of protein from the respective allergenic source. If both samples of the same food product were found to be positive, then the highest concentration was used in the risk assessment.

Consumption

The food products in the FSA survey were combined into 20 food categories, including the following:

apple pie, Bombay mix and trail mixes, breakfast oat porridge, cereal bars, cheesecakes without nuts, chewy sweets, chocolate spread without nuts, corn snacks, dark chocolate, dry mix sauces and seasoning mixes, ham excluding parma, ice lolly, Indian ready meals, yeast extract, milk chocolate, tortillas, vegetable samosas, vegetarian sausages, white bread rolls and white chocolate.

A consumption distribution was defined based on the UK National Diet and Nutrition Survey (NDNS) for each of the food categories which tested positive for peanut, hazelnut, milk and/or wheat cross-contamination in the FSA Survey (30). No direct match exists between the NDNS food groupings and the food categories sampled in the FSA survey, so the NDNS data were recorded based on the highest individual amount consumed per eating occasion per person for all positive samples. As food consumption patterns differ between males and females, and children (1.5–18 years) and adults (19 years and older), separate consumption data (when available) were calculated for each of these groups.

Threshold distributions

Threshold distributions for peanut, hazelnut, milk and wheat were derived from the compiled TNO and FARRP clinical threshold data. This database was previously described and used to determine the VITAL[®] 2.0 reference doses (16, 17). The database contains individual human data on the minimum eliciting doses based on the first objective reactions that occurred during clinical double-blind, placebo-controlled food challenges (DBPCFC). Where possible, differences in threshold distributions were investigated for children and adults, and males and females; however, no significant differences were observed. Therefore, the risk assessments utilized allergen-specific threshold distributions based on the overall population using both the log-normal and the log-logistic distributions.

Probabilistic risk assessment

Probabilistic risk assessments (21) were performed for each of the food products that tested positive in the UK Food Standards Agency (FSA) Survey (27). For each food product, a Monte Carlo simulation combined the input variables for consumption and concentration to determine allergen exposure and an exposure distribution was generated. The probability of an allergic reaction was determined by combining the exposure distribution and the threshold distribution. If the exposure dose (mg) was higher than an individual threshold dose in the simulation, a reaction would be predicted to occur. The probabilistic risk assessments for each food product were performed using the consumption data from nine population groups (all ages/adults/children, both genders/men/women) coupled with the overall population threshold distribution for each respective allergen. Risk assessments were conducted at the food product level and reported for the allergic user population, a very conservative estimate that assumes that everyone is allergic to the respective allergen and everyone consumes the particular product in question.

Comparison with VITAL® 2.0

Based on the results of the NDNS consumption grouping and the reference doses as defined by VITAL® 2.0 and ILSI-Europe Expert Group, action levels for each food category and allergen were derived using the mean and p95 consumption estimates for each food category. The action levels were compared to the levels of unintended presence of allergens found in the FSA survey. Special attention was given to the comparison of products with and without precautionary allergen statements to investigate how the precautionary allergen statements would have been used by food manufacturers if the recommendations of VITAL® 2.0 were incorporated in their internal risk assessments.

Results

Concentration

The RSSL found detectable levels of gluten in 6.1%, milk in 8.2%, hazelnut in 2.9% and peanut in 0.21% of products with PAL. Additionally, gluten was found in 3.3%, milk in 2.1% and hazelnut and peanut in 0% of products with no allergen declaration. The range of converted concentrations for each of the food products/types can be found in Table 1. For more details regarding the original results, please refer to (27). Risk assessments were only conducted for products with positive analytical findings.

Consumption

Mean and p95 consumption values, as well as the full consumption distributions, were determined for the food categories containing food products that tested positive during the FSA survey (Table S1). The consumption data from the NDNS survey were not available for premade sandwiches or

dried stuffing mixes, and probabilistic risk assessments were not conducted for these products.

Probabilistic risk assessment

The results for all available probabilistic risk assessment scenarios are summarized by food category in Table 1. Results by individual food product can be found in Table S2.

