Food and Chemical Toxicology 146 (2020) 111831

Contents lists available at ScienceDirect

Food and Chemical Toxicology

journal homepage: www.elsevier.com/locate/foodchemtox

Full range of population Eliciting Dose values for 14 priority allergenic foods and recommendations for use in risk characterization

Geert F. Houben [a,*], Joseph L. Baumert [b], W. Marty Blom [a], Astrid G. Kruizinga [a], Marie Y. Meima [a], Benjamin C. Remington [b,c], Matthew W. Wheeler [d], Joost Westerhout [a], Steve L. Taylor [b]

[a] The Netherlands Organisation for Applied Scientific Research TNO, Utrecht, the Netherlands
[b] Food Allergy Research and Resource Program, University of Nebraska, Lincoln, USA
[c] Remington Consulting Group B.V., Utrecht, the Netherlands
[d] Biostatistics and Computational Biology Branch, National Institute of Environmental Health, Research Triangle Park, NC, USA

ARTICLE INFO

Keywords:
Food allergy
Food allergen
Allergenic food
Eliciting dose
Risk assessment
Risk management

ABSTRACT

Previously, we published selected Eliciting Dose (ED) values (i.e. ED01 and ED05 values) for 14 allergenic foods, predicted to elicit objective allergic symptoms in 1% and 5%, respectively, of the allergic population (Remington et al., 2020). These ED01 and ED05 values were specifically presented and discussed in the context of establishing Reference Doses for allergen management and the calculation of Action Levels for Precautionary Allergen Labeling (PAL). In the current paper, we publish the full range of ED values for these allergenic foods and provide recommendations for their use, specifically in the context of characterizing risks of concentrations of (unintended) allergenic proteins in food products.

The data provided in this publication give risk assessors access to full population ED distribution information for 14 priority allergenic foods, based on the largest threshold database worldwide. The ED distributions were established using broad international consensus regarding suitable datapoints and methods for establishing individual patient's NOAELs and LOAELs and state of the art statistical modelling. Access to these ED data enables risk assessors to use this information for state-of-the-art food allergen risk assessment. This paper contributes to a harmonization of food allergen risk assessment and risk management and PAL practices.

1. Introduction

Allergen management is a crucial element of food safety management to protect allergic consumers from allergic reactions upon consumption of food intentionally or unintentionally containing allergenic proteins. In most regions of the world, existing regulations obligate food business operators to label the intentional use of priority allergens, as defined by particular jurisdictions. However, the use or absence of allergenic ingredient declarations is not always in agreement with actual presence or absence of allergenic ingredients in food products. Furthermore, no clear regulations exist for the communication regarding potential Unintended Allergen Presence (UAP) in food and the use of precautionary allergen labeling (PAL) statements. Food allergic consumers therefore cannot always rely on the information regarding allergen presence, or the absence of reference to certain allergens, on food labels, particularly regarding UAP. This poses significant risks to the food allergic consumer, as shown previously for instance by Spanjersberg et al. (2010), Remington et al. (2015) and Blom et al. (2018).

As in all areas of food safety management, elimination of all risks is impossible and it is key to strike the right balance between minimizing risks on the one hand and feasibility and practicality of management measures on the other hand, and at the same time to account for potentially competing societal priorities, such as minimizing food waste. For this, it is crucial to understand the risk associated with certain concentrations of allergenic protein in a food product. The overall risk is dependent upon both the concentration of the allergenic protein in the food product and the quantities of that food that may be eaten by allergic consumers. Together, these two factors determine the doses of allergenic protein that consumers are exposed to. These exposure doses, together with the sensitivity distribution of the allergic individuals, determines

* Corresponding author. Princetonlaan 6, 3584 CB, Utrecht, the Netherlands.
E-mail address: geert.houben@tno.nl (G.F. Houben).

https://doi.org/10.1016/j.fct.2020.111831
Received 30 July 2020; Received in revised form 8 October 2020; Accepted 23 October 2020
Available online 7 November 2020
0278-6915/© 2020 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

the probability of an allergic reaction, for instance expressed as the proportion of the at risk population that will react if the food containing the allergenic protein is used by this population. If the risk is to be considered in a broader public health dimension, other factors such as the number of product units available for consumption at any one time or in a certain time period may be factored in the risk calculation.

The last decade we saw a great advance in risk analysis of allergenic proteins in food by combining and analyzing information from different oral food challenge studies. Taylor et al. (2014) published results of analyses of thresholds for allergic reactions of about 1750 individual patients for 11 different allergenic foods. These analyses were based on data from low-dose food challenges in food allergic subjects that were systematically collected by the Netherlands Organisation for Applied Scientific Research (TNO) and the Food Allergy Research and Resources Program (FARRP) of the University of Nebraska-Lincoln, USA. Reference Doses (RDs) based on doses predicted to elicit mild objective allergic symptoms in no more than 1–5% of the allergic population were proposed. These RDs were intended to balance minimizing risks for allergic consumers and feasibility in implementing RDs for food business operators. The RDs can be used to calculate Action Levels (ALs) for Precautionary Allergen Labeling (PAL) of food products. These RDs were adopted by the Allergen Bureau of Australia & New Zealand in 2012 and implemented in their Voluntary Incidental Trace Allergen Labeling (VITAL) program (http://allergenbureau.net/vital/) as VITAL Version 2.0 RDs (Taylor et al., 2014; Allen et al., 2014). The VITAL RDs are increasingly being used by food business operators worldwide to guide their allergen risk management including the calculation of ALs for PAL. Also patient groups welcome the use of RDs as evidence-based approach to the application of precautionary allergen labelling (DunnGalvin 2019). In recent years, also several food safety authorities of north-western European countries have adopted the principle of using RDs as a benchmark in their allergen risk assessment and management (BVL 2015; Bolin and Lindeberg 2016; NVWA 2016; FASFC 2017; Waiblinger and Schulze 2018).

The RDs proposed by Taylor et al. (2014) are expressed in mg total protein from the allergenic food. Levels of allergenic substance in food complying with RDs and ALs for PAL can be derived from these RDs by selecting appropriate food intake figures and using the following equation:

$$\mathrm{AL}(\text{in mg total protein from the allergenic food/kg food}) = \frac{\mathrm{RD}(\text{in mg total protein from the allergenic food})}{\text{Amount of food consumed(in kg)}}$$

In this equation, the “Amount of food consumed” refers to the amount consumed on a single eating occasion of a food product in which a certain amount of protein from an allergenic food is present (also see Discussion section).

Since the 2014 publication of the RDs by Taylor et al. (2014), TNO and FARRP continued systematically collecting threshold data and increased the number of available and useful datapoints from about 1750 to over 3400 for 14 different allergenic foods. In collaboration with a large panel of experts, including many clinicians internationally, TNO and FARRP recently published a consensus paper specifying how outcomes from food challenges are used to derive individual patients’ No-Observed-Adverse-Effect-Levels (NOAELs) and Lowest-Observed-Adverse-Effect-Levels (LOAELs) for objective symptoms (Westerhout et al., 2019), which are needed to derive population threshold dose distributions for objective symptoms (Taylor et al., 2009). Population threshold dose distribution modelling uses different statistical models (Taylor et al., 2014), where the estimated RD is model-dependent. As there is frequently no biological or statistical basis for preferring one model over another, the use of different models results in different risk predictions (predicted proportions reacting) for the same dose of protein. Previously, the RDs from different models were derived by applying expert judgement, including judgement of the fit of the various models with the actual challenge data, with emphasis on the region encompassing the ED01 and ED05. To reduce the subjectivity and uncertainty of choosing a RD from a single statistical model it is possible to apply Bayesian model averaging (Hoeting et al., 1999) or Bayesian Stacking (Yao et al., 2018). These techniques, hereafter generically referred to as model averaging, are statistical approaches that derive a single outcome based on different models while accounting for the degree of fit of the various models with the actual datapoints (EFSA Scientific Committee 2017; US EPA et al., 2019). Until recently, software for model averaging methods was not available for analyzing the interval-censored dose-to-failure distributions obtained for allergic symptoms in oral food challenges. TNO and FARRP therefore entered into collaboration with international experts in model averaging and developed a model averaging method, based upon Bayesian Stacking (Yao et al., 2018), suitable for modeling dose-to-failure distributions for allergy thresholds (Wheeler et al., 2020). Using all these achievements, we recently updated our threshold dose distribution analyses for 14 allergenic foods and published doses (and their 95% confidence intervals) that are predicted to elicit mild objective allergic symptoms in 1% (the Eliciting Dose 01 or ED01) or 5% (ED05) of the allergic population (Remington et al., 2020). The ED01 values from this publication were adopted by the Allergen Bureau of Australia & New Zealand in a VITAL program update in 2019 and implemented as VITAL Version 3.0 RDs (http://allergenbureau.net/vital/).

In the publication by Remington et al. (2020), the ED01 and ED05 values were specifically presented and discussed in the framework of establishing RDs for allergen management and the calculation of ALs for PAL. Besides for the elaboration of RDs, population threshold dose distributions can also be used to characterize the risks of other, broader ranges of doses of allergenic proteins. This would be of value for the quantification of risks when a certain concentration of (unintended) allergenic protein is found in a food product. Risk assessors and risk managers therefore would benefit from accessibility to a broader range of ED values for the various allergenic foods. The recently developed model averaging method enables the publication of unique single ED values. In this paper, we provide these ED values for the 14 priority allergenic foods and give recommendations for their use, specifically in the context of characterizing the risks of various concentrations of (unintended) allergenic proteins in food products, in this paper generally expressed as the predicted proportion of reactions in the at-risk population.

2. Data and methods

Full details on the methods for deriving the population threshold dose distributions for 14 priority allergenic foods and the data used are given in Remington et al. (2020). In brief: individual patients’ NOAELs and LOAELs for the elicitation of objective allergic symptoms were established from publications and unpublished clinical records of low-dose oral challenges using criteria as published previously by

Westerhout et al. (2019). Only data from double-blind, placebo-controlled food challenges (DBPCFCs) were used, except in case of data from infants and very young children and for wheat. The data were collected and assessed in terms of discrete dose and cumulative dose datasets and expressed in mg of total protein from the allergenic food. Individuals were left-censored if they reacted with objective symptoms to the first challenge dose, while individuals were right-censored if they failed to respond with objective symptoms to the uppermost challenge dose but did have clear histories of allergic reactions upon consumption of the offending food.

Individual studies were combined per allergenic food and analyzed with the Model Averaging approach developed by Wheeler et al. (2020). The approach combines five parametric survival distributions (Weibull distribution, Log-Gaussian (or Log-Normal), Log-Logistic, Generalized Pareto and Log-Laplace (or Log-Double-Exponential)) into a single model averaging outcome that was used to determine population EDs on the basis of both discrete dosing and cumulative dosing. The method is based upon a Bayesian stacking methodology and estimates dose-to-failure based upon Markov chain Monte Carlo (MCMC) simulation. As this methodology is a stochastic approximation based upon simulation, final ED estimates can have small variations. Because the method requires large amounts of computer resources, a single MCMC chain cannot be run to the required length to minimize Monte Carlo error. Instead, to minimize variability, the stacked model averaging estimation procedure is repeated independently 10 times and the mean of 10 ED estimates is used as a central estimate. For each allergenic food, the random sampling procedure is truncated at the highest given dose (discrete or cumulative), based on all of the studies included in the dataset for that specific allergenic food, as extrapolation beyond the highest given dose would lead to a change in the model average survival curve, resulting in overestimation of lower ED values (also see Discussion section).

3. Results

3.1. Eliciting Dose values from model averaged population threshold dose distributions for 14 priority allergenic foods

Table 1 gives ED01 to ED10 and ED15, ED20, ED25, and ED50 values from the model averaged population threshold dose distributions for the 14 priority allergenic foods. Both the EDs based on the discrete and the cumulative dose datasets are given. Full lists of ED values based on discrete (Table S1) and cumulative (Table S2) dose datasets with incremental steps of 0.1 from the ED0.1 to the ED0.9 and steps of 1 from the ED01 to the ED99 are given as supplementary data.

3.2. Eliciting Dose curves from model averaged population threshold dose distributions for 14 priority allergenic foods

Fig. 1 gives the curves of the ED values from the model averaged population threshold dose distributions for the 14 priority allergenic foods, based on the discrete and cumulative dose datasets.

4. Discussion and recommendations for use of ED values in risk characterization

The ED01 and ED05 values for the 14 allergenic foods published by us previously (Remington et al., 2020) were presented and discussed specifically in the context of establishing RDs for allergen management and the calculation of ALs for PAL. The publication of the broad range of ED values for these allergenic foods in the current paper is meant to support the characterization of the risk associated with the (unintended) presence of allergenic proteins in food products by providing the doses of allergenic protein to which defined proportions of the at-risk population are predicted to react. Allergen risk characterization can be applied to inform risk managers for example in cases of unintended presence of allergens or mislabeling (absence) of allergenic ingredients in food products on the market or to assess the efficacy of cleaning procedures. However, population ED values are only one of the elements needed for the characterization of risks of allergens in food. The ED values need to be accessed in combination with information on concentrations of allergenic proteins in food products and information on food intake. A risk assessment further needs to be attuned to the risk management question which should specify the outcomes of interest and the outcomes should be expressed and interpreted in a correct way. For instance, is the risk assessment outcome to be expressed as the proportion of allergic individuals that will react if a food containing an allergenic protein is used by them, or as the number of people expected to react considering the number of product units available in a certain region or period of time? Several choices need to be made that determine the correctness of the outcomes and the suitability for the purpose of the risk assessment. Therefore, in this section, we provide some recommendations for the use of the presented ED values to support risk assessors and risk managers in the application and interpretation of these for the characterization of risks of concentrations of (unintended) allergenic proteins in food products. In addition, we discuss several aspects of the datasets and ED values that are relevant for the applicability and suitability in use.

4.1. "Larger than" values and cut-off curves

In Table 1 and Tables S1 and S2 sometimes "larger than" (>xx) values are reported, and in Fig. 1 some curves do not run up to the 100% cumulative percentage of responders. This is due to truncated random sampling procedures. As indicated in section 2. Data and methods, for each allergen, the random sampling procedure is truncated at the highest dose (discrete or cumulative) given in the clinical challenges in the studies included in the dataset for that specific allergen. Extrapolation beyond this dose would possibly lead to a slight change in the model average survival curve, resulting in overestimation of the lower ED values and thus an underestimation of risks of low doses of allergenic protein. To avoid this, the random sampling procedures were truncated as described. Due to the truncation, it is not possible to estimate the high ED values for some of the allergens as these values would be higher than the highest given dose in challenge studies. Therefore, "larger than" (>xx) values are reported in the tables in these cases and some of the curves in Fig. 1 are cut off at some point. Yet, ED values up to at least the ED70 are available for all 14 allergenic foods.

4.2. Discrete versus cumulative dose datasets

As already discussed by Remington et al. (2020), in the challenge trials from which the ED values were derived, increasing doses were given with short intervals (usually between 15 and 30 min) to identify the patient's NOAEL and LOAEL. It cannot be excluded that in some cases a previous dose may have contributed to the total dose triggering allergic symptoms and using cumulative doses for establishing the NOAELs and LOAELs might be appropriate. However, allergic symptoms may well develop within minutes after allergen intakes, indicating that discrete doses may also be appropriate to use. This paper therefore, similarly as done by Remington et al. (2020), presents results from both discrete and cumulative dose datasets.

The ED values derived from the discrete dose datasets are often slightly lower than those derived from the cumulative dose datasets. However, there are cases where the ED values derived from the cumulative datasets, particularly low ED values, are slightly lower than the values derived from the discrete datasets (see for instance the low ED values for mustard, celery or fish in Table 1 and Supplementary Tables S1 and S2). Although the differences are rather small, it is recommended to consider both the discrete and cumulative dose datasets in all risk assessments and use the ED value or percentage of predicted responders that is most appropriate for the purpose of the assessment at

Table 1
ED01 to ED10 and ED15, ED20, ED25, and ED50 values from the model averaged population threshold dose distributions for 14 priority allergenic foods, based on discrete (A) and cumulative (B) dose datasets. The 95% confidence interval is represented by the lower confidence interval (LCI) and the upper confidence interval (UCI). ED values are expressed in mg total protein from the allergenic food.