Risk assessments for food products with precautionary allergen labelling (39) were conducted, and 31 of 39 posed a risk to the respective allergic population if consumed (both the log-normal and log-logistic simulations predicted >1.0% of eating occasions to result in an allergic reaction). Further, nine of these food products posed a serious risk to public health with >10% of the simulated eating occasions predicted to result in an allergic reaction. Milk in dark chocolate with PAL was the food with the highest risk levels as seven products contained milk at concentrations predicted to cause reactions in 21–52% of the simulated eating occasions.

Risk assessments were conducted for 12 products that tested positive but had no labelling declaration for the allergen. Three products in a total of three categories posed a serious risk to public health with milk in an ice lolly and a vegetable samosa and wheat in a ready-made Indian meal predicted to cause reactions in up to 8.7%, 13% and 17% of the simulated eating occasions, respectively. Three products were predicted to be a moderate risk to the allergic population with predicted reactions in up to 2.4% of the simulated eating occasions. The remaining six products were predicted to cause reactions in <1.0% of the simulated eating occasions.

Comparison with VITAL® 2.0

The levels of unintended presence of allergens found in for each food product were compared to actions levels derived by the VITAL® 2.0 guidelines. Of the 39 products with PAL for the tested allergen that tested positive in the FSA survey, 35 contained allergen concentrations greater than the recommended VITAL® 2.0 action level for their respective product category (Fig. 1). For the products with no allergen declaration, 7 of the 12 products contained allergen concentrations greater than the recommended VITAL® 2.0 action level for their respective product category. Details of the recommended action level for PAL for each of the food product categories can be found in Tables S1 and S3.

Discussion

This was the first study to estimate the level of health risk posed to the UK food-allergic consumer by the unintended presence of peanut, hazelnut, milk and wheat protein in UK retail food products with or without PAL. The RSSL study found a number of products with and without PAL tested positive for the allergens of interest (27). However, it should be noted that products expected to have negligible levels of unintended allergens were not included in the labelling study and the reported proportion of products with positive

Table 1 The concentrations of products with positive test results in the FSA Survey of Allergen precautionary allergen Labelling (27) summarized by food categories and the subsequent per cent of simulated eating occasions predicted to result in an objective allergic reaction upon the ingestion of these products by the 'at-risk' allergic population. Reactions are conservatively predicted in the allergic user population that assumes that everyone is allergic to the respective allergen and everyone consumes the particular product in question. There is no biological or statistical reason to distinguish between the choice log-normal (LN) and log-logistic (LL) distribution for the threshold distribution during the Monte Carlo simulation; therefore, both results are presented and treated with equal weight. If both samples of the same food product were found to be positive, then the highest concentration was reported and used in the risk assessments

Food category and labelling	Number of unique products	Range of tested concentrations (ppm protein)	Predicted reactions in allergic user population	
			Range of LN (%)	Range of LL (%)
Hazelnut – Precautionary allergen labelling				
Cheesecakes	1	1	0.27–0.38	0.87–1.06
Chocolate spread	2	77–120	4.37–6.65	5.42–7.66
Dark chocolate	3	18–78	1.17–4.38	2.06–5.44
Milk chocolate	9	1–170	0.11–10.32	0.48–10.97
Milk – Precautionary allergen labelling				
Chewy sweets	1	14	2.51–3.18	3.23–3.89
Dry mix sauces and seasoning mixes	1	31	0.66–1.59	1.18–2.21
Ham excluding parma	1	6.6	1.04–1.46	1.8–2.23
Ice lolly	1	2.7	0.99–1.12	1.73–1.87
Dark chocolate	9	9.7–4400	0.96–52.17	1.62–50.69
White chocolate	1	100	7.39–9.82	7.62–9.7
White bread rolls	1	3.9	1.12–1.59	1.89–2.39
Milk – Not Declared				
Apple pie only	1	2.6	0.97–1.54	1.72–2.42
Dry mix sauces and seasoning mixes	1	4.2	0.08–0.19	0.31–0.57
Ice lolly	1	29	7.92–8.64	8.08–8.68
Sandwiches	2	13–52	*	*
Vegetable samosas	1	45	11.15–13.29	10.85–12.65
Peanut – Precautionary allergen labelling				
Milk chocolate	1	18	2.4–2.84	2.9–3.34
Wheat – Precautionary allergen labelling				
Bombay mix and trail mixes	1	38.75	1.08–1.35	1.47–1.77
Breakfast oat porridge	1	43.75	0.38–0.47	0.81–0.93
Cereal Bars	1	262.5	9.49–11.55	8.63–10.28
Corn snacks	1	17.5	0.12–0.16	0.41–0.5
Dry mix sauces and seasoning mixes	2	32.5–82.5	0.05–0.69	0.18–1.04
Milk chocolate	1	66.25	2.23–2.77	2.52–3.04
Vegetarian sausages	1	17.5	1.1–2.03	1.58–2.5
Wheat – Not Declared				
Bombay mix and trail mixes	1	40	1.14–1.41	1.52–1.82
Breakfast oat porridge	1	47.5	0.43–0.54	0.88–1.01
Cereal Bars	1	48.75	1.24–1.62	1.72–2.11
Dried stuffing mixes	1	28.75	*	*
Dry mix sauces and seasoning mixes	2	37.5–62.5	0.07–0.46	0.21–0.78
Indian ready meals	1	31.25	12.78–17.09	11.28–14.93
Yeast extract	1	30	0.02–0.05	0.12–0.21
Tortillas	1	13.75	0.15–0.27	0.43–0.6

*Consumption data are not available for this product category, and no quantitative risk assessments were performed.

allergen tests is likely higher than if products were included at random. Milk and wheat were most frequently detected in the tested food products, but all four allergens were detected at levels demonstrated to be a health risk to allergic consumers in one or more products. Our results indicate that within this selection of UK products, the majority that tested positive for an allergen indeed contained a concentration of

allergen predicted to cause a reaction in >1% of the allergic population. The concentrations of allergens measured were greater than the VITAL[®] 2.0 action level and would trigger PAL. This was found both for products which already contained PAL and for those products without PAL.

The most concerning risk assessments regard the products with high levels of unlabelled allergens. Within this study,

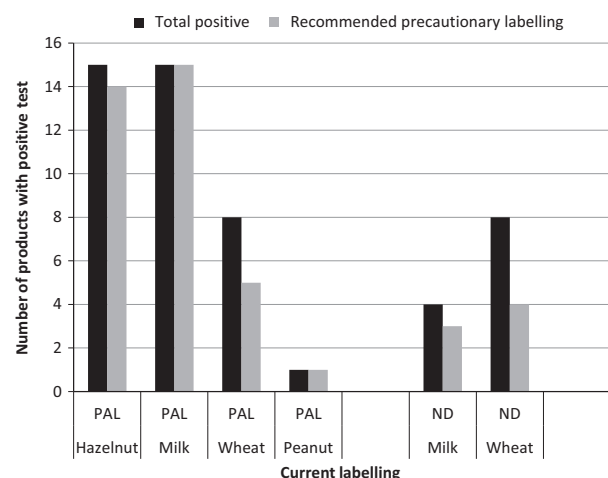


Figure 1 The total number of products which tested positive in the FSA Survey of Allergen precautionary allergen Labelling (27) are shown in black. Products are separated in groups by products with precautionary allergen labelling for allergens (PAL) and products with no declaration (ND) of allergens. Based on the VITAL[®] 2.0 guidelines for precautionary allergen labelling and analysed concentrations in the survey, the number of products recommended to have precautionary allergen labelling is shown in grey.

milk in an ice lolly and vegetable samosas and wheat in a ready-made Indian meal were predicted to cause reactions in up to 8.7–17% of the simulated eating occasions. Thus, many allergic individuals following strict avoidance diets including all products with PAL are still at risk for a reaction from the consumption of certain prepackaged foods without allergen ingredient statements or PAL. Reactions at these high doses of allergen could be potentially severe, and their undeclared nature is troubling.

Additionally, some food-allergic consumers are known to ignore PAL (9). The risk posed by such behaviour is unknown. Here, a number of foods with PAL posed a significant and possibly severe risk to the allergic population. Milk in dark chocolate was the product category with the highest levels of allergen cross-contact and the most significant health risks with reactions predicted in up to 52% of the simulated eating occasions. Similarly, chocolate products constituted the majority of products testing positive for hazelnut and the only product with peanut detected, both at levels predicted to be a significant health risk to allergic consumers. The high risk of milk protein in dark chocolate was previously found by others in the US and the Netherlands (12, 24). The hazelnut and peanut results are also similar to those found by researchers in France and the Netherlands (21, 26). Chocolate manufacturing equipment is notoriously hard, if not impossible to clean as wet cleaning cannot be applied due to microbial concerns and only dedicated allergen-free production equipment is able to produce allergen-free chocolate. Our results indicate that milk-, hazelnut- and peanut-allergic individuals in the UK, and other countries, should avoid chocolates with PAL due to an elevated risk of allergic reaction.