A. Discrete dose datasets

ED	Cashew	LCI	UCI	Celery	LCI	UCI	Egg	LCI	UCI	Fish	LCI	UCI
ED01.0	0.05	0.02	0.3	0.07	0.02	1.9	0.2	0.1	0.5	2.6	1.0	12.0
ED02.0	0.1	0.04	0.9	0.3	0.04	4.0	0.6	0.3	1.3	4.8	1.8	20.1
ED03.0	0.3	0.08	1.9	0.6	0.1	6.4	1.1	0.5	2.3	7.1	2.7	28.0
ED04.0	0.5	0.1	3.3	1.0	0.2	9.0	1.6	0.8	3.4	9.5	3.6	35.8
ED05.0	0.8	0.2	5.0	1.5	0.3	11.8	2.3	1.2	4.7	12.1	4.5	43.9
ED06.0	1.2	0.3	7.1	2.2	0.5	15.0	2.9	1.6	6.1	14.7	5.6	52.2
ED07.0	1.6	0.4	9.5	2.9	0.6	18.3	3.7	2.0	7.5	17.5	6.6	60.8
ED08.0	2.1	0.6	12.3	3.8	0.8	22.0	4.5	2.4	9.1	20.4	7.8	69.8
ED09.0	2.7	0.7	15.5	4.8	1.1	25.9	5.4	2.9	10.8	23.5	9.0	79.0
ED10.0	3.4	0.9	19.0	5.9	1.4	30.2	6.3	3.4	12.6	26.7	10.2	88.7
ED15.0	7.8	2.1	42.7	13.0	3.3	55.8	11.8	6.5	22.9	45.5	17.6	143
ED20.0	14.5	3.9	77.5	23.3	6.2	89.9	18.5	10.4	35.5	69.2	27.0	210
ED25.0	23.9	6.3	125	36.9	10.3	134	26.7	15.0	50.5	99.1	38.8	293
ED50.0	139	34.7	666	180	55.2	596	94.5	53.1	173	418	163	1146
ED	**Hazelnut**	**LCI**	**UCI**	**Lupin**	**LCI**	**UCI**	**Milk**	**LCI**	**UCI**	**Mustard**	**LCI**	**UCI**
ED01.0	0.1	0.07	0.6	2.9	1.3	9.1	0.2	0.1	0.5	0.07	0.009	1.1
ED02.0	0.6	0.2	2.1	5.9	2.6	18.4	0.6	0.3	1.3	0.1	0.03	1.8
ED03.0	1.3	0.4	4.5	8.9	4.0	27.8	1.1	0.5	2.4	0.2	0.05	2.4
ED04.0	2.3	0.8	7.8	12.1	5.3	37.3	1.7	0.9	3.6	0.3	0.07	3.0
ED05.0	3.5	1.3	12.1	15.3	6.7	47.0	2.4	1.3	5.0	0.4	0.1	3.6
ED06.0	5.1	1.8	17.2	18.6	8.1	56.9	3.2	1.7	6.6	0.6	0.1	4.3
ED07.0	6.9	2.5	23.2	21.9	9.6	66.9	4.1	2.1	8.3	0.7	0.2	5.0
ED08.0	9.0	3.3	30.1	25.4	11.1	77.1	5.0	2.7	10.1	0.8	0.2	5.7
ED09.0	11.4	4.3	38.0	28.9	12.6	87.5	6.0	3.2	12.1	0.9	0.2	6.5
ED10.0	14.1	5.3	46.8	32.5	14.1	98.1	7.1	3.8	14.2	1.1	0.3	7.3
ED15.0	32.4	12.4	105	51.9	22.2	154	13.8	7.5	26.7	1.9	0.4	11.9
ED20.0	59.2	22.8	190	73.8	31.1	215	22.2	12.3	42.5	2.9	0.7	17.5
ED25.0	95.5	37.0	302	98.4	41.0	283	32.7	18.2	61.8	4.2	1.0	24.3
ED50.0	489	183	1405	287	113	781	125	70.1	227	17.2	3.6	88.4
ED	**Peanut**	**LCI**	**UCI**	**Sesame**	**LCI**	**UCI**	**Shrimp**	**LCI**	**UCI**	**Soy**	**LCI**	**UCI**
ED01.0	0.2	0.1	0.4	0.1	0.03	2.7	26.2	2.7	166	0.5	0.2	3.5
ED02.0	0.4	0.2	1.2	0.4	0.07	7.8	75.6	10.9	336	1.5	0.4	11.2
ED03.0	0.9	0.5	2.1	1.0	0.1	14.8	137	24.8	512	3.5	0.7	22.4
ED04.0	1.5	0.8	3.3	1.7	0.2	23.4	205	44.3	693	6.3	1.2	36.9
ED05.0	2.1	1.2	4.6	2.7	0.4	33.6	280	69.3	880	10.0	2.2	54.6
ED06.0	2.9	1.7	6.0	3.8	0.6	45.3	360	99.5	1072	14.5	3.3	75.6
ED07.0	3.8	2.2	7.7	5.1	0.8	58.4	445	135	1271	19.9	4.6	99.8
ED08.0	4.8	2.8	9.4	6.7	1.1	72.9	534	175	1475	26.3	6.3	127
ED09.0	5.9	3.4	11.3	8.4	1.5	88.9	627	219	1687	33.6	8.3	158
ED10.0	7.1	4.1	13.4	10.3	1.9	106	723	268	1903	41.9	10.6	192
ED15.0	14.6	8.6	26.3	22.8	4.7	214	1258	560	3089	99.1	27.1	419
ED20.0	24.7	14.8	43.6	40.2	9.0	355	1876	907	4457	186	53.4	748
ED25.0	37.7	22.7	65.7	62.9	14.7	530	2583	1289	6031	308	91.1	1197
ED50.0	165	99.0	282	306	66.1	1988	7906	3757	17917	1779	547	6459

ED	Walnut	LCI	UCI	Wheat	LCI	UCI
ED01.0	0.03	0.01	0.5	0.7	0.3	2.5
ED02.0	0.1	0.02	1.6	1.8	0.7	5.4
ED03.0	0.3	0.04	3.4	3.1	1.3	8.6
ED04.0	0.5	0.06	5.8	4.6	1.9	12.0
ED05.0	0.8	0.1	8.9	6.1	2.6	15.6
ED06.0	1.2	0.2	12.7	7.8	3.4	19.4
ED07.0	1.7	0.2	17.2	9.6	4.2	23.3
ED08.0	2.3	0.3	22.4	11.4	5.1	27.4
ED09.0	3.0	0.4	28.3	13.4	6.1	31.6
ED10.0	3.8	0.6	35.0	15.4	7.1	35.9
ED15.0	9.7	1.5	81.1	26.9	12.8	59.6
ED20.0	19.3	3.1	152	40.3	19.7	86.9
ED25.0	33.5	5.5	252	55.9	27.6	118
ED50.0	235	37.8	>1050	174	87.7	344

B. Cumulative dose datasets

ED	Cashew	LCI	UCI	Celery	LCI	UCI	Egg	LCI	UCI	Fish	LCI	UCI
ED01.0	0.09	0.04	0.5	0.05	0.02	0.5	0.2	0.1	0.5	1.3	0.4	12.7
ED02.0	0.3	0.09	1.8	0.2	0.04	1.6	0.6	0.3	1.4	3.9	1.0	29.0
ED03.0	0.6	0.2	3.7	0.4	0.07	3.2	1.1	0.5	2.5	7.2	1.8	49.7
ED04.0	1.0	0.3	6.2	0.8	0.1	5.3	1.7	0.9	3.8	11.1	3.1	74.3
ED05.0	1.6	0.4	9.4	1.3	0.2	7.9	2.4	1.3	5.3	15.6	4.6	102

(*continued on next page*)

Table 1 (*continued*)

B. Cumulative dose datasets

ED	Cashew	LCI	UCI	Celery	LCI	UCI	Egg	LCI	UCI	Fish	LCI	UCI
ED06.0	2.3	0.6	13.2	1.8	0.4	11.0	3.3	1.7	6.9	20.6	6.4	134
ED07.0	3.1	0.8	17.6	2.5	0.5	14.6	4.2	2.2	8.7	26.2	8.3	169
ED08.0	4.0	1.1	22.6	3.4	0.7	18.7	5.2	2.7	10.7	32.2	10.5	206
ED09.0	5.0	1.3	28.2	4.3	0.9	23.2	6.2	3.3	12.8	38.7	12.8	247
ED10.0	6.2	1.7	34.6	5.4	1.2	28.3	7.4	3.9	15.1	45.6	15.3	290
ED15.0	14.0	3.8	76.2	13.0	3.1	61.7	14.4	7.8	28.5	87.6	30.1	545
ED20.0	25.6	7.0	136	24.6	6.1	110	23.4	12.8	45.6	142	48.7	858
ED25.0	41.7	11.3	217	41.1	10.5	177	34.6	19.1	66.6	208	71.5	1225
ED50.0	232	59.5	1106	246	66.5	957	134	74.5	250	793	267	3822
ED	**Hazelnut**	**LCI**	**UCI**	**Lupin**	**LCI**	**UCI**	**Milk**	**LCI**	**UCI**	**Mustard**	**LCI**	**UCI**
ED01.0	0.2	0.09	0.7	2.6	0.5	14.8	0.3	0.2	0.6	0.05	0.006	0.9
ED02.0	0.7	0.2	2.7	5.8	1.4	28.5	0.7	0.4	1.6	0.1	0.02	1.6
ED03.0	1.7	0.6	5.8	9.3	2.4	42.2	1.3	0.7	3.0	0.2	0.04	2.3
ED04.0	3.0	1.1	10.1	13.0	3.5	55.9	2.1	1.1	4.6	0.3	0.06	3.1
ED05.0	4.7	1.7	15.7	16.8	4.7	70.0	3.1	1.6	6.6	0.5	0.09	3.9
ED06.0	6.8	2.5	22.5	20.8	6.0	84.1	4.1	2.1	8.7	0.6	0.1	4.8
ED07.0	9.3	3.4	30.5	25.0	7.4	98.6	5.3	2.8	11.1	0.8	0.2	5.8
ED08.0	12.2	4.5	39.8	29.3	8.9	113	6.6	3.5	13.7	0.9	0.2	6.9
ED09.0	15.5	5.8	50.4	33.7	10.4	128	8.1	4.2	16.6	1.1	0.2	8.0
ED10.0	19.3	7.3	62.4	38.3	12.0	144	9.6	5.1	19.6	1.3	0.3	9.2
ED15.0	44.9	17.2	143	63.3	21.0	225	19.1	10.3	38.1	2.5	0.6	16.4
ED20.0	83.1	32.1	260	92.3	31.7	316	31.6	17.2	62.0	4.1	0.9	25.8
ED25.0	136	52.7	419	126	44.2	419	47.3	25.8	91.7	6.2	1.4	37.6
ED50.0	728	276	2064	402	144	1254	192	106	359	29.4	5.9	154
ED	**Peanut**	**LCI**	**UCI**	**Sesame**	**LCI**	**UCI**	**Shrimp**	**LCI**	**UCI**	**Soy**	**LCI**	**UCI**
ED01.0	0.7	0.5	1.3	0.2	0.04	4.8	30.8	3.4	326	0.7	0.3	4.5
ED02.0	1.5	1.1	2.6	0.7	0.09	13.8	98.3	14.3	676	2.0	0.6	15.0
ED03.0	2.3	1.6	4.0	1.5	0.2	25.8	190	33.1	1047	4.8	1.0	30.5
ED04.0	3.1	2.2	5.5	2.7	0.3	40.5	301	59.8	1440	8.8	1.7	51.0
ED05.0	3.9	2.8	7.1	4.2	0.6	57.7	429	94.0	1854	14.1	3.1	76.2
ED06.0	4.8	3.4	8.8	6.0	0.9	77.3	571	136	2293	20.8	4.7	106
ED07.0	5.8	4.1	10.6	8.1	1.3	99.1	727	185	2753	28.8	6.7	141
ED08.0	6.8	4.8	12.6	10.4	1.7	123	895	242	3237	38.2	9.2	181
ED09.0	7.9	5.5	14.8	13.1	2.3	149	1074	305	3745	49.2	12.2	226
ED10.0	9.0	6.2	17.3	16.1	2.9	178	1265	376	4274	61.6	15.6	277
ED15.0	16.8	10.6	34.0	35.1	7.3	350	2377	823	7299	149	41.2	613
ED20.0	30.8	17.0	56.8	61.1	13.7	574	3745	1415	11007	284	82.5	1110
ED25.0	48.2	28.2	87.1	94.3	22.1	847	5374	2132	15457	475	143	1801
ED50.0	236	138	412	443	91.5	2993	18867	7690	52732	2858	903	10140

ED	Walnut	LCI	UCI	Wheat	LCI	UCI
ED01.0	0.04	0.02	0.6	1.1	0.4	3.8
ED02.0	0.1	0.03	2.3	2.8	1.0	8.5
ED03.0	0.4	0.06	4.9	4.7	1.9	13.6
ED04.0	0.7	0.09	8.4	6.9	2.8	19.1
ED05.0	1.2	0.1	13.0	9.3	3.9	24.9
ED06.0	1.7	0.2	18.6	11.9	5.0	31.0
ED07.0	2.5	0.3	25.2	14.7	6.3	37.4
ED08.0	3.3	0.5	33.0	17.6	7.7	44.0
ED09.0	4.4	0.6	41.9	20.7	9.1	50.9
ED10.0	5.6	0.8	52.0	23.9	10.6	58.1
ED15.0	14.3	2.2	122	41.9	19.3	97.4
ED20.0	28.7	4.6	231	63.3	29.7	143
ED25.0	50.2	8.2	386	88.1	41.9	194
ED50.0	360	57.0	>1693	279	135	578

hand. This will generally be the one that, from a precautionary principle, gives the most conservative risk characterization (i.e. the risk of a certain concentration of allergenic protein in food is assumed a bit higher).

4.3. Establishment of the percentage of responders to be expected for a dose of allergenic substance

The percentage of allergic individuals expected to experience objective allergic symptoms when consuming a certain dose of protein from an allergenic food can be retrieved by using the ED value tables presented in this paper. For example, for a dose 0.8 mg total cashew protein, the discrete dose dataset predicts that around 5% (2–9% based on the confidence intervals) of the cashew allergic individuals will show an objective allergic reaction (see Table 1 and Supplementary data Table S1). The cumulative dose dataset predicts that between 3 and 4% (2–7% based on the confidence intervals) of the cashew allergic individuals will have an objective allergic reaction (Table 1 and Supplementary data Table S2). Appropriate use of the ED value tables and correct determination of the percentage responders to be expected for a certain dose of allergenic substance depend on a correct establishment and expression of the dose to use for comparison with the ED values, which is addressed in the following paragraph.