The UK FSA has published voluntary guidance on the evaluation and application of precautionary allergen labelling in packaged foods (31). For risk management purposes, it is important to investigate whether the voluntary guidance affected the risk of packaged food products to allergic consumers in the UK in comparison to other geographic locations. Packaged foods in the UK carried a similar risk to comparable foods from other Western countries (9, 10, 12, 21, 24, 26) but had a lower risk than products found in a Thai survey (32).

Currently, allergic individuals suffer a decreased quality of life due to the limited number of prepackaged food products in some categories that do not bear contains or precautionary allergen statements (33). Additionally, allergic consumers can obviously face health risks from the ingestion of products containing detectable levels of allergen regardless of the presence of PAL. Allergic consumers would benefit from the adoption of an industry-wide, risk-based approach for the application of PAL, such as VITAL[®] 2.0. By imposing a risk-based approach, the number of *APPROPRIATE* precautionary allergen statements will increase within the product categories that were selected for this survey (categories known to have a higher prevalence of allergen cross-contact risk). However, further analytical investigations may show that some products do not contain detectable allergen from the FSA survey and their PALs could be removed. The overall impact on the usage of PAL remains to be seen, but risk-based approaches should lead to a higher correlation between PAL usage and actual risks and thus lead to higher consumer trust and hopefully better PAL labelling adherence. Eventual adoption of this approach would further open food choices for allergic consumers and increase the quality of life for them and their families.

This study demonstrates that allergic consumers could react if they ignore the precautionary allergen statements on product labels. This study also demonstrates that some products with no allergen declaration or PAL also contained sufficient undeclared allergen residues to pose a risk to public health. These findings underscore the need for the food industry and regulators to adopt a transparent, risk-based approach such as VITAL[®] 2.0 for assessment of the risk associated with potential cross-contact that could occur in the processing facility. It is critical that clinicians advise their patients to avoid products with PAL especially in certain high-risk categories (15, 34). Additionally, it is crucial that all stakeholders prioritize the simplification and clarification of PAL in an effort to ease the burden of disease on allergic individuals and provide consistency in risk communication for allergens.

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Conflict of interest

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

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Supplementary Material

Supplementary Table 1 – Consumption estimates for each food category as determined by the UK National Diet and Nutrition Survey (NDNS) (Bates and others 2012)[†] and the recommend VITAL[®] Action Level. The action levels are calculated concentrations based on an accepted risk within the allergic population which help guide precautionary allergen labelling decisions. For more information please visit the VITAL[®] website (<http://allergenbureau.net/vital/>).

	Reference Dose	Mean Consume (g)*	p95 consume (g)**	Recommended VITAL [®] Action Level (ppm)***
Hazelnut				
Cheesecakes	0.1	115.6	227.5	0.87
Chocolate spread	0.1	28.6	60	3.5
Dark chocolate	0.1	28.3	125	3.53
Milk chocolate	0.1	39.6	125	2.53
Milk				
Apple pie only	0.1	125.3	200	0.67
Chewy sweets	0.1	57.3	250	1.75
Dry mix sauces and seasoning mixes	0.1	11	34	9.09
Ham excluding parma	0.1	44.9	100	1.52
Ice lolly	0.1	85.6	210	0.71
Dark chocolate	0.1	28.3	125	3.53
White chocolate	0.1	40.3	226.5	2.52
Sandwiches	0.1	N/A	N/A	N/A
Vegetable samosas	0.1	109.8	210	0.91
White bread rolls	0.1	85.5	180	0.91
Peanut				
Milk chocolate	0.2	39.6	125	2.29
Wheat				
Bombay mix and trail mixes	1	45.3	100	22.08
Breakfast oat porridge	1	18.9	31.2	45.87
Cereal Bars	1	37	80	20
Corn snacks	1	24.2	44	33.33
Dried stuffing mixes	1	N/A	N/A	N/A
Dry mix sauces and seasoning mixes	1	11	34	66.67
Indian ready meals	1	474.8	550	1.82
Marmite	1	6.6	18	83.33
Milk chocolate	1	39.6	125	11.43
Tortillas	1	41.2	117.8	16.31
Vegetarian sausages	1	123.7	200	6.67

- † Bates B, Lennox A, Prentice A, Bates C, Swan G. National Diet and Nutrition Survey: Headline results from Years 1, 2 and 3 (combined) of the rolling programme (2008/09-2010/11). Available from:
<https://www.gov.uk/government/statistics/national-diet-and-nutrition-survey-headline-results-from-years-1-2-and-3-combined-of-the-rolling-programme-200809-201011>
- * Max mean consumption among 9 population combinations of age (adults, children, all ages) and gender (male, female, all persons)
- ** Max p95 consumption among 9 population combinations of age (adults, children, all ages) and gender (male, female, all persons)
- *** Recommended action level from 9 population combinations of age (adults, children, all ages) and gender (male, female, all persons). Please note this action level does not always directly relate to the maximum consumption value from all 9 populations but could be derived from any of the 9 depending on the results of the subsequent quantitative risk assessments testing the calculated action levels.

Supplementary Table 2 – The concentrations of individual products with positive test results in the FSA Survey of Allergen Advisory Labelling (Hirst and Reading Scientific Services Ltd 2014)[†] and the subsequent percent of simulated eating occasions predicted to have result in an objective allergic reaction upon ingestion of these products by the at risk allergic population. Reactions are conservatively predicted in the allergic user population which assumes that everyone is allergic to the respective allergen and everyone consumes the particular product in question. There is no biological or statistical reason to distinguish between the choice log-normal (LN) and log-logistic (LL) distribution for the threshold distribution during the Monte Carlo simulation, therefore both results are presented and treated with equal weight. If both samples of the same food product were found to be positive then the highest concentration was reported and used in the risk assessments.

	Conc tested (mg/kg)	Predicted Reactions in Allergic User Population	
Hazelnut - May Contain		Range of LN (%)	Range of LL (%)
<i>Cheesecakes</i>			
Morrison's Double Chocolate Cheesecake	1	0.27 - 0.38	0.87 - 1.06
<i>Chocolate spread</i>			
Morrison's Chocolate spread	77	4.37 - 4.91	5.42 - 5.93
Whole Earth Milk Chocolate Spread	120	5.98 - 6.65	7.03 - 7.66
<i>Plain dark chocolate</i>			
Bournville Classic dark chocolate	78	3.84 - 4.38	4.86 - 5.44
Chocolat Patissier Swiss Dark Chocolate 70% cocoa	44	2.44 - 2.86	3.51 - 3.96
Fry's Chocolate Cream Chocolate with fondant centre	18	1.17 - 1.41	2.06 - 2.34
<i>Plain milk chocolate</i>			
Balance Milk chocolate (38% cocoa) with stevia - no sugar added	170	9.04 - 10.32	9.83 - 10.97
Bon Bon Buddies One Direction milk chocolate egg with choc bars	84	5.69 - 6.55	6.66 - 7.52
Divine Milk chocolate	12	1.26 - 1.5	2.16 - 2.44
Green & Black's Organic milk chocolate with butterscotch	1	0.11 - 0.13	0.48 - 0.54
Lindt Lindor Milk chocolate truffles with a smooth filling	4.4	0.49 - 0.59	1.18 - 1.33
Morrison's Coconut milk chocolate bars (10)	58	4.4 - 5.08	5.4 - 6.07
Morrison's Crunchy biscuit & caramel twin bars	4.8	0.53 - 0.64	1.25 - 1.4
Morrison's Salted butterscotch milk chocolate	68	4.91 - 5.69	5.9 - 6.66
Nestle Vice Versas	26	2.39 - 2.81	3.44 - 3.86
Milk - May Contain			
<i>Chewy sweets</i>			
£ One pounders Strawberry bonbons	14	2.51 - 3.18	3.23 - 3.89
<i>Dry mix sauces and seasoning mixes</i>			
Knorr Gourmet Oriental Stir Fry Chicken Recipe Mix	31	0.66 - 1.59	1.18 - 2.21
<i>Ham excluding parma</i>			
Farmfoods 12 slices lean breaded ham	6.6	1.04 - 1.46	1.8 - 2.23