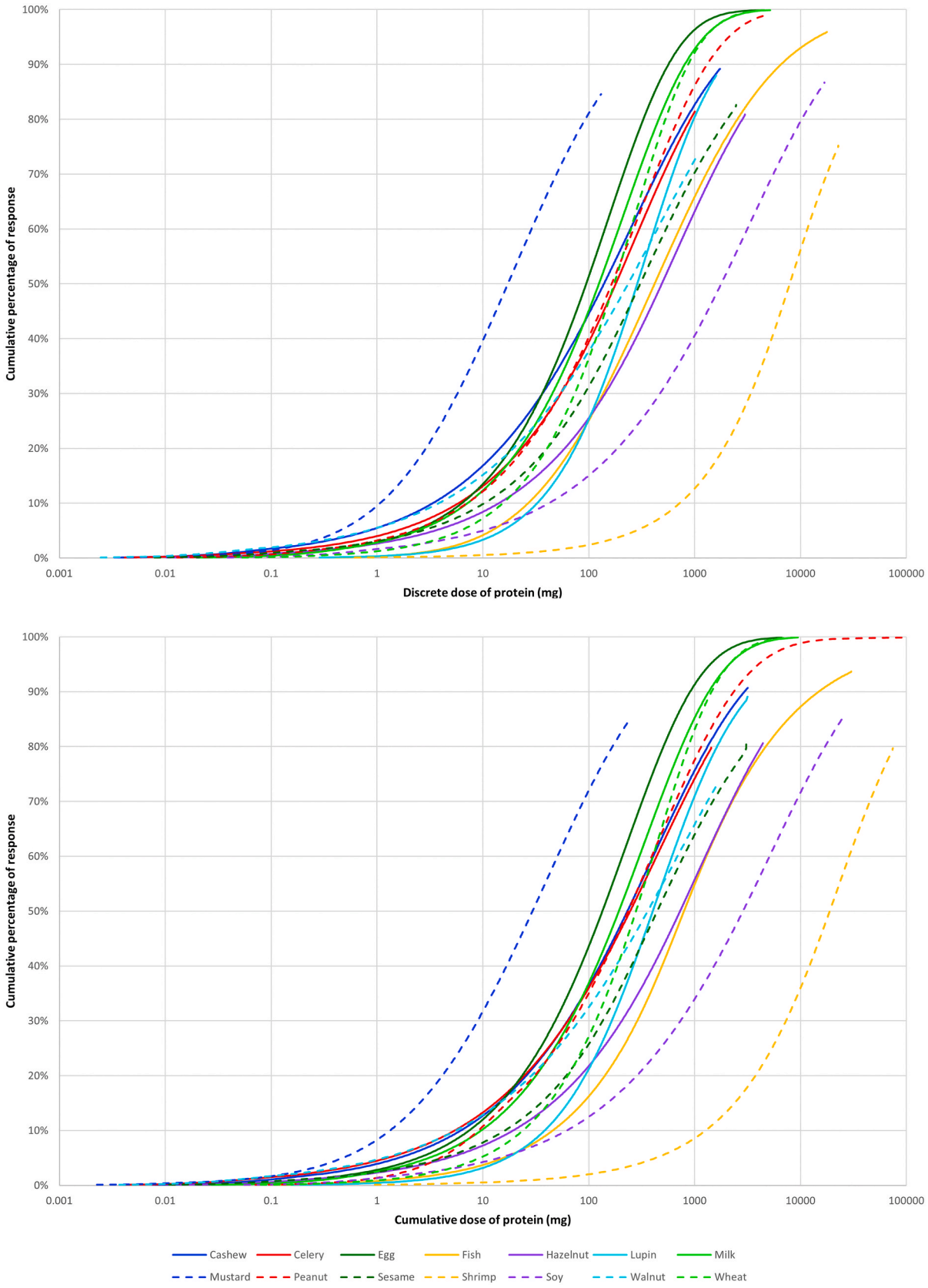

Fig. 1. ED curves from the model averaged population threshold dose distributions for 14 priority allergenic foods, based on discrete (upper graphs) and cumulative (lower graphs) dose datasets. Doses are expressed in mg total protein from the allergenic food.

4.4. Establishment and expression of the dose of allergenic substance

The ED values given in this paper are doses expressed in mg total protein from the allergenic food. For the quantification of the risk associated with a certain concentration of allergenic substance in a food, this concentration needs to be transformed into a dose of allergenic substance by multiplying it by the amount of the food consumed at a single eating occasion using the following equation and reporting units:

$$\underset{\text{(in mg total protein from the allergenic food/kg food)}}{\text{Concentration of allergenic substance}} \times \text{Amount of food consumed(in kg)} = \underset{\text{(in mg total protein from the allergenic food)}}{\text{Dose of allergenic substance}}$$

Again, "Amount of food consumed" refers to the amount consumed of a food product in which a certain amount of protein from an allergenic food is present.

4.4.1. Amount of food consumed

Food allergic reactions generally develop rapidly (within half an hour) and the amount of allergenic protein consumed within a short period of time determines the relevant dose for use in the risk assessment of allergenic protein in food. Therefore, the amount of a food consumed at a single eating occasion is to be used for establishing the dose, rather than for instance daily intakes (Spanjersberg et al., 2007; Kruizinga et al., 2008). Preferably, data derived from surveys on real food intake should be used. Recommended serving sizes provided by, for instance, food manufacturers or nutritional guides, refer to single eating occasions but should NOT be used, because they generally are provided for nutritional purposes, e.g. to discourage the use of large amounts of high caloric foods, and generally do not reflect real intakes. However, also from data on real food intake, various intake figures can be selected for single eating occasions, ranging from the mean, various percentile (P)-values (e.g. P75, P80, P90., P95, P97.5) or even maximum values. It should be realized that using higher intake values results in more conservative risk assessments that may overestimate the actual risks. Although this appears safe from a risk management perspective, using too high intake figures may miss the right balance between being protective on one hand and being practical and feasible to implement on the other hand and thus may not optimally inform risk managers. It therefore is crucial to carefully consider the selection of the most appropriate food intake figure when performing a risk assessment.

The importance of selecting an appropriate intake figure was clearly illustrated by Blom et al. (2019), who performed sensitivity analyses to establish what food intake point estimate is most appropriate for use in deterministic food allergen risk assessment in the context of applying RDs as proposed by Taylor et al. (2014). They showed that using the P50 intake of a food product in the population of users of the product provides a deterministic risk assessment outcome as safe as a probabilistic risk assessment for 99% of the food groups. Using the P75 resulted in a deterministic risk assessment outcome as safe as the one calculated through probabilistic modelling for all food groups. In these analyses, a probabilistic risk assessment was used as a reference, as this approach is generally considered the most appropriate method for population risk assessment and management purposes (Madsen et al., 2009). Based on these results, the P75 was recommended for use as a point estimate in deterministic risk assessment for compliance with RDs as proposed by Taylor et al. (2014) rather than higher intake figures. The P75 is sufficiently conservative and provides a good balance between compliance with the predefined food safety objective and feasibility and practicality of management measures (Blom et al., 2019). A list of population p75 intakes at single eating occasions for a broad range of food groups was developed by combining food consumption data from various north-western European countries and was published by Birot et al. (2018).

4.4.2. Reporting units

Concentrations, amounts and doses of allergenic substances can be expressed in various reporting units (e.g. based on whole peanut, peanut butter or defatted peanut flour, raw whole egg, dried whole egg or dried egg white, crushed sesame seeds or sesame seed flour, milk or milk protein). Whole allergenic food amounts, processed allergenic food or fraction amounts and amounts of total protein from these foods can be converted into each other (Taylor et al., 2014). As the ED values given in this paper are doses expressed in mg total protein from the allergenic food, results from analyses always need to be carefully checked regarding reporting units used and, if required, converted into mg total protein from the allergenic food to allow comparison with the ED values given in this paper. For example, if from analyses it is reported that a food product contains 30 mg of milk/100 g food product, this equals about 1 mg of milk protein/100 g if liquid milk is used as reporting unit, based on a protein content of milk of 3.3% (Taylor et al., 2014). If this food product would concern a herb or spices mix, bouillon cube, or yeast extract, the north-western European population p75 intake at a single eating occasion would be about 20 g (Birot et al., 2018). An intake of 20 g of such food product would lead to a dose of about 0.2 mg of protein from milk, which is the right unit to compare with the ED values presented in this paper. Supplementary Tables S1 and S2 show that this dose will be unlikely to elicit objective allergic symptoms in more than 1% of the milk allergic population. This dose does not exceed the VITAL 3.0 RD for milk of 0.2 mg protein from milk (http://allergenbureau.net/vital/) and indicates that allergic reactions that incidentally might be triggered generally will be mild (Remington et al., 2020). However, if it is reported that such food product contains 30 mg of milk protein/100 g food product, the dose resulting from intake of 20 g of such food product would be 6 mg of protein from milk. This dose equals the discrete dose dataset ED09 (Supplementary Table S1), indicating that 9% of the milk allergic patients may be expected to suffer objective allergic symptoms. The predicted risk from the cumulative dose dataset is in the same range but slightly lower than the risk predicted by the discrete dose dataset (the dose of 6 mg is between the cumulative dose dataset ED07 and ED08 (Supplementary Table S2), suggesting between 7 and 8% of responders with objective symptoms). From a precautionary approach, the 9% responders predicted by the discrete dose dataset should be used. The potential for some milk-allergic consumers to experience severe reactions at such doses is unknown but cannot be easily excluded.

4.5. Deterministic versus probabilistic risk assessment

As indicated above, probabilistic risk assessment is considered the most appropriate method for population allergen risk assessment and management purposes (Madsen et al., 2009; Crevel et al., 2014). The ED values presented in this paper can be used for probabilistic risk assessment. However, for such advanced risk assessment, specific expertise, advanced statistical modelling programs and experience and additional datasets like population single eating occasion food intake distributions are needed (Spanjersberg et al., 2010; Rimbaud et al., 2010; Remington et al., 2015; Blom et al. 2017, 2018). These conditions cannot always be met by all risk assessors and the ED values can then be used for deterministic risk assessment as an alternative, if the recommendations given

in the previous paragraphs are followed. Such a deterministic approach may be opportune for many risk management goals or can be performed as a first-tier risk assessment. In case where an appropriate deterministic risk assessment does not indicate a risk in excess of what is considered tolerable, a more advanced risk assessment may not be needed. If a risk in excess of what is considered tolerable cannot be excluded based on a deterministic risk assessment, risk mitigation measures can be applied whenever possible, or a more advanced probabilistic risk assessment involving experienced experts with access to the required models and datasets can be considered to more precisely characterize the risks.

4.6. Reliability, representativeness and robustness of ED values and uncertainties in risk assessment

Considerable research has been done to investigate the reliability, representativeness and robustness of ED values as elaborated. A major achievement was published by Hourihane et al. (2017), who, using a novel single dose challenge protocol, documented that dosing peanut allergic individuals at the ED05 only resulted in mild symptoms. Further, their observation that at the ED05 only 2.3% of the challenged individuals showed predefined positive reactions, indicates that either some selection bias occurred or that the approach used to elaborate the ED values introduces some conservatism, providing a small undocumented additional safety margin. For a summary and discussion of this and other studies on the safety of ED values we refer to the discussion section of our previous paper in which we published the ED01 and ED05 values in the context of establishing RDs (Remington et al., 2020). Most datasets contained over 60 datapoints, while Klein Entink et al. (2014) reported that above 60 datapoints, ED estimates are relatively stable. Particularly for the datasets with low numbers of subjects, the data were carefully checked on irregular distributions, which would disqualify the data for modeling the ED distribution for the specific allergenic food. All data used were further carefully checked on methodological criteria, as specified in Remington et al. (2020), and the consensus methodology for elaborating NOAELs and LOAELs from the datasets as published by Westerhout et al. (2019) was applied. Finally, the model averaging method applied includes and combines different statistical models, uses predictive inference assigned weights to the various models based upon predictive accuracy, and best accounts for study-to-study heterogeneity (Wheeler et al., 2020) and avoids ED estimate differences by different statistical models, some of which sometimes poorly match the actual challenge data, as discussed by Taylor et al. (2014). As reported by Remington et al. (2020), "prior attempts to study possible differences between age groups or differences arising from variations in geographic location or challenge material have found no difference between the studies, or have been confounded by patient selection bias and differing study protocols/dosing schemes and no true differences could be observed". Therefore, all available data could be combined to derive the ED value distributions, suitable for direct use in risk assessment for each age group without the need to apply uncertainty corrections to these. However, other sources of uncertainly may exist when doing a risk assessment, for instance regarding representativeness of samples analyzed for allergenic substance concentrations or uncertainties regarding the amounts of food actually consumed by individuals at single eating occasions. These uncertainties may indicate the need for uncertainty corrections in a risk assessment, to be considered on a case-by-case basis for each risk assessment conducted. These uncertainties however are not unique to food allergen risk assessment as these apply generically to any domain of food risk assessment.

Although we thus acknowledge that there will be uncertainties, it should also be recognized that there is a rather unique advantage supporting the reliability of food allergen risk assessment based on ED values as we present in this paper. Scientific information has accumulated over the past decades and the reliability of data on the sensitivity of food allergic individuals enables a more reliable hazard characterization compared to many other areas of risk assessment and food safety standard setting. Numerous risk assessments have been conducted and standards have been set in toxicology, based on animal test data subject to significant uncertainties in the extrapolation to humans. The data published in this paper give insight into the sensitivity distribution specifically of the defined human subpopulation at risk of a food allergic reaction for which the risk assessment and risk management is performed. Remaining uncertainties in food allergen hazard, risk and safety assessment, based on this insight, will likely be negligible in comparison to uncertainties associated with many of the animal to human extrapolations as generally applied in toxicology.

4.7. Comparison of allergenic potencies of protein from different foods

The ED values presented in this paper allow comparison of the allergenic potencies of protein from different allergenic foods. The results show that allergenic potencies differ between foods. This particularly is clear from the ED distribution graphs given in Fig. 1. From this figure and Tables 1, S1 and S2, it is directly clear that mustard is the most potent allergenic food and soy and shrimp are least potent. For other allergenic foods, it sometimes is difficult to decide which allergenic food is more potent than another, as curves may cross each other. Previously, an Expert Group of the European branch of the International Life Science Institute (ILSI Europe) discussed the best value for comparing allergenic potencies of protein from different foods and concluded that the ED50 is the most suitable and robust parameter for this (Houben et al., 2016). This analysis was performed in the context of prioritization of allergenic foods for inclusion in allergen labeling legislation. The Expert group proposed and gave a proof of principle of using this parameter in combination with the prevalence of allergy for the allergenic foods in a 2-parameter scaling approach to express and compare the allergenicity of existing allergenic foods. A working group of the EU Cost Action project ImpARAS (https://imparas.eu) continued on this idea of a 2-parameter scaling approach to express and compare the allergenicity of foods. They presented a concept of using this scaling approach to develop a benchmark for the interpretation of results of allergenicity assessments of novel or modified food proteins (Houben et al., 2019). They also including a proof of principle applying this to allergenicity assessment results of insect proteins. The ED values published here may support efforts for developing criteria and methods also for the allergenicity risk assessment of novel (sustainable) food protein supply systems.

5. Final remarks

Our publication of the full range of ED values for the 14 EU priority allergenic foods is meant to support the characterization of risks posed by levels of (unintended) allergenic protein in food products. The information published in this paper can also be used to support the process of establishing and harmonizing RDs for risk management purposes, like for the calculation of ALs for PAL. It can be used in conjunction with industry guidance such as provided by the Allergen Bureau of Australia & New Zealand (Food Industry Guide to the Voluntary Incidental Trace Allergen Labelling (VITAL®) Program: http://allergenbureau.net/vital/) or FoodDrinkEurope (Guidance on Food Allergen Management for Food Manufacturers: https://www.fooddrinkeurope.eu/) to support food businesses at different levels in the supply chain. Currently, the use of PAL is not guided by harmonized regulation and differences in practices exist between companies or sectors as well as authorities from

different countries. The current situation poses significant risks to allergic consumers, as for instance shown by a recent prospective study on the occurrence of unexpected allergic reactions (Michelsen-Huisman et al., 2018; Blom et al., 2018) and there is an urgent need to improve and harmonize risk management and communication practices. It is not in the benefit of any of the stakeholders, and at least in the benefit of allergic consumers, if individual companies or individual authorities make their own and different choices in establishing RDs, and harmonization will benefit all stakeholders and most of all the allergic consumer. The establishment of a food safety objective and selection of ED values for establishing harmonized RDs for food allergen risk management and PAL by food business operators and regulatory agencies preferably should be supported through a process involving all stakeholders. An Expert Group of ILSI Europe recently analyzed and discussed various aspects of processes for establishing safety standards and proposed a framework for establishing a level of tolerable risk for allergen management based on criteria suggested by Murphy and Gardoni (2008) (Madsen et al., 2020). Based on these criteria, the Expert Group concluded that sufficient knowledge is available to apply the framework and move forward with developing a harmonized RD-based guidance for allergen risk management and the application of PAL.

One of the criteria derived from Murphy and Gardoni that Madsen et al. (2020) considered crucial for the establishment of a broadly accepted tolerable level of risk and RDs for PAL is that required data inputs are accurate, available and accessible. They indicated that a significant step towards common standards has been achieved with the recent publication of Westerhout et al. (2019) and that publication of full population ED-distribution details would provide important true availability and accessibility of input data. The data provided in this publication give risk assessors and risk managers this access to full population ED distribution information for 14 priority allergenic foods, based on the worldwide largest threshold database, using broad international consensus regarding suitable datapoints and methods to apply for establishing individual patient's NOAELs and LOAELs and state of the art statistical modelling, and enable them to use this in food allergen risk assessment and management. This paper therefore gives a strong contribution to a harmonization of food allergen risk assessment and risk management and PAL practices.