<i>Ice lolly</i>			
Mini Calippo Orange & Lemon-Lime Ices	2.7	0.99 - 1.12	1.73 - 1.87
<i>Plain dark chocolate</i>			
Asda Dark chocolate	4400	48.02 - 52.17	46.62 - 50.69
Bournville Classic dark chocolate	2200	38.22 - 41.69	36.58 - 39.85
Chocolat Patissier Swiss Dark Chocolate 70% cocoa	540	20.49 - 22.73	19.31 - 21.4
Fry's Chocolate Cream Chocolate with fondant centre	1100	28.82 - 31.75	27.25 - 29.92
Lindt Extra fine dark chocolate (70% cocoa)	40	3.52 - 4.11	4.13 - 4.73
Montezuma's Organic 73% cocoa very dark chocolate	9.7	0.96 - 1.21	1.62 - 1.87
Ryelands Plain chocolate	810	25.08 - 27.71	23.62 - 26.06
Thorntons Dark chocolate (70% cocoa)	2600	40.55 - 44.2	38.95 - 42.45
Waitrose Cooks' Ingredients Dark Chocolate	1800	35.42 - 38.71	33.72 - 36.87
<i>Plain white chocolate</i>			
Organica Vegan Diets Organic white bar	100	7.39 - 9.82	7.62 - 9.7
<i>White bread rolls</i>			
Ormo White flour baps	3.9	1.12 - 1.59	1.89 - 2.39
Milk - Not Declared			
<i>Apple pie only</i>			
Conditorei Coppenrath & Wiese Apple Strudel	2.6	0.97 - 1.54	1.72 - 2.42
<i>Dry mix sauces and seasoning mixes</i>			
Sainsbury's Bread Sauce Mix	4.2	0.08 - 0.19	0.31 - 0.57
<i>Ice lolly</i>			
Waitrose Fruit Sorbet Lollies	29	7.92 - 8.64	8.08 - 8.68
<i>Sandwiches</i>			
Morrison's Deep Filled Chicken & Stuffing Sandwich	13	*	*
SuperValu Egg, Onion & Mayo Sandwich on White Bread	52	*	*
<i>Vegetable samosas</i>			
Shana Mixed Vegetable Samosas (20)	45	11.15 - 13.29	10.85 - 12.65
Peanut - May Contain			
<i>Plain milk chocolate</i>			
Bon Bon Buddies One Direction milk chocolate egg with choc bars	18	2.4 - 2.84	2.9 - 3.34
Wheat - May Contain			
<i>Bombay mix and trail mixes</i>			
Cofresh Bombay Mix	38.75	1.08 - 1.35	1.47 - 1.77
<i>Breakfast oat porridge</i>			
Scott's Porage Oats Thick Scottish milled oats	43.75	0.38 - 0.47	0.81 - 0.93
<i>Cereal Bars</i>			
Meridian Organic Peanut Butter & Oat Bar	262.5	9.49 - 11.55	8.63 - 10.28
<i>Corn snacks</i>			
Walkers Wotsits Cheesy Flavour Corn Puffs	17.5	0.12 - 0.16	0.41 - 0.5
<i>Dry mix sauces and seasoning mixes</i>			
Dunn's River All Purpose Seasoning	82.5	0.22 - 0.69	0.44 - 1.04

Knorr Gourmet Oriental Stir Fry Chicken Recipe Mix	32.5	0.05 - 0.16	0.18 - 0.41
Plain milk chocolate			
Bon Bon Buddies One Direction milk chocolate egg with choc bars	66.25	2.23 - 2.77	2.52 - 3.04
Vegetarian sausages			
Linda McCartney Vegetarian Red Onion & Rosemary Sausages	17.5	1.1 - 2.03	1.58 - 2.5
Wheat - Not Declared			
Bombay mix and trail mixes			
Sainsbury's Bombay Mix	40	1.14 - 1.41	1.52 - 1.82
Breakfast oat porridge			
Hamlyns of Scotland Scottish porridge oats	47.5	0.43 - 0.54	0.88 - 1.01
Cereal Bars			
Wholebake Pecan Flapjack	48.75	1.24 - 1.62	1.72 - 2.11
Dried stuffing mixes			
Mrs Crimble's Sage & Onion Stuffing Mix	28.75	*	*
Dry mix sauces and seasoning mixes			
East End Madras Curry Powder (hot)	37.5	0.07 - 0.2	0.21 - 0.47
Tropics All Purpose Seasoning	62.5	0.15 - 0.46	0.34 - 0.78
Indian ready meals			
Mumtaz Chicken Dopiaza & Pilau Rice	31.25	12.78 - 17.09	11.28 - 14.93
Marmite			
Tesco Yeast Extract	30	0.02 - 0.05	0.12 - 0.21
Tortillas			
Tesco Lightly Salted Tortilla Chips	13.75	0.15 - 0.27	0.43 - 0.6

† Hirst B, Reading Scientific Services Ltd. Survey of allergen advisory labelling and allergen content of UK retail pre-packed processed foods. Food Standards Agency (FSA) Project Code: FS241038.
<http://www.food.gov.uk/science/research/allergy-research/fs241038>. Available from:
<http://www.food.gov.uk/science/research/allergy-research/fs241038>

* Consumption data is not available for this product category and no quantitative risk assessments were performed.

Supplementary Table 3 – Range of tested concentrations during the UK Food Standards Agency (FSA) Survey of Allergen Advisory Labelling (Hirst and Reading Scientific Services Ltd 2014)[†] compared to the recommended VITAL[®] Action Level. The action levels are calculated concentrations based on an accepted risk within the allergic population which help guide precautionary allergen labelling decisions. For more information please visit the VITAL[®] website (<http://allergenbureau.net/vital/>).

	Range of Tested Concentrations (ppm protein)	Recommended VITAL [®] Action Level(ppm)*
Hazelnut - May Contain		
Cheesecakes	1	0.87
Chocolate spread	77 - 120	3.5
Dark chocolate	18 - 78	3.53
Milk chocolate	1 - 170	2.53
Milk - May Contain		
Chewy sweets	14	1.75
Dry mix sauces and seasoning mixes	31	9.09
Ham excluding parma	6.6	1.52
Ice lolly	2.7	0.71
Dark chocolate	9.7 - 4400	3.53
White chocolate	100	2.52
White bread rolls	3.9	0.91
Milk - Not Declared		
Apple pie only	2.6	0.67
Dry mix sauces and seasoning mixes	4.2	9.09
Ice lolly	29	0.71
Sandwiches	13 - 52	N/A
Vegetable samosas	45	0.91
Peanut - May Contain		
Milk chocolate	18	2.29
Wheat - May Contain		
Bombay mix and trail mixes	38.75	22.08
Breakfast oat porridge	43.75	45.87
Cereal Bars	262.5	20
Corn snacks	17.5	33.33
Dry mix sauces and seasoning mixes	32.5 - 82.5	66.67
Milk chocolate	66.25	11.43
Vegetarian sausages	17.5	6.67
Wheat - Not Declared		
Bombay mix and trail mixes	40	22.08
Breakfast oat porridge	47.5	45.87
Cereal Bars	48.75	20
Dried stuffing mixes	28.75	N/A
Dry mix sauces and seasoning mixes	37.5 - 62.5	66.67

Indian ready meals	31.25	1.82
Marmite	30	83.33
Tortillas	13.75	16.31

† Hirst B, Reading Scientific Services Ltd. Survey of allergen advisory labelling and allergen content of UK retail pre-packed processed foods. Food Standards Agency (FSA) Project Code: FS241038.
<http://www.food.gov.uk/science/research/allergy-research/fs241038>. Available from:
<http://www.food.gov.uk/science/research/allergy-research/fs241038>

* Recommended action level from 9 population combinations of age (adults, children, all ages) and gender (male, female, all persons). Please note this action level does not always directly relate to the maximum consumption value from all 9 populations but could be derived from any of the 9 depending on the results of the subsequent quantitative risk assessments testing the calculated action levels.