CRediT authorship contribution statement

Geert F. Houben: Conceptualization, Methodology, Investigation, Resources, Writing - original draft, Supervision, Project administration, Funding acquisition. **Joseph L. Baumert:** Conceptualization, Methodology, Software, Investigation, Resources, Data curation, Writing - review & editing, Supervision, Project administration, Funding acquisition. **W. Marty Blom:** Conceptualization, Investigation, Data curation, Writing - review & editing, Supervision, Project administration. **Astrid G. Kruizinga:** Conceptualization, Resources, Writing - review & editing, Project administration. **Marie Y. Meima:** Data curation, Investigation, Writing - review & editing. **Benjamin C. Remington:** Conceptualization, Writing - review & editing, Methodology, Software, Validation, Formal analysis, Investigation, Visualization, Supervision, Data curation. **Matthew W. Wheeler:** Methodology, Software, Writing - review & editing. **Joost Westerhout:** Methodology, Software, Data curation, Validation, Formal analysis, Investigation, Writing - review & editing, Visualization. **Steve L. Taylor:** Conceptualization, Resources, Writing - review & editing, Supervision, Project administration, Funding acquisition.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

This research was partly financially supported through Dutch Governmental TNO Research Cooperation Funds, the Netherlands.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.fct.2020.111831.

References

Allen, K.J., Remington, B.C., Baumert, J.L., Crevel, R.W.R., Houben, G.F., Brooke-Taylor, S., Kruizinga, A.G., Taylor, S.L., 2014. Allergen reference doses for precautionary labeling (VITAL 2.0): clinical implications. J. Allergy Clin. Immunol. 133 (1), 156–164. https://doi.org/10.1016/j.jaci.2013.06.042.

Birot, S., Madsen, C.B., Kruizinga, A.G., Crépet, A., Christensen, T., Brockhoff, P.B., 2018. Food groups for allergen risk assessment: combining food consumption data from different countries in Europe. Food Chem. Toxicol. 118, 371–381. https://doi.org/10.1016/j.fct.2018.05.042.

Blom, W.M., Kruizinga, A.G., Rubingh, C.M., Remington, B.C., Crevel, R.W.R., Houben, G.F., 2017. Assessing food allergy risks from residual peanut protein in highly refined vegetable oil. Food Chem. Toxicol. 106, 306–313. https://doi.org/10.1016/j.fct.2017.05.072.

Blom, W.M., Michelsen-Huisman, A.D., van Os-Medendorp, H., van Duijn, G., de Zeeuw-Brouwer, M.-L., Versluis, A., Castenmiller, J.J.M., Noteborn, H.P.J.M., Kruizinga, A. G., Knulst, A.C., Houben, G.F., 2018. Accidental food allergy reactions: products and undeclared ingredients. J. Allergy Clin. Immunol. 142 (3), 865–875. https://doi.org/10.1016/j.jaci.2018.04.041.

Blom, W.M., Remington, B.C., Baumert, J.L., Bucchini, L., Crépet, A., Crevel, R.W.R., Madsen, C.B., Taylor, S.L., Houben, G.F., Kruizinga, A.G., 2019. Sensitivity analysis to derive a food consumption point estimate for deterministic food allergy risk assessment. Food Chem. Toxicol. 125, 413–421. https://doi.org/10.1016/j.fct.2019.01.025.

Bolin Sjögren, Y., Lindeberg, I., 2016. Undeclared Allergens in Food: Food Control, Analyses and Risk Assessment. ISSN: 0908-6692, vol. 528. Nordic Council of Ministers, Nordic Council of Ministers Secretariat, Copenhagen. https://doi.org/10.6027/TN2016-528. Nordisk Ministerråd, TemaNord Series.

BVL, 2015. (German federal office of consumer protection and food safety). Beurteilungswerte allergene. http://www.bvl.bund.de/SharedDocs/Downloads/01_Lebensmittel/ALS_ALTS/ALTS_Beschluesse_74_Arbeitstagung_Dez_2014.pdf?__blob=publicationFile&v=2, 5.

Crevel, R.W.R., Baumert, J.L., Baka, A., Houben, G.F., Knulst, A.C., Kruizinga, A.G., Luccioli, S., Taylor, S.L., Madsen, C.B., 2014. Development and evolution of risk assessment for food allergens. Food Chem. Toxicol. 67, 262–276. https://doi.org/10.1016/j.fct.2014.01.032.

DunnGalvin, A., Roberts, G., Schnadt, S., Astley, S., Austin, M., Blom, W.M., Baumert, J., Chan, C.-H., Crevel, R.W.R., Grimshaw, K.E.C., Kruizinga, A.G., Regent, L., Taylor, S., Walker, M., Mills, E.N.C., 2019. Evidence-based approaches to the application of precautionary allergen labelling: report from two iFAAM workshops. Clin. Exp. Allergy 49 (9), 1191–1200. https://doi.org/10.1111/cea.13464.

EFSA Scientific Committee, 2017. Update: use of the benchmark dose approach in risk assessment. EFSA J 15, 1–41. https://doi.org/10.2903/j.efsa.2017.4658.

FASFC (Belgium Federal Agency for the Safety of the Food Chain, 2017. Reference Doses for the Allergens Mentioned in Annex II of Regulation (EU) N° 1169/2011 of 25 October 2011. http://www.afsca.be/wetenschappelijkcomite/adviezen/2017/_documents/Advies24-2017_SciCom2017-01_referentiedosissenallergenen.pdf.

US EPA, Gift, J., Davis, J.A., Blessinger, T., Wheeler, M., Olszyk, L., Simmons, C., Allen, B., Brown, M.E., 2019. Benchmark Dose Software (BMDS 3.0) User Manual. EPA/600/R-18/310. https://www.epa.gov/sites/production/files/2018-09/documents/bmds_3.0_user_guide.pdf.

Hoeting, J.A., Madigan, D., Raftery, A.E., Volinsky, C.T., 1999. Bayesian model averaging: a tutorial. Stat. Sci. 14 (4), 382–401. https://doi.org/10.1214/ss/1009212519.

Houben, G., Burney, P., Chan, C.-H., Crevel, R., Dubois, A., Faludi, R., Klein Entink, R., Knulst, A., Taylor, S., Ronsmans, S., 2016. Prioritisation of allergenic foods with respect to public health relevance. Report from an ILSI Europe food allergy task force expert group. Food Chem. Toxicol. 89, 8–18. https://doi.org/10.1016/j.fct.2015.12.028.

Houben, G., Blom, M., Alvito, P., Assunção, R., Crevel, R., Fæste, C.K., Le, T.-M., Madsen, C.B., Remington, B., Stroheker, T., Vassilopoulou, E., Verhoeckx, K., Žiarovská, J., Constable, A., 2019. Defining the targets for the assessment of IgE-mediated allergenicity of new or modified food proteins. Food Chem. Toxicol. 127, 61–69. https://doi.org/10.1016/j.fct.2019.02.036.

Hourihane, J.O., Allen, K.J., Shreffler, W.G., Dunngalvin, G., Nordlee, J.A., Zurzolo, G.A., Dunngalvin, A., Gurrin, L.C., Baumert, J.L., Taylor, S.L., 2017. Peanut Allergen Threshold Study (PATS): novel single-dose oral food challenge study to validate eliciting doses in children with peanut allergy. J. Allergy Clin. Immunol. 139 (5), 1583–1590. https://doi.org/10.1016/j.jaci.2017.01.030.

Klein Entink, R.H., Remington, B.C., Blom, W.M., Rubingh, C.M., Kruizinga, A.G., Baumert, J.L., Houben, G.F., 2014. Food allergy population thresholds: an evaluation of the number of oral food challenges and dosing schemes on the accuracy of

threshold dose distribution modeling. Food Chem. Toxicol. 70, 134–143. https://doi.org/10.1016/j.fct.2014.05.001.

Kruizinga, A.G., Briggs, D., Crevel, R.W.R., Knulst, A.C., Bosch, L.M.C.v.d., Houben, G.F., 2008. Probabilistic risk assessment model for allergens in food: sensitivity analysis of the minimum eliciting dose and food consumption. Food Chem. Toxicol. 46 (5), 1437–1443. https://doi.org/10.1016/j.fct.2007.09.109.

Madsen, C.B., Hattersley, S., Buck, J., Gendel, S.M., Houben, G.F., Hourihane, J.O.B., Mackie, A., Mills, E.N.C., Nørhede, P., Taylor, S.L., Crevel, R.W.R., 2009. Approaches to risk assessment in food allergy: report from a workshop "developing a framework for assessing the risk from allergenic foods. Food Chem. Toxicol. 47 (2), 480–489. https://doi.org/10.1016/j.fct.2008.12.001.

Madsen, C.B., van den Dungen, M.W., Cochrane, S., Houben, G.F., Knibb, R.C., Knulst, A. C., Ronsmans, S., Yarham, R.A.R., Schnadt, S., Turner, P.J., Baumert, J., Cavandoli, E., Chan, C.-H., Warner, A., Crevel, R.W.J., 2020. Can we define a level of protection for allergic consumers that everyone can accept? Regul. Toxicol. Pharmacol. 117, 104751 https://doi.org/10.1016/j.yrtph.2020.104751.

Michelsen-Huisman, A.D., van Os-Medendorp, H., Blom, W.M., Versluis, A., Castenmiller, J.J.M., Noteborn, H.P.J.M., Kruizinga, A.G., Houben, G.F., Knulst, A. C., 2018. Accidental allergic reactions in food allergy: causes related to products and patient's management. Allergy: European Journal of Allergy and Clinical Immunology 73 (12), 2377–2381. https://doi.org/10.1111/all.13560.

Murphy, C., Gardoni, P., 2008. The acceptability and the tolerability of societal risks: a capabilities-based approach. Sci. Eng. Ethics 14 (1), 77–92. https://doi.org/10.1007/s11948-007-9031-8.

NVWA (Netherlands Food and Consumer Product Safety Authority), 2016. Advice on Preliminary Reference Doses for Food Allergens. https://english.nvwa.nl/binaries/nvwa-en/documents/consumers/food/safety/documents/advice-of-buro-on-preliminary-reference-doses-for-food-allergens/advice-of-buro-on-preliminary-reference-doses-for-food-allergens.pdf.

Remington, B.C., Baumert, J.L., Blom, W.M., Houben, G.F., Taylor, S.L., Kruizinga, A.G., 2015. Unintended allergens in precautionary labelled and unlabelled products pose significant risks to UK allergic consumers. Allergy: European Journal of Allergy and Clinical Immunology 70 (7), 813–819. https://doi.org/10.1111/all.12625.

Remington, B.C., Westerhout, J., Meima, M.Y., Blom, W.M., Kruizinga, A.G., Wheeler, M. W., Taylor, S.L., Houben, G.F., Baumert, J.L., 2020. Updated population minimal eliciting dose distributions for use in risk assessment of 14 priority food allergens. Food Chem. Toxicol. 139, 111259 https://doi.org/10.1016/j.fct.2020.111259.

Rimbaud, L., Heraud, F., La Vieille, S., Leblanc, J.-C., Crepet, A., 2010. Quantitative risk assessment relating to adventitious presence of allergens in food: a probabilistic model applied to peanut in chocolate. Risk Anal. 30, 7–19. https://doi.org/10.1111/j.1539-6924.2009.01322.x.

Spanjersberg, M.Q.I., Kruizinga, A.G., Rennen, M.A.J., Houben, G.F., 2007. Risk assessment and food allergy: the probabilistic model applied to allergens. Food Chem. Toxicol. 45 (1), 49–54. https://doi.org/10.1016/j.fct.2006.07.018.

Spanjersberg, M.Q.I., Knulst, A.C., Kruizinga, A.G., van Duijn, G., Houben, G.F., 2010. Concentrations of undeclared allergens in food products can reach levels that are relevant for public health. Food Addit. Contam. Part A Chemistry, Analysis, Control, Exposure and Risk Assessment 27 (2), 169–174. https://doi.org/10.1080/19440040903317513.

Taylor, S.L., Crevel, R.W.R., Sheffield, D., Kabourek, J., Baumert, J., 2009. Threshold dose for peanut: risk characterization based upon published results from challenges of peanut-allergic individuals. Food Chem. Toxicol. 47 (6), 1198–1204. https://doi.org/10.1016/j.fct.2009.02.011.

Taylor, S.L., Baumert, J.L., Kruizinga, A.G., Remington, B.C., Crevel, R.W.R., Brooke-Taylor, S., Allen, K.J., Houben, G., 2014. Establishment of reference doses for residues of allergenic foods: report of the VITAL expert panel. Food Chem. Toxicol. 63, 9–17. https://doi.org/10.1016/j.fct.2013.10.032.

Waiblinger, H.-U., Schulze, G., 2018. Action levels for food allergens: an approach for official food control in Germany. J. AOAC Int. 101 (1), 17–22. https://doi.org/10.5740/jaoacint.17-0383.

Westerhout, J., Baumert, J.L., Blom, W.M., Allen, K.J., Ballmer-Weber, B., Crevel, R.W. R., Dubois, A.E.J., Fernández-Rivas, M., Greenhawt, M.J., Hourihane, J.O., Koplin, J. J., Kruizinga, A.G., Le, T.-M., Sampson, H.A., Shreffler, W.G., Turner, P.J., Taylor, S. L., Houben, G.F., Remington, B.C., 2019. Deriving individual threshold doses from clinical food challenge data for population risk assessment of food allergens. J. Allergy Clin. Immunol. 144 (5), 1290–1309. https://doi.org/10.1016/j.jaci.2019.07.046.

Wheeler, M.W., Remington, B.C., Baumert, J.L., Westerhout, J., 2020. Bayesian Stacked Parametric Survival with Frailty Components and Interval Censored Failure Times: Anapplication to Food Allergy Risk (2020) Risk Analysis. https://doi.org/10.1111/risa.13585 (in press).

Yao, Y., Vehtari, A., Simpson, D., Gelman, A., 2018. Using stacking to average Bayesian predictive distributions (with discussion). Bayesian Analysis 13 (3), 917–1007. https://doi.org/10.1214/17-BA1091.

Table S1 - Discrete dose dataset ED values, in mg total protein from the allergenic food, with 95% lower (LCI) and upper confidence interval (UCI)

ED	Cashew			Celery			Egg			Fish			Hazelnut			Lupin			Milk		
		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI
ED00.1	0.004	0.002	0.01	0.004	0.002	0.2	0.02	0.01	0.04	0.4	0.1	2.9	0.01	0.006	0.02	0.3	0.1	0.9	0.02	0.01	0.04
ED00.2	0.008	0.004	0.02	0.009	0.003	0.4	0.04	0.02	0.08	0.7	0.2	4.3	0.02	0.01	0.05	0.6	0.3	1.8	0.04	0.03	0.08
ED00.3	0.01	0.006	0.04	0.01	0.005	0.5	0.06	0.04	0.1	1.0	0.3	5.5	0.03	0.02	0.08	0.9	0.4	2.7	0.07	0.04	0.1
ED00.4	0.02	0.007	0.06	0.02	0.006	0.7	0.08	0.05	0.2	1.2	0.4	6.5	0.05	0.02	0.1	1.2	0.5	3.6	0.09	0.05	0.2
ED00.5	0.02	0.009	0.07	0.02	0.008	0.9	0.1	0.06	0.2	1.5	0.5	7.5	0.06	0.03	0.2	1.4	0.6	4.5	0.1	0.07	0.2
ED00.6	0.03	0.01	0.1	0.03	0.01	1.1	0.1	0.08	0.3	1.7	0.6	8.5	0.07	0.04	0.2	1.7	0.8	5.4	0.1	0.08	0.3
ED00.7	0.03	0.01	0.1	0.04	0.01	1.3	0.2	0.09	0.3	1.9	0.7	9.4	0.09	0.04	0.3	2.0	0.9	6.4	0.2	0.1	0.3
ED00.8	0.03	0.02	0.2	0.04	0.01	1.5	0.2	0.1	0.4	2.2	0.8	10.3	0.1	0.05	0.4	2.3	1.0	7.3	0.2	0.1	0.4
ED00.9	0.04	0.02	0.2	0.05	0.02	1.7	0.2	0.1	0.4	2.4	0.9	11.2	0.1	0.06	0.5	2.6	1.2	8.2	0.2	0.1	0.4
ED01.0	0.05	0.02	0.3	0.07	0.02	1.9	0.2	0.1	0.5	2.6	1.0	12.0	0.1	0.07	0.6	2.9	1.3	9.1	0.2	0.1	0.5
ED02.0	0.1	0.04	0.9	0.3	0.04	4.0	0.6	0.3	1.3	4.8	1.8	20.1	0.6	0.2	2.1	5.9	2.6	18.4	0.6	0.3	1.3
ED03.0	0.3	0.08	1.9	0.6	0.1	6.4	1.1	0.5	2.3	7.1	2.7	28.0	1.3	0.4	4.5	8.9	4.0	27.8	1.1	0.5	2.4
ED04.0	0.5	0.1	3.3	1.0	0.2	9.0	1.6	0.8	3.4	9.5	3.6	35.8	2.3	0.8	7.8	12.1	5.3	37.3	1.7	0.9	3.6
ED05.0	0.8	0.2	5.0	1.5	0.3	11.8	2.3	1.2	4.7	12.1	4.5	43.9	3.5	1.3	12.1	15.3	6.7	47.0	2.4	1.3	5.0
ED06.0	1.2	0.3	7.1	2.2	0.5	15.0	2.9	1.6	6.1	14.7	5.6	52.2	5.1	1.8	17.2	18.6	8.1	56.9	3.2	1.7	6.6
ED07.0	1.6	0.4	9.5	2.9	0.6	18.3	3.7	2.0	7.5	17.5	6.6	60.8	6.9	2.5	23.2	21.9	9.6	66.9	4.1	2.1	8.3
ED08.0	2.1	0.6	12.3	3.8	0.8	22.0	4.5	2.4	9.1	20.4	7.8	69.8	9.0	3.3	30.1	25.4	11.1	77.1	5.0	2.7	10.1
ED09.0	2.7	0.7	15.5	4.8	1.1	25.9	5.4	2.9	10.8	23.5	9.0	79.0	11.4	4.3	38.0	28.9	12.6	87.5	6.0	3.2	12.1
ED10.0	3.4	0.9	19.0	5.9	1.4	30.2	6.3	3.4	12.6	26.7	10.2	88.7	14.1	5.3	46.8	32.5	14.1	98.1	7.1	3.8	14.2
ED11.0	4.1	1.1	22.9	7.1	1.7	34.7	7.3	4.0	14.4	30.1	11.6	98.7	17.1	6.5	56.6	36.2	15.6	109	8.3	4.5	16.5
ED12.0	4.9	1.3	27.3	8.4	2.0	39.5	8.3	4.6	16.4	33.7	13.0	109	20.5	7.8	67.3	40.0	17.2	120	9.6	5.2	18.8
ED13.0	5.8	1.5	32.0	9.8	2.4	44.6	9.4	5.2	18.5	37.4	14.4	120	24.1	9.2	79.1	43.9	18.8	131	10.9	5.9	21.3
ED14.0	6.7	1.8	37.1	11.4	2.8	50.0	10.6	5.8	20.6	41.4	16.0	131	28.1	10.7	91.8	47.9	20.5	142	12.3	6.7	24.0
ED15.0	7.8	2.1	42.7	13.0	3.3	55.8	11.8	6.5	22.9	45.5	17.6	143	32.4	12.4	105	51.9	22.2	154	13.8	7.5	26.7
ED16.0	8.9	2.4	48.7	14.8	3.8	61.9	13.0	7.2	25.2	49.8	19.3	155	37.0	14.2	120	56.1	23.9	166	15.3	8.4	29.6
ED17.0	10.2	2.7	55.2	16.8	4.3	68.3	14.3	8.0	27.6	54.3	21.1	168	42.0	16.1	136	60.4	25.6	178	16.9	9.3	32.7
ED18.0	11.5	3.1	62.2	18.8	4.9	75.1	15.7	8.7	30.2	59.1	23.0	182	47.4	18.2	153	64.7	27.4	190	18.6	10.3	35.8
ED19.0	13.0	3.4	69.6	21.0	5.5	82.3	17.1	9.5	32.8	64.0	24.9	196	53.1	20.5	171	69.2	29.2	202	20.4	11.3	39.1
ED20.0	14.5	3.9	77.5	23.3	6.2	89.9	18.5	10.4	35.5	69.2	27.0	210	59.2	22.8	190	73.8	31.1	215	22.2	12.3	42.5
ED21.0	16.1	4.3	86.0	25.7	6.9	97.9	20.1	11.2	38.3	74.7	29.1	225	65.6	25.3	210	78.5	33.0	228	24.2	13.4	46.1
ED22.0	17.9	4.8	95.0	28.3	7.7	106	21.6	12.1	41.2	80.4	31.4	241	72.5	28.0	231	83.3	34.9	241	26.2	14.6	49.8
ED23.0	19.8	5.3	104	31.0	8.5	115	23.3	13.0	44.2	86.3	33.7	257	79.7	30.9	253	88.2	36.9	255	28.3	15.7	53.6
ED24.0	21.8	5.8	115	33.9	9.4	124	24.9	14.0	47.3	92.6	36.2	275	87.4	33.9	277	93.2	38.9	269	30.4	17.0	57.6
ED25.0	23.9	6.3	125	36.9	10.3	134	26.7	15.0	50.5	99.1	38.8	293	95.5	37.0	302	98.4	41.0	283	32.7	18.2	61.8

Table S1 - Discrete dose dataset ED values – continued

ED	Cashew			Celery			Egg			Fish			Hazelnut			Lupin			Milk		
		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI
ED26.0	26.1	6.9	137	40.1	11.2	144	28.5	16.0	53.8	106	41.5	311	104	40.3	328	104	43.1	297	35.0	19.6	66.0
ED27.0	28.5	7.5	148	43.4	12.2	155	30.4	17.1	57.2	113	44.3	331	113	43.8	355	109	45.3	312	37.4	21.0	70.5
ED28.0	31.0	8.2	161	46.9	13.3	166	32.3	18.2	60.7	121	47.3	351	122	47.5	383	115	47.5	327	40.0	22.4	75.1
ED29.0	33.7	8.9	174	50.6	14.4	178	34.3	19.3	64.4	128	50.4	373	132	51.4	413	120	49.8	343	42.6	23.9	79.9
ED30.0	36.5	9.6	188	54.4	15.6	190	36.3	20.5	68.1	137	53.6	395	143	55.4	444	126	52.1	359	45.3	25.4	84.8
ED31.0	39.5	10.4	203	58.4	16.8	203	38.4	21.7	72.0	145	57.0	418	153	59.7	476	132	54.5	375	48.1	27.0	89.9
ED32.0	42.7	11.2	218	62.6	18.1	217	40.6	22.9	76.0	154	60.5	443	165	64.1	510	139	56.9	391	51.0	28.6	95.1
ED33.0	46.0	12.0	234	67.0	19.5	231	42.9	24.2	80.1	164	64.2	468	177	68.7	545	145	59.4	408	54.0	30.3	101
ED34.0	49.5	12.9	251	71.6	21.0	246	45.2	25.5	84.3	174	68.1	495	189	73.6	582	152	62.0	426	57.1	32.1	106
ED35.0	53.2	13.9	269	76.4	22.5	261	47.6	26.9	88.7	184	72.2	523	202	78.6	620	158	64.6	444	60.3	33.9	112
ED36.0	57.1	14.9	288	81.4	24.0	278	50.1	28.3	93.2	195	76.4	552	216	83.9	660	165	67.2	462	63.7	35.8	118
ED37.0	61.2	15.9	308	86.6	25.7	294	52.7	29.8	97.9	206	80.9	582	230	89.3	701	172	70.0	481	67.1	37.8	124
ED38.0	65.5	17.0	328	92.1	27.4	312	55.3	31.3	103	218	85.5	614	245	95.1	743	180	72.8	500	70.7	39.8	131
ED39.0	70.0	18.1	350	97.8	29.2	331	58.0	32.8	108	231	90.4	648	261	101	788	187	75.7	520	74.4	41.9	137
ED40.0	74.8	19.3	372	104	31.1	350	60.8	34.4	113	244	95.5	683	277	107	834	195	78.6	540	78.2	44.0	144
ED41.0	79.9	20.5	396	110	33.1	370	63.7	36.0	118	258	101	720	294	114	882	203	81.7	561	82.2	46.2	151
ED42.0	85.2	21.8	421	116	35.1	391	66.7	37.7	123	272	107	758	312	120	932	211	84.8	582	86.2	48.5	159
ED43.0	90.8	23.2	447	123	37.3	413	69.8	39.4	129	287	112	799	331	127	983	220	88.0	605	90.5	50.9	166
ED44.0	96.6	24.6	474	130	39.5	436	73.0	41.2	135	303	119	841	350	134	1037	228	91.3	627	94.9	53.4	174
ED45.0	103	26.1	502	138	41.9	460	76.3	43.1	141	320	125	886	371	142	1093	237	94.7	651	99.4	55.9	182
ED46.0	109	27.7	532	145	44.3	485	79.7	45.0	147	338	132	933	392	150	1151	247	98.2	675	104	58.6	191
ED47.0	116	29.3	563	153	46.9	511	83.2	46.9	153	356	139	982	415	158	1211	256	102	701	109	61.3	199
ED48.0	123	31.1	596	162	49.5	538	86.9	48.9	159	376	146	1034	439	166	1273	266	105	726	114	64.1	208
ED49.0	131	32.9	630	171	52.3	566	90.6	51.0	166	397	154	1088	463	175	1338	276	109	753	119	67.0	217
ED50.0	139	34.7	666	180	55.2	596	94.5	53.1	173	418	163	1146	489	183	1405	287	113	781	125	70.1	227
ED51.0	147	36.7	704	189	58.3	627	98.5	55.3	180	441	171	1207	517	193	1475	298	117	810	130	73.2	237
ED52.0	156	38.8	744	199	61.4	660	103	57.6	188	466	181	1271	545	202	1549	309	121	840	136	76.4	247
ED53.0	166	41.0	785	210	64.7	694	107	60.0	195	491	190	1339	576	213	1628	321	126	870	142	79.8	258
ED54.0	175	43.2	828	221	68.2	730	111	62.4	203	518	200	1410	608	224	1711	333	130	902	148	83.2	269
ED55.0	186	45.6	874	232	71.8	768	116	64.9	212	547	211	1485	641	235	1799	346	135	936	155	86.8	280
ED56.0	197	48.1	922	245	75.6	807	121	67.5	220	577	223	1565	677	247	1892	359	140	970	162	90.5	292
ED57.0	208	50.7	972	257	79.5	849	126	70.2	229	609	235	1650	714	259	1991	373	145	1006	169	94.4	305
ED58.0	221	53.4	1024	271	83.6	892	131	73.0	238	643	247	1740	754	273	2095	387	150	1043	176	98.4	317
ED59.0	234	56.3	1079	285	88.0	938	136	75.9	247	679	261	1834	795	287	2206	402	155	1082	183	103	331
ED60.0	247	59.3	1137	300	92.5	985	142	78.9	257	718	275	1935	840	302	2323	418	161	1123	191	107	344

Table S1 - Discrete dose dataset ED values - continued

ED	Cashew			Celery			Egg			Fish			Hazelnut			Lupin			Milk		
		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI
ED61.0	262	62.5	1198	316	97.2	>1000	148	82.1	267	759	290	2043	887	318	2448	434	166	1166	199	111	359
ED62.0	277	65.9	1263	332	102	>1000	154	85.3	278	802	306	2158	937	335	2582	451	172	1211	208	116	374
ED63.0	293	69.4	1330	350	107	>1000	160	88.7	289	849	323	2280	990	353	2724	468	178	1259	217	121	389
ED64.0	311	73.1	1402	368	113	>1000	167	92.2	300	898	341	2411	1046	372	2876	487	185	1308	226	126	405
ED65.0	329	77.0	1477	388	118	>1000	173	95.8	312	951	360	2550	1106	393	>3000	506	192	1360	236	131	422
ED66.0	348	81.1	1556	409	124	>1000	180	99.7	325	1008	381	2699	1170	415	>3000	526	198	1415	246	137	440
ED67.0	369	85.4	1642	431	131	>1000	188	104	337	1069	403	2859	1238	438	>3000	548	206	1474	257	143	458
ED68.0	391	90.0	1727	454	137	>1000	196	108	351	1134	426	3032	1312	463	>3000	570	213	1536	268	149	477
ED69.0	415	94.9	>1736	479	144	>1000	204	112	365	1205	451	3217	1390	490	>3000	594	221	1598	279	155	498
ED70.0	440	100	>1736	506	152	>1000	212	117	380	1281	478	3417	1474	518	>3000	619	230	>1600	291	161	519
ED71.0	467	105	>1736	535	160	>1000	221	121	395	1362	507	3633	1565	549	>3000	645	238	>1600	304	168	541
ED72.0	496	111	>1736	565	168	>1000	231	126	411	1451	538	3864	1662	582	>3000	673	247	>1600	318	176	564
ED73.0	527	117	>1736	598	177	>1000	240	132	428	1547	571	4116	1768	618	>3000	703	257	>1600	332	183	588
ED74.0	560	124	>1736	633	186	>1000	251	137	446	1652	608	4392	1881	657	>3000	735	267	>1600	347	191	614
ED75.0	597	131	>1736	671	196	>1000	262	143	465	1766	647	4694	2005	698	>3000	768	278	>1600	363	200	641
ED76.0	635	138	>1736	711	206	>1000	273	149	484	1890	689	5025	2140	743	>3000	804	289	>1600	380	208	670
ED77.0	678	146	>1736	756	217	>1000	286	156	505	2027	736	5385	2286	791	>3000	843	301	>1600	397	218	700
ED78.0	723	154	>1736	804	229	>1000	299	163	527	2177	786	5781	2447	844	>3000	885	314	>1600	416	228	732
ED79.0	773	164	>1736	856	241	>1000	313	170	551	2344	842	6221	2624	900	>3000	929	328	>1600	437	238	767
ED80.0	828	174	>1736	913	255	>1000	328	178	576	2528	903	6708	2818	962	>3000	978	342	>1600	458	250	803
ED81.0	888	184	>1736	975	269	>1000	343	186	603	2733	970	7251	>3000	1029	>3000	1031	358	>1600	481	262	842
ED82.0	954	196	>1736	>1000	285	>1000	360	195	631	2963	1045	7859	>3000	1102	>3000	1089	374	>1600	506	275	884
ED83.0	1026	208	>1736	>1000	302	>1000	379	204	662	3221	1128	8547	>3000	1182	>3000	1152	392	>1600	533	288	929
ED84.0	1107	222	>1736	>1000	320	>1000	399	215	696	3513	1222	9322	>3000	1268	>3000	1222	412	>1600	562	303	977
ED85.0	1198	237	>1736	>1000	340	>1000	420	226	732	3847	1327	10208	>3000	1362	>3000	1300	433	>1600	593	319	1030
ED86.0	1300	253	>1736	>1000	362	>1000	444	237	771	4230	1447	11226	>3000	1467	>3000	1387	456	>1600	628	337	1087
ED87.0	1415	272	>1736	>1000	387	>1000	469	250	815	4673	1584	12405	>3000	1582	>3000	1486	482	>1600	666	356	1150
ED88.0	1547	292	>1736	>1000	413	>1000	498	265	863	5192	1743	13785	>3000	1708	>3000	1597	510	>1600	708	377	1219
ED89.0	1699	315	>1736	>1000	443	>1000	530	280	917	5807	1928	15424	>3000	1850	>3000	>1600	542	>1600	755	400	1296
ED90.0	>1736	342	>1736	>1000	477	>1000	565	298	979	6545	2146	17391	>3000	2008	>3000	>1600	577	>1600	807	426	1381
ED91.0	>1736	372	>1736	>1000	515	>1000	606	317	1051	7446	2407	>17800	>3000	2188	>3000	>1600	618	>1600	867	456	1478
ED92.0	>1736	407	>1736	>1000	560	>1000	653	339	1134	8569	2727	>17800	>3000	2396	>3000	>1600	665	>1600	936	489	1590
ED93.0	>1736	448	>1736	>1000	612	>1000	707	365	1235	10004	3128	>17800	>3000	2638	>3000	>1600	720	>1600	1017	529	1719
ED94.0	>1736	498	>1736	>1000	675	>1000	773	395	1359	11898	3644	>17800	>3000	2932	>3000	>1600	788	>1600	1114	575	1873
ED95.0	>1736	560	>1736	>1000	752	>1000	854	432	1520	14510	4335	>17800	>3000	>3000	>3000	>1600	871	>1600	1234	631	2061
ED96.0	>1736	641	>1736	>1000	851	>1000	958	478	1741	>17800	5314	>17800	>3000	>3000	>3000	>1600	978	>1600	1388	702	2299
ED97.0	>1736	753	>1736	>1000	986	>1000	1101	539	2079	>17800	6814	>17800	>3000	>3000	>3000	>1600	1127	>1600	1598	797	2620
ED98.0	>1736	923	>1736	>1000	>1000	>1000	1319	629	2716	>17800	9462	>17800	>3000	>3000	>3000	>1600	1357	>1600	1916	938	3098
ED99.0	>1736	1252	>1736	>1000	>1000	>1000	1749	790	3681	>17800	15829	>17800	>3000	>3000	>3000	>1600	>1600	>1600	2524	1193	3978

Table S1 - Discrete dose dataset ED values - continued

ED	Mustard			Peanut			Sesame			Shrimp			Soy			Walnut			Wheat		
		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI
ED00.1	0.003	0.001	0.3	0.01	0.009	0.03	0.008	0.003	0.09	0.6	0.1	16.3	0.04	0.02	0.2	0.002	0.001	0.01	0.05	0.02	0.2
ED00.2	0.008	0.001	0.5	0.03	0.02	0.07	0.02	0.005	0.2	1.7	0.3	32.7	0.08	0.03	0.3	0.005	0.002	0.03	0.1	0.05	0.4
ED00.3	0.01	0.002	0.6	0.04	0.03	0.1	0.03	0.008	0.4	3.6	0.4	49.1	0.1	0.05	0.5	0.008	0.003	0.05	0.2	0.07	0.6
ED00.4	0.02	0.003	0.7	0.05	0.04	0.1	0.03	0.01	0.7	5.9	0.6	65.6	0.2	0.07	0.8	0.01	0.004	0.09	0.2	0.1	0.9
ED00.5	0.03	0.003	0.7	0.07	0.05	0.2	0.04	0.01	0.9	8.5	0.8	82.2	0.2	0.09	1.1	0.01	0.005	0.1	0.3	0.1	1.1
ED00.6	0.03	0.004	0.8	0.09	0.06	0.2	0.06	0.02	1.2	11.5	1.0	98.7	0.3	0.1	1.5	0.02	0.006	0.2	0.4	0.2	1.4
ED00.7	0.04	0.005	0.9	0.1	0.07	0.3	0.07	0.02	1.6	14.8	1.3	115	0.3	0.1	1.9	0.02	0.007	0.2	0.5	0.2	1.7
ED00.8	0.05	0.006	1.0	0.1	0.08	0.3	0.08	0.02	1.9	18.4	1.6	132	0.4	0.1	2.4	0.02	0.008	0.3	0.6	0.2	1.9
ED00.9	0.06	0.008	1.0	0.1	0.09	0.4	0.09	0.03	2.3	22.2	2.1	149	0.4	0.2	2.9	0.03	0.009	0.4	0.6	0.2	2.2
ED01.0	0.07	0.009	1.1	0.2	0.1	0.4	0.1	0.03	2.7	26.2	2.7	166	0.5	0.2	3.5	0.03	0.01	0.5	0.7	0.3	2.5
ED02.0	0.1	0.03	1.8	0.4	0.2	1.2	0.4	0.07	7.8	75.6	10.9	336	1.5	0.4	11.2	0.1	0.02	1.6	1.8	0.7	5.4
ED03.0	0.2	0.05	2.4	0.9	0.5	2.1	1.0	0.1	14.8	137	24.8	512	3.5	0.7	22.4	0.3	0.04	3.4	3.1	1.3	8.6
ED04.0	0.3	0.07	3.0	1.5	0.8	3.3	1.7	0.2	23.4	205	44.3	693	6.3	1.2	36.9	0.5	0.06	5.8	4.6	1.9	12.0
ED05.0	0.4	0.1	3.6	2.1	1.2	4.6	2.7	0.4	33.6	280	69.3	880	10.0	2.2	54.6	0.8	0.1	8.9	6.1	2.6	15.6
ED06.0	0.6	0.1	4.3	2.9	1.7	6.0	3.8	0.6	45.3	360	99.5	1072	14.5	3.3	75.6	1.2	0.2	12.7	7.8	3.4	19.4
ED07.0	0.7	0.2	5.0	3.8	2.2	7.7	5.1	0.8	58.4	445	135	1271	19.9	4.6	99.8	1.7	0.2	17.2	9.6	4.2	23.3
ED08.0	0.8	0.2	5.7	4.8	2.8	9.4	6.7	1.1	72.9	534	175	1475	26.3	6.3	127	2.3	0.3	22.4	11.4	5.1	27.4
ED09.0	0.9	0.2	6.5	5.9	3.4	11.3	8.4	1.5	88.9	627	219	1687	33.6	8.3	158	3.0	0.4	28.3	13.4	6.1	31.6
ED10.0	1.1	0.3	7.3	7.1	4.1	13.4	10.3	1.9	106	723	268	1903	41.9	10.6	192	3.8	0.6	35.0	15.4	7.1	35.9
ED11.0	1.2	0.3	8.1	8.4	4.9	15.7	12.4	2.4	125	823	320	2126	51.2	13.2	230	4.7	0.7	42.5	17.6	8.1	40.4
ED12.0	1.4	0.3	9.0	9.8	5.7	18.1	14.7	2.9	145	927	376	2356	61.5	16.1	272	5.8	0.9	50.8	19.8	9.2	45.0
ED13.0	1.5	0.4	9.9	11.3	6.6	20.7	17.2	3.4	167	1034	434	2592	73.0	19.4	317	7.0	1.1	60.0	22.1	10.4	49.7
ED14.0	1.7	0.4	10.9	12.9	7.6	23.4	19.9	4.1	190	1144	495	2836	85.5	23.1	366	8.3	1.3	70.1	24.4	11.6	54.6
ED15.0	1.9	0.4	11.9	14.6	8.6	26.3	22.8	4.7	214	1258	560	3089	99.1	27.1	419	9.7	1.5	81.1	26.9	12.8	59.6
ED16.0	2.1	0.5	12.9	16.4	9.7	29.4	25.9	5.5	239	1375	626	3347	114	31.5	476	11.3	1.8	93.1	29.4	14.1	64.8
ED17.0	2.3	0.5	14.0	18.3	10.9	32.6	29.2	6.3	266	1495	694	3613	130	36.3	537	13.1	2.1	106	32.0	15.4	70.1
ED18.0	2.5	0.6	15.1	20.3	12.1	36.1	32.6	7.1	294	1619	763	3887	147	41.6	603	15.0	2.4	120	34.7	16.8	75.6
ED19.0	2.7	0.6	16.3	22.4	13.4	39.7	36.3	8.0	324	1746	834	4167	166	47.2	673	17.1	2.8	135	37.5	18.2	81.2
ED20.0	2.9	0.7	17.5	24.7	14.8	43.6	40.2	9.0	355	1876	907	4457	186	53.4	748	19.3	3.1	152	40.3	19.7	86.9
ED21.0	3.1	0.7	18.8	27.0	16.2	47.6	44.3	10.0	387	2011	981	4755	207	59.9	827	21.8	3.6	169	43.3	21.2	92.7
ED22.0	3.4	0.8	20.1	29.5	17.7	51.8	48.6	11.1	421	2148	1056	5062	230	67.0	912	24.4	4.0	188	46.3	22.7	98.8
ED23.0	3.6	0.8	21.4	32.1	19.3	56.2	53.2	12.2	456	2290	1133	5377	254	74.5	1001	27.2	4.5	208	49.4	24.3	105
ED24.0	3.9	0.9	22.9	34.8	21.0	60.9	57.9	13.4	492	2435	1210	5698	280	82.5	1096	30.3	5.0	229	52.6	26.0	111
ED25.0	4.2	1.0	24.3	37.7	22.7	65.7	62.9	14.7	530	2583	1289	6031	308	91.1	1197	33.5	5.5	252	55.9	27.6	118

Table S1 - Discrete dose dataset ED values - continued

ED	Mustard			Peanut			Sesame			Shrimp			Soy			Walnut			Wheat		
		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI
ED26.0	4.4	1.0	25.9	40.7	24.5	70.8	68.2	16.0	569	2736	1369	6372	337	100	1304	37.1	6.1	276	59.2	29.4	124
ED27.0	4.8	1.1	27.5	43.8	26.4	76.1	73.7	17.4	610	2892	1450	6722	368	110	1416	40.8	6.8	302	62.7	31.2	131
ED28.0	5.1	1.2	29.1	47.0	28.4	81.7	79.4	18.8	653	3053	1532	7081	400	120	1535	44.8	7.4	329	66.2	33.0	138
ED29.0	5.4	1.2	30.9	50.4	30.5	87.5	85.4	20.3	697	3218	1615	7448	435	131	1659	49.1	8.1	358	69.9	34.9	145
ED30.0	5.7	1.3	32.7	53.9	32.6	93.5	91.7	21.9	742	3386	1699	7827	471	142	1792	53.7	8.9	389	73.6	36.8	152
ED31.0	6.1	1.4	34.5	57.6	34.9	99.8	98.2	23.5	788	3560	1785	8219	510	155	1931	58.5	9.7	421	77.5	38.8	160
ED32.0	6.5	1.5	36.5	61.5	37.2	106	105	25.2	837	3737	1873	8622	550	167	2079	63.7	10.6	456	81.4	40.8	168
ED33.0	6.9	1.5	38.5	65.5	39.7	113	112	26.9	886	3919	1961	9033	593	181	2233	69.2	11.5	492	85.4	42.8	175
ED34.0	7.3	1.6	40.6	69.6	42.2	120	120	28.7	937	4106	2050	9456	638	195	2395	75.1	12.5	531	89.6	45.0	183
ED35.0	7.7	1.7	42.7	74.0	44.8	128	128	30.6	990	4298	2141	9886	686	210	2566	81.3	13.5	571	93.9	47.2	192
ED36.0	8.2	1.8	45.0	78.5	47.5	135	136	32.5	1045	4494	2234	10330	736	226	2745	87.9	14.6	614	98.2	49.4	200
ED37.0	8.6	1.9	47.3	83.2	50.4	144	145	34.5	1101	4696	2328	10784	789	242	2933	94.9	15.7	660	103	51.7	209
ED38.0	9.1	2.0	49.8	88.1	53.3	152	154	36.5	1159	4903	2424	11249	844	259	3132	102	16.9	708	107	54.1	218
ED39.0	9.6	2.1	52.3	93.1	56.4	161	163	38.7	1219	5116	2523	11729	903	278	3342	110	18.2	758	112	56.5	227
ED40.0	10.2	2.2	55.0	98.4	59.6	170	173	40.8	1280	5334	2623	12220	964	297	3561	119	19.5	811	117	59.0	236
ED41.0	10.7	2.3	57.7	104	62.9	179	184	43.1	1343	5558	2725	12725	1028	317	3790	127	21.0	868	122	61.5	246
ED42.0	11.3	2.4	60.6	110	66.3	189	195	45.4	1407	5789	2830	13242	1096	338	4031	137	22.5	927	127	64.2	256
ED43.0	12.0	2.6	63.6	116	69.9	199	206	47.8	1474	6026	2937	13774	1167	360	4285	147	24.1	990	132	66.8	266
ED44.0	12.6	2.7	66.7	122	73.6	209	218	50.2	1541	6270	3046	14319	1242	383	4551	157	25.7	1048	138	69.6	276
ED45.0	13.3	2.8	69.9	128	77.4	220	231	52.7	1611	6522	3158	14879	1321	407	4830	168	27.5	>1050	143	72.4	287
ED46.0	14.0	2.9	73.3	135	81.4	232	244	55.3	1682	6781	3271	15456	1404	433	5125	180	29.4	>1050	149	75.3	298
ED47.0	14.7	3.1	76.8	142	85.6	244	259	57.9	1756	7049	3389	16048	1491	459	5434	193	31.3	>1050	155	78.3	309
ED48.0	15.5	3.2	80.5	149	89.9	256	273	60.6	1832	7325	3508	16657	1582	487	5758	206	33.4	>1050	161	81.3	320
ED49.0	16.3	3.4	84.4	157	94.4	269	289	63.3	1910	7611	3631	17281	1678	516	6098	220	35.5	>1050	167	84.5	332
ED50.0	17.2	3.6	88.4	165	99.0	282	306	66.1	1988	7906	3757	17917	1779	547	6459	235	37.8	>1050	174	87.7	344
ED51.0	18.1	3.7	92.6	173	104	296	323	69.0	2071	8213	3886	18579	1886	579	6836	251	40.2	>1050	180	91.0	357
ED52.0	19.1	3.9	97.1	181	109	311	342	72.1	2159	8531	4019	19280	1998	612	7232	267	42.7	>1050	187	94.4	370
ED53.0	20.1	4.1	102	190	114	326	362	75.3	2253	8861	4158	20015	2116	648	7648	285	45.4	>1050	194	97.9	383
ED54.0	21.1	4.3	107	200	120	341	382	78.6	2352	9205	4301	20793	2240	684	8088	304	48.2	>1050	201	102	397
ED55.0	22.2	4.5	112	209	125	358	404	82.2	2435	9562	4450	21616	2370	723	8550	324	51.1	>1050	209	105	411
ED56.0	23.4	4.7	117	219	131	375	428	86.0	>2462	9936	4603	22479	2508	763	9035	345	54.2	>1050	216	109	425
ED57.0	24.7	4.9	122	230	137	392	453	90.1	>2462	10326	4761	>22800	2653	806	9546	368	57.5	>1050	224	113	440
ED58.0	26.0	5.1	128	241	144	411	479	94.3	>2462	10734	4926	>22800	2807	850	10086	392	61.0	>1050	233	117	456
ED59.0	27.4	5.4	>130	253	151	430	507	98.8	>2462	11161	5097	>22800	2969	897	10653	417	64.6	>1050	241	121	472
ED60.0	28.8	5.6	>130	265	158	450	537	104	>2462	11609	5275	>22800	3140	947	11252	444	68.5	>1050	250	126	488

Table S1 - Discrete dose dataset ED values - continued

ED	Mustard			Peanut			Sesame			Shrimp			Soy			Walnut			Wheat		
		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI
ED61.0	30.4	5.9	>130	277	165	472	569	109	>2462	12080	5460	>22800	3320	998	11884	473	72.6	>1050	259	130	505
ED62.0	32.0	6.2	>130	290	173	494	603	114	>2462	12575	5651	>22800	3511	1053	12556	504	76.9	>1050	268	135	522
ED63.0	33.7	6.5	>130	304	181	517	640	120	>2462	13097	5850	>22800	3714	1109	13263	537	81.4	>1050	278	139	541
ED64.0	35.6	6.8	>130	319	189	541	679	126	>2462	13648	6057	>22800	3928	1170	14012	572	86.3	>1050	288	144	560
ED65.0	37.6	7.1	>130	334	198	566	721	132	>2462	14231	6272	>22800	4156	1232	14803	610	91.4	>1050	299	149	579
ED66.0	39.7	7.5	>130	350	207	593	766	139	>2462	14849	6498	>22800	4398	1299	15640	650	96.8	>1050	310	155	599
ED67.0	41.9	7.8	>130	367	217	621	814	147	>2462	15504	6733	>22800	4654	1369	16533	694	102	>1050	321	160	620
ED68.0	44.3	8.2	>130	384	227	650	866	155	>2462	16201	6979	>22800	4928	1443	>16854	740	109	>1050	333	166	642
ED69.0	46.8	8.6	>130	403	238	681	923	164	>2462	16944	7237	>22800	5219	1521	>16854	790	115	>1050	346	171	665
ED70.0	49.6	9.1	>130	423	249	713	984	173	>2462	17737	7508	>22800	5530	1603	>16854	843	122	>1050	358	178	689
ED71.0	52.5	9.5	>130	443	261	747	1050	183	>2462	18587	7791	>22800	5862	1690	>16854	901	129	>1050	372	184	714
ED72.0	55.6	10.0	>130	465	274	783	1122	194	>2462	19499	8088	>22800	6218	1783	>16854	964	137	>1050	386	191	740
ED73.0	59.0	10.6	>130	488	288	822	1200	206	>2462	20481	8400	>22800	6600	1881	>16854	1031	145	>1050	401	197	767
ED74.0	62.7	11.1	>130	513	302	862	1286	219	>2462	21542	8730	>22800	7009	1986	>16854	>1050	154	>1050	416	205	795
ED75.0	66.7	11.8	>130	539	317	905	1380	234	>2462	22683	9075	>22800	7451	2097	>16854	>1050	163	>1050	433	212	825
ED76.0	71.0	12.4	>130	567	333	950	1483	249	>2462	>22800	9440	>22800	7927	2215	>16854	>1050	174	>1050	450	220	856
ED77.0	75.7	13.1	>130	597	350	999	1598	266	>2462	>22800	9827	>22800	8442	2341	>16854	>1050	184	>1050	468	228	889
ED78.0	80.8	13.9	>130	628	368	1050	1724	285	>2462	>22800	10238	>22800	9001	2476	>16854	>1050	196	>1050	487	237	923
ED79.0	86.4	14.7	>130	662	387	1105	1866	306	>2462	>22800	10672	>22800	9609	2621	>16854	>1050	209	>1050	508	246	960
ED80.0	92.6	15.6	>130	699	408	1165	2024	329	>2462	>22800	11134	>22800	10272	2777	>16854	>1050	222	>1050	529	256	999
ED81.0	99.4	16.5	>130	738	431	1228	2202	355	>2462	>22800	11630	>22800	10998	2943	>16854	>1050	237	>1050	552	266	1040
ED82.0	107	17.6	>130	780	455	1297	2400	383	>2462	>22800	12163	>22800	11797	3125	>16854	>1050	253	>1050	577	277	1084
ED83.0	115	18.8	>130	826	481	1372	>2462	415	>2462	>22800	12736	>22800	12680	3322	>16854	>1050	271	>1050	603	288	1130
ED84.0	125	20.0	>130	877	510	1453	>2462	451	>2462	>22800	13358	>22800	13659	3537	>16854	>1050	291	>1050	632	301	1181
ED85.0	>130	21.5	>130	931	541	1542	>2462	492	>2462	>22800	14033	>22800	14752	3770	>16854	>1050	312	>1050	663	314	1235
ED86.0	>130	23.1	>130	992	575	1639	>2462	538	>2462	>22800	14764	>22800	15980	4028	>16854	>1050	336	>1050	696	328	1294
ED87.0	>130	24.9	>130	1058	613	1747	>2462	589	>2462	>22800	15568	>22800	>16854	4314	>16854	>1050	362	>1050	733	344	1358
ED88.0	>130	26.8	>130	1133	654	1867	>2462	648	>2462	>22800	16457	>22800	>16854	4630	>16854	>1050	392	>1050	773	360	1427
ED89.0	>130	29.1	>130	1216	701	2002	>2462	717	>2462	>22800	17446	>22800	>16854	4987	>16854	>1050	425	>1050	818	379	1504
ED90.0	>130	31.8	>130	1311	753	2156	>2462	795	>2462	>22800	18567	>22800	>16854	5388	>16854	>1050	463	>1050	868	399	1589
ED91.0	>130	34.8	>130	1419	812	2333	>2462	886	>2462	>22800	19830	>22800	>16854	5849	>16854	>1050	507	>1050	924	421	1684
ED92.0	>130	38.4	>130	1545	881	2540	>2462	994	>2462	>22800	21295	>22800	>16854	6385	>16854	>1050	559	>1050	989	447	1792
ED93.0	>130	42.7	>130	1694	961	2787	>2462	1121	>2462	>22800	22772	>22800	>16854	7014	>16854	>1050	620	>1050	1065	476	1917
ED94.0	>130	48.1	>130	1875	1057	3092	>2462	1273	>2462	>22800	>22800	>22800	>16854	7769	>16854	>1050	694	>1050	1155	510	2064
ED95.0	>130	54.9	>130	2100	1174	3482	>2462	1459	>2462	>22800	>22800	>22800	>16854	8705	>16854	>1050	787	>1050	1266	551	2242
ED96.0	>130	63.9	>130	2393	1324	4003	>2462	1696	>2462	>22800	>22800	>22800	>16854	9909	>16854	>1050	909	>1050	1407	601	2466
ED97.0	>130	76.6	>130	2800	1528	4681	>2462	2009	>2462	>22800	>22800	>22800	>16854	11558	>16854	>1050	>1050	>1050	1599	667	2761
ED98.0	>130	96.8	>130	3432	1834	>5000	>2462	2419	>2462	>22800	>22800	>22800	>16854	14066	>16854	>1050	>1050	>1050	1889	761	3193
ED99.0	>130	>130	>130	4677	2407	>5000	>2462	>2462	>2462	>22800	>22800	>22800	>16854	>16854	>16854	>1050	>1050	>1050	2441	927	3971

Table S2 - Cumulative dose dataset ED values, in mg total protein from the allergenic food, with 95% lower (LCI) and upper confidence interval (UCI)

ED	Cashew			Celery			Egg			Fish			Hazelnut			Lupin			Milk		
		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI
ED00.1	0.007	0.004	0.02	0.004	0.002	0.02	0.02	0.01	0.04	0.1	0.04	1.7	0.01	0.008	0.03	0.2	0.03	1.8	0.03	0.02	0.05
ED00.2	0.02	0.007	0.05	0.008	0.003	0.04	0.04	0.02	0.07	0.2	0.08	2.9	0.03	0.02	0.07	0.4	0.07	3.4	0.06	0.03	0.1
ED00.3	0.02	0.01	0.08	0.01	0.005	0.07	0.06	0.04	0.1	0.3	0.1	4.0	0.04	0.02	0.1	0.6	0.1	4.9	0.08	0.05	0.2
ED00.4	0.03	0.01	0.1	0.02	0.007	0.1	0.08	0.05	0.2	0.5	0.2	5.1	0.06	0.03	0.1	0.9	0.2	6.3	0.1	0.07	0.2
ED00.5	0.04	0.02	0.2	0.02	0.008	0.2	0.1	0.06	0.2	0.6	0.2	6.3	0.08	0.04	0.2	1.1	0.2	7.8	0.1	0.09	0.3
ED00.6	0.05	0.02	0.2	0.03	0.01	0.2	0.1	0.07	0.3	0.7	0.2	7.5	0.1	0.05	0.3	1.4	0.3	9.2	0.2	0.1	0.3
ED00.7	0.06	0.03	0.3	0.03	0.01	0.3	0.1	0.09	0.3	0.9	0.3	8.7	0.1	0.06	0.4	1.7	0.3	10.6	0.2	0.1	0.4
ED00.8	0.07	0.03	0.4	0.04	0.01	0.3	0.2	0.1	0.4	1.0	0.3	10.0	0.1	0.07	0.5	2.0	0.4	12.0	0.2	0.1	0.4
ED00.9	0.08	0.03	0.4	0.04	0.02	0.4	0.2	0.1	0.4	1.2	0.4	11.3	0.2	0.08	0.6	2.3	0.5	13.4	0.3	0.2	0.5
ED01.0	0.09	0.04	0.5	0.05	0.02	0.5	0.2	0.1	0.5	1.3	0.4	12.7	0.2	0.09	0.7	2.6	0.5	14.8	0.3	0.2	0.6
ED02.0	0.3	0.09	1.8	0.2	0.04	1.6	0.6	0.3	1.4	3.9	1.0	29.0	0.7	0.2	2.7	5.8	1.4	28.5	0.7	0.4	1.6
ED03.0	0.6	0.2	3.7	0.4	0.07	3.2	1.1	0.5	2.5	7.2	1.8	49.7	1.7	0.6	5.8	9.3	2.4	42.2	1.3	0.7	3.0
ED04.0	1.0	0.3	6.2	0.8	0.1	5.3	1.7	0.9	3.8	11.1	3.1	74.3	3.0	1.1	10.1	13.0	3.5	55.9	2.1	1.1	4.6
ED05.0	1.6	0.4	9.4	1.3	0.2	7.9	2.4	1.3	5.3	15.6	4.6	102	4.7	1.7	15.7	16.8	4.7	70.0	3.1	1.6	6.6
ED06.0	2.3	0.6	13.2	1.8	0.4	11.0	3.3	1.7	6.9	20.6	6.4	134	6.8	2.5	22.5	20.8	6.0	84.1	4.1	2.1	8.7
ED07.0	3.1	0.8	17.6	2.5	0.5	14.6	4.2	2.2	8.7	26.2	8.3	169	9.3	3.4	30.5	25.0	7.4	98.6	5.3	2.8	11.1
ED08.0	4.0	1.1	22.6	3.4	0.7	18.7	5.2	2.7	10.7	32.2	10.5	206	12.2	4.5	39.8	29.3	8.9	113	6.6	3.5	13.7
ED09.0	5.0	1.3	28.2	4.3	0.9	23.2	6.2	3.3	12.8	38.7	12.8	247	15.5	5.8	50.4	33.7	10.4	128	8.1	4.2	16.6
ED10.0	6.2	1.7	34.6	5.4	1.2	28.3	7.4	3.9	15.1	45.6	15.3	290	19.3	7.3	62.4	38.3	12.0	144	9.6	5.1	19.6
ED11.0	7.5	2.0	41.5	6.6	1.5	33.9	8.6	4.6	17.5	53.1	17.9	336	23.5	8.9	75.6	43.0	13.7	159	11.3	6.0	22.9
ED12.0	8.9	2.4	49.1	8.0	1.8	40.0	10.0	5.3	20.0	61.0	20.8	385	28.1	10.7	90.3	47.9	15.4	175	13.1	7.0	26.4
ED13.0	10.5	2.8	57.4	9.5	2.2	46.6	11.4	6.1	22.7	69.4	23.7	436	33.2	12.7	106	52.9	17.2	192	15.0	8.0	30.1
ED14.0	12.2	3.3	66.4	11.2	2.6	53.9	12.8	6.9	25.5	78.3	26.8	489	38.8	14.9	124	58.0	19.1	208	17.0	9.1	34.0
ED15.0	14.0	3.8	76.2	13.0	3.1	61.7	14.4	7.8	28.5	87.6	30.1	545	44.9	17.2	143	63.3	21.0	225	19.1	10.3	38.1
ED16.0	16.0	4.4	86.6	15.0	3.6	70.2	16.0	8.7	31.6	97.5	33.5	603	51.5	19.8	163	68.8	23.1	243	21.4	11.5	42.4
ED17.0	18.2	5.0	97.8	17.1	4.1	79.2	17.8	9.7	34.9	108	37.1	663	58.6	22.6	185	74.4	25.1	260	23.8	12.8	47.0
ED18.0	20.5	5.6	110	19.4	4.7	89.0	19.6	10.7	38.3	119	40.8	726	66.2	25.5	209	80.2	27.3	279	26.3	14.2	51.7
ED19.0	23.0	6.3	122	21.9	5.4	99.3	21.5	11.7	41.9	130	44.6	791	74.4	28.7	234	86.2	29.5	297	28.9	15.6	56.7
ED20.0	25.6	7.0	136	24.6	6.1	110	23.4	12.8	45.6	142	48.7	858	83.1	32.1	260	92.3	31.7	316	31.6	17.2	62.0
ED21.0	28.4	7.8	150	27.5	6.9	122	25.5	14.0	49.5	154	52.9	928	92.4	35.8	289	98.7	34.1	336	34.5	18.7	67.4
ED22.0	31.5	8.6	166	30.6	7.7	135	27.7	15.2	53.6	167	57.3	999	102	39.7	319	105	36.5	356	37.5	20.4	73.1
ED23.0	34.7	9.5	182	33.9	8.6	148	29.9	16.4	57.8	180	61.9	1072	113	43.8	351	112	39.0	376	40.6	22.1	79.1
ED24.0	38.1	10.4	199	37.4	9.5	162	32.2	17.8	62.1	194	66.6	1148	124	48.1	384	119	41.5	397	43.9	24.0	85.2
ED25.0	41.7	11.3	217	41.1	10.5	177	34.6	19.1	66.6	208	71.5	1225	136	52.7	419	126	44.2	419	47.3	25.8	91.7

Table S2 - Cumulative dose dataset ED values – continued

ED	Cashew			Celery			Egg			Fish			Hazelnut			Lupin			Milk		
		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI
ED26.0	45.5	12.4	236	45.1	11.6	193	37.2	20.5	71.3	223	76.6	1304	148	57.6	457	133	46.9	441	50.9	27.8	98.4
ED27.0	49.5	13.5	256	49.3	12.8	210	39.8	22.0	76.2	238	81.9	1385	161	62.7	496	141	49.7	464	54.6	29.9	105
ED28.0	53.8	14.6	277	53.8	14.0	227	42.5	23.5	81.2	254	87.4	1468	175	68.1	537	148	52.6	487	58.4	32.0	113
ED29.0	58.3	15.8	299	58.5	15.3	246	45.3	25.1	86.5	270	93.1	1553	190	73.8	580	156	55.5	511	62.4	34.2	120
ED30.0	63.0	17.1	323	63.5	16.7	265	48.2	26.7	91.9	287	99.0	1641	205	79.8	625	165	58.6	536	66.6	36.5	128
ED31.0	68.0	18.4	347	68.8	18.1	286	51.2	28.4	97.5	305	105	1730	221	86.0	672	173	61.8	561	70.9	38.9	136
ED32.0	73.3	19.8	373	74.4	19.6	308	54.4	30.2	103	323	111	1823	238	92.6	721	182	65.0	588	75.4	41.4	144
ED33.0	78.9	21.2	400	80.3	21.3	331	57.6	32.0	109	341	118	1916	256	99.5	773	191	68.3	615	80.1	44.0	153
ED34.0	84.7	22.7	428	86.5	23.0	355	61.0	33.9	116	361	125	2011	274	107	826	200	71.8	642	84.9	46.6	162
ED35.0	90.9	24.3	457	93.1	24.8	380	64.5	35.8	122	381	132	2110	294	114	883	210	75.3	671	90.0	49.4	171
ED36.0	97.3	26.0	488	100	26.7	407	68.1	37.8	129	402	139	2209	314	122	941	220	79.0	701	95.2	52.3	181
ED37.0	104	27.8	521	107	28.8	435	71.8	39.9	136	423	147	2310	336	130	1002	230	82.7	732	101	55.3	191
ED38.0	111	29.6	555	115	30.9	464	75.7	42.1	143	445	154	2413	358	139	1065	241	86.6	764	106	58.4	201
ED39.0	119	31.5	590	123	33.1	495	79.7	44.3	150	468	162	2518	382	148	1131	252	90.7	797	112	61.6	212
ED40.0	127	33.5	627	132	35.4	528	83.8	46.6	158	492	170	2627	406	157	1199	263	94.7	831	118	64.9	223
ED41.0	135	35.7	666	141	37.9	562	88.1	49.0	166	517	179	2737	432	167	1271	275	99.0	867	124	68.3	235
ED42.0	144	37.9	706	150	40.5	598	92.6	51.5	174	543	188	2849	459	177	1346	287	103	904	131	71.9	247
ED43.0	153	40.2	749	160	43.2	635	97.2	54.0	182	569	197	2965	487	188	1423	300	108	942	138	75.6	259
ED44.0	163	42.6	793	170	46.1	675	102	56.6	191	597	206	3081	517	199	1504	313	113	981	145	79.4	272
ED45.0	173	45.1	840	181	49.1	716	107	59.4	200	626	215	3199	548	211	1588	326	117	1022	152	83.4	285
ED46.0	183	47.7	888	193	52.3	760	112	62.2	209	657	225	3320	581	223	1676	341	122	1065	159	87.5	299
ED47.0	195	50.5	939	205	55.6	805	117	65.1	219	688	235	3441	615	235	1767	355	127	1109	167	91.8	313
ED48.0	206	53.3	992	218	59.1	853	123	68.1	229	721	246	3566	651	248	1862	370	133	1155	175	96.2	328
ED49.0	219	56.3	1048	232	62.7	904	128	71.3	239	756	256	3693	689	262	1961	386	138	1204	184	101	343
ED50.0	232	59.5	1106	246	66.5	957	134	74.5	250	793	267	3822	728	276	2064	402	144	1254	192	106	359
ED51.0	245	62.8	1167	261	70.6	1012	141	77.8	261	831	278	3956	770	290	2172	419	150	1307	201	111	376
ED52.0	260	66.2	1231	276	74.8	1071	147	81.3	273	871	289	4099	814	306	2286	437	156	1362	211	116	393
ED53.0	275	69.8	1298	293	79.3	1132	154	84.9	285	914	302	4251	860	322	2407	456	162	1420	221	121	410
ED54.0	291	73.6	1368	311	84.0	1197	160	88.6	297	959	314	4412	909	339	2534	475	169	1481	231	127	429
ED55.0	308	77.5	1440	329	88.9	1265	168	92.4	310	1006	328	4582	960	356	2670	495	176	1545	241	132	448
ED56.0	325	81.6	1517	349	94.1	1336	175	96.4	323	1057	342	4762	1014	375	2812	516	183	1612	252	138	468
ED57.0	344	85.9	1598	369	99.5	1411	183	101	337	1110	357	4957	1071	395	2963	538	190	1682	264	144	489
ED58.0	364	90.4	1682	391	105	>1433	191	105	351	1166	373	5163	1131	416	3122	561	198	1757	276	151	510
ED59.0	384	95.1	1770	414	111	>1433	199	109	366	1227	389	5380	1195	438	3290	585	206	1836	288	158	533
ED60.0	406	100	1863	438	118	>1433	208	114	382	1291	407	5611	1263	462	3471	611	214	1919	301	164	556

Table S2 - Cumulative dose dataset ED values - continued

ED	Cashew			Celery			Egg			Fish			Hazelnut			Lupin			Milk		
		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI
ED61.0	430	105	1961	464	124	>1433	217	119	398	1359	425	5858	1334	486	3661	637	223	2008	315	172	580
ED62.0	454	111	2063	491	131	>1433	226	124	415	1433	445	6125	1410	513	3864	665	232	2102	329	179	606
ED63.0	480	117	2170	519	139	>1433	236	129	433	1511	467	6411	1491	540	4081	695	241	2202	344	187	632
ED64.0	508	123	2283	550	146	>1433	246	135	451	1595	489	6718	1577	570	4313	726	251	2308	359	195	659
ED65.0	537	129	2403	582	154	>1433	257	140	470	1686	513	7054	1668	602	>4433	758	261	2422	375	204	688
ED66.0	568	136	2529	617	163	>1433	268	146	490	1784	539	7417	1765	635	>4433	793	272	2542	392	213	718
ED67.0	601	143	2661	653	172	>1433	280	153	511	1890	567	7809	1869	671	>4433	830	283	2671	410	222	750
ED68.0	636	150	2801	692	182	>1433	293	159	533	2004	597	8229	1980	710	>4433	868	295	2810	428	232	783
ED69.0	674	158	2949	734	192	>1433	306	166	556	2128	629	8689	2099	751	>4433	910	308	2961	448	242	817
ED70.0	714	166	3107	778	203	>1433	319	173	580	2264	664	9191	2226	795	>4433	954	321	3105	468	253	853
ED71.0	756	175	>3180	826	214	>1433	334	181	605	2412	702	9740	2363	842	>4433	1000	335	>3150	490	264	892
ED72.0	802	184	>3180	877	227	>1433	349	189	631	2573	743	10340	2510	892	>4433	1051	349	>3150	513	276	932
ED73.0	851	194	>3180	931	240	>1433	365	197	659	2751	788	10992	2668	945	>4433	1104	365	>3150	537	289	974
ED74.0	904	205	>3180	990	253	>1433	382	206	689	2947	837	11718	2840	1004	>4433	1162	381	>3150	562	302	1018
ED75.0	960	216	>3180	1053	268	>1433	400	215	720	3163	891	12521	3025	1066	>4433	1224	399	>3150	589	316	1065
ED76.0	1022	228	>3180	1121	284	>1433	418	225	753	3404	951	13409	3226	1134	>4433	1291	418	>3150	618	331	1115
ED77.0	1088	240	>3180	1195	301	>1433	439	236	787	3672	1017	14412	3446	1206	>4433	1364	437	>3150	648	347	1168
ED78.0	1160	254	>3180	1275	319	>1433	460	247	824	3972	1090	15535	3685	1284	>4433	1444	458	>3150	680	363	1225
ED79.0	1238	269	>3180	1362	338	>1433	483	259	864	4310	1172	16807	3948	1369	>4433	1530	481	>3150	715	381	1285
ED80.0	1323	284	>3180	>1433	359	>1433	507	271	906	4692	1264	18254	4236	1461	>4433	1625	505	>3150	752	400	1349
ED81.0	1417	301	>3180	>1433	382	>1433	533	285	951	5126	1367	19895	>4433	1560	>4433	1730	532	>3150	792	420	1417
ED82.0	1519	320	>3180	>1433	406	>1433	562	299	999	5625	1484	21787	>4433	1667	>4433	1847	560	>3150	835	442	1491
ED83.0	1633	340	>3180	>1433	433	>1433	592	315	1051	6199	1618	23970	>4433	1783	>4433	1977	591	>3150	881	465	1571
ED84.0	1759	361	>3180	>1433	462	>1433	625	332	1108	6867	1772	26558	>4433	1910	>4433	2123	625	>3150	931	490	1657
ED85.0	1899	385	>3180	>1433	494	>1433	661	350	1170	7651	1949	29619	>4433	2049	>4433	2288	662	>3150	986	517	1750
ED86.0	2057	411	>3180	>1433	529	>1433	701	369	1237	8580	2157	>30260	>4433	2201	>4433	2477	703	>3150	1046	547	1852
ED87.0	2236	440	>3180	>1433	569	>1433	744	391	1312	9695	2403	>30260	>4433	2371	>4433	2696	748	>3150	1112	580	1964
ED88.0	2439	473	>3180	>1433	612	>1433	792	415	1395	11050	2695	>30260	>4433	2558	>4433	2951	799	>3150	1186	616	2088
ED89.0	2674	509	>3180	>1433	661	>1433	846	441	1488	12723	3053	>30260	>4433	2766	>4433	3145	856	>3150	1268	656	2226
ED90.0	2947	550	>3180	>1433	717	>1433	907	471	1593	14829	3491	>30260	>4433	3001	>4433	>3150	921	>3150	1361	701	2380
ED91.0	>3180	597	>3180	>1433	781	>1433	976	504	1715	17542	4039	>30260	>4433	3270	>4433	>3150	996	>3150	1466	751	2555
ED92.0	>3180	652	>3180	>1433	856	>1433	1057	542	1857	21137	4738	>30260	>4433	3582	>4433	>3150	1083	>3150	1589	810	2757
ED93.0	>3180	716	>3180	>1433	944	>1433	1151	586	2029	26073	5659	>30260	>4433	3950	>4433	>3150	1188	>3150	1733	877	2992
ED94.0	>3180	794	>3180	>1433	1050	>1433	1264	638	2238	>30260	6915	>30260	>4433	4391	>4433	>3150	1314	>3150	1906	958	3273
ED95.0	>3180	890	>3180	>1433	1182	>1433	1405	702	2503	>30260	8696	>30260	>4433	>4433	>4433	>3150	1471	>3150	2121	1057	3618
ED96.0	>3180	1015	>3180	>1433	1353	>1433	1587	783	2852	>30260	11385	>30260	>4433	>4433	>4433	>3150	1680	>3150	2398	1181	4058
ED97.0	>3180	1187	>3180	>1433	>1433	>1433	1838	891	3358	>30260	15810	>30260	>4433	>4433	>4433	>3150	1971	>3150	2779	1350	4653
ED98.0	>3180	1448	>3180	>1433	>1433	>1433	2224	1051	4195	>30260	24186	>30260	>4433	>4433	>4433	>3150	2425	>3150	3361	1600	5543
ED99.0	>3180	1948	>3180	>1433	>1433	>1433	2986	1343	5195	>30260	>30260	>30260	>4433	>4433	>4433	>3150	3150	>3150	4483	2060	7200

Table S2 - Cumulative dose dataset ED values - continued

ED	Mustard			Peanut			Sesame			Shrimp			Soy			Walnut			Wheat		
		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI
ED00.1	0.002	0.000	0.2	0.07	0.05	0.1	0.01	0.003	0.2	1.0	0.2	31.4	0.06	0.02	0.2	0.004	0.001	0.02	0.08	0.03	0.3
ED00.2	0.005	0.001	0.3	0.1	0.1	0.2	0.02	0.007	0.5	2.1	0.5	63.1	0.1	0.05	0.4	0.007	0.003	0.04	0.2	0.07	0.6
ED00.3	0.008	0.002	0.4	0.2	0.2	0.4	0.03	0.01	0.8	3.7	0.8	95.2	0.2	0.08	0.7	0.01	0.004	0.08	0.3	0.1	1.0
ED00.4	0.01	0.002	0.5	0.3	0.2	0.5	0.05	0.01	1.2	6.1	1.1	128	0.2	0.1	1.0	0.02	0.006	0.1	0.4	0.1	1.3
ED00.5	0.02	0.003	0.6	0.4	0.3	0.6	0.06	0.02	1.7	9.3	1.4	160	0.3	0.1	1.4	0.02	0.007	0.2	0.5	0.2	1.7
ED00.6	0.02	0.003	0.6	0.4	0.3	0.8	0.08	0.02	2.3	12.7	1.7	193	0.4	0.2	1.9	0.02	0.009	0.3	0.6	0.2	2.1
ED00.7	0.03	0.004	0.7	0.5	0.4	0.9	0.09	0.03	2.8	16.7	2.1	226	0.4	0.2	2.4	0.03	0.01	0.3	0.7	0.3	2.5
ED00.8	0.03	0.005	0.8	0.6	0.4	1.0	0.1	0.03	3.5	21.0	2.5	259	0.5	0.2	3.1	0.03	0.01	0.4	0.8	0.3	2.9
ED00.9	0.04	0.005	0.8	0.6	0.5	1.1	0.1	0.03	4.1	25.7	2.9	293	0.6	0.2	3.8	0.04	0.01	0.5	1.0	0.4	3.4
ED01.0	0.05	0.006	0.9	0.7	0.5	1.3	0.2	0.04	4.8	30.8	3.4	326	0.7	0.3	4.5	0.04	0.02	0.6	1.1	0.4	3.8
ED02.0	0.1	0.02	1.6	1.5	1.1	2.6	0.7	0.09	13.8	98.3	14.3	676	2.0	0.6	15.0	0.1	0.03	2.3	2.8	1.0	8.5
ED03.0	0.2	0.04	2.3	2.3	1.6	4.0	1.5	0.2	25.8	190	33.1	1047	4.8	1.0	30.5	0.4	0.06	4.9	4.7	1.9	13.6
ED04.0	0.3	0.06	3.1	3.1	2.2	5.5	2.7	0.3	40.5	301	59.8	1440	8.8	1.7	51.0	0.7	0.09	8.4	6.9	2.8	19.1
ED05.0	0.5	0.09	3.9	3.9	2.8	7.1	4.2	0.6	57.7	429	94.0	1854	14.1	3.1	76.2	1.2	0.1	13.0	9.3	3.9	24.9
ED06.0	0.6	0.1	4.8	4.8	3.4	8.8	6.0	0.9	77.3	571	136	2293	20.8	4.7	106	1.7	0.2	18.6	11.9	5.0	31.0
ED07.0	0.8	0.2	5.8	5.8	4.1	10.6	8.1	1.3	99.1	727	185	2753	28.8	6.7	141	2.5	0.3	25.2	14.7	6.3	37.4
ED08.0	0.9	0.2	6.9	6.8	4.8	12.6	10.4	1.7	123	895	242	3237	38.2	9.2	181	3.3	0.5	33.0	17.6	7.7	44.0
ED09.0	1.1	0.2	8.0	7.9	5.5	14.8	13.1	2.3	149	1074	305	3745	49.2	12.2	226	4.4	0.6	41.9	20.7	9.1	50.9
ED10.0	1.3	0.3	9.2	9.0	6.2	17.3	16.1	2.9	178	1265	376	4274	61.6	15.6	277	5.6	0.8	52.0	23.9	10.6	58.1
ED11.0	1.5	0.3	10.5	10.3	7.0	20.1	19.3	3.6	208	1467	453	4831	75.7	19.6	332	6.9	1.0	63.4	27.2	12.2	65.5
ED12.0	1.8	0.4	11.9	11.7	7.8	23.1	22.9	4.4	240	1679	536	5410	91.4	24.1	394	8.5	1.3	76.0	30.7	13.8	73.1
ED13.0	2.0	0.4	13.3	13.2	8.7	26.6	26.7	5.3	275	1902	626	6012	109	29.2	461	10.2	1.6	90.1	34.3	15.6	81.0
ED14.0	2.3	0.5	14.8	14.9	9.6	30.2	30.8	6.2	312	2134	722	6644	128	34.9	534	12.2	1.9	105	38.0	17.4	89.1
ED15.0	2.5	0.6	16.4	16.8	10.6	34.0	35.1	7.3	350	2377	823	7299	149	41.2	613	14.3	2.2	122	41.9	19.3	97.4
ED16.0	2.8	0.6	18.1	19.0	11.6	38.0	39.7	8.4	391	2630	931	7987	172	48.1	699	16.7	2.6	141	45.9	21.2	106
ED17.0	3.1	0.7	19.9	21.6	12.8	42.2	44.7	9.6	433	2894	1044	8699	197	55.6	791	19.3	3.1	161	50.1	23.2	115
ED18.0	3.4	0.8	21.8	24.5	14.1	46.8	49.8	10.9	478	3167	1163	9438	223	63.9	890	22.2	3.5	182	54.3	25.3	124
ED19.0	3.8	0.8	23.7	27.6	15.4	51.6	55.3	12.3	525	3451	1287	10212	252	72.8	996	25.3	4.0	205	58.7	27.5	133
ED20.0	4.1	0.9	25.8	30.8	17.0	56.8	61.1	13.7	574	3745	1415	11007	284	82.5	1110	28.7	4.6	231	63.3	29.7	143
ED21.0	4.5	1.0	28.0	33.9	18.8	62.2	67.1	15.2	625	4049	1549	11841	317	93.0	1231	32.4	5.2	258	68.0	32.0	152
ED22.0	4.9	1.1	30.2	37.2	20.8	67.9	73.4	16.9	677	4364	1688	12696	353	104	1361	36.3	5.9	287	72.8	34.3	163
ED23.0	5.3	1.2	32.6	40.6	23.1	74.0	80.1	18.6	732	4690	1832	13585	391	116	1498	40.6	6.6	318	77.7	36.8	173
ED24.0	5.8	1.3	35.0	44.3	25.6	80.4	87.0	20.3	789	5026	1979	14503	432	129	1645	45.2	7.4	350	82.8	39.3	183
ED25.0	6.2	1.4	37.6	48.2	28.2	87.1	94.3	22.1	847	5374	2132	15457	475	143	1801	50.2	8.2	386	88.1	41.9	194

Table S2 - Cumulative dose dataset ED values - continued

ED	Mustard			Peanut			Sesame			Shrimp			Soy			Walnut			Wheat		
		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI
ED26.0	6.7	1.5	40.3	52.3	30.8	94.2	102	24.1	908	5733	2290	16442	521	158	1965	55.5	9.0	423	93.5	44.5	205
ED27.0	7.2	1.6	43.1	56.7	33.5	102	110	26.1	970	6104	2452	17455	570	173	2140	61.2	10.0	463	99.0	47.2	217
ED28.0	7.8	1.7	46.0	61.2	36.1	109	118	28.2	1035	6487	2619	18503	622	190	2323	67.3	11.0	506	105	50.0	229
ED29.0	8.3	1.8	49.1	66.0	38.9	118	127	30.4	1102	6881	2790	19601	677	208	2519	73.8	12.1	551	111	52.9	241
ED30.0	8.9	1.9	52.2	71.0	41.8	126	136	32.6	1170	7289	2966	20729	735	226	2724	80.8	13.2	599	117	55.8	253
ED31.0	9.5	2.0	55.6	76.2	44.9	135	145	34.9	1241	7709	3148	21894	796	246	2942	88.2	14.5	650	123	58.9	266
ED32.0	10.2	2.2	59.0	81.7	48.1	145	155	37.3	1314	8142	3335	23093	861	267	3171	96.1	15.7	703	129	62.0	278
ED33.0	10.9	2.3	62.7	87.4	51.6	155	165	39.8	1388	8589	3526	24328	930	290	3412	105	17.1	760	136	65.2	292
ED34.0	11.6	2.5	66.4	93.4	55.2	165	176	42.3	1465	9050	3723	25605	1003	313	3667	113	18.6	820	142	68.5	305
ED35.0	12.3	2.6	70.3	99.7	59.0	176	187	44.9	1544	9525	3926	26932	1079	338	3935	123	20.1	884	149	71.9	319
ED36.0	13.1	2.8	74.4	106	62.9	187	199	47.5	1625	10015	4132	28300	1160	363	4219	133	21.7	951	156	75.3	334
ED37.0	14.0	2.9	78.7	113	67.0	199	211	50.3	1708	10521	4345	29707	1245	391	4517	144	23.4	1022	164	78.9	348
ED38.0	14.8	3.1	83.2	120	71.2	211	224	53.0	1794	11043	4565	31163	1334	420	4830	155	25.3	1097	171	82.5	363
ED39.0	15.8	3.3	87.8	128	75.6	224	238	55.9	1882	11582	4788	32660	1428	450	5160	167	27.2	1175	179	86.3	379
ED40.0	16.7	3.5	92.6	135	80.3	238	252	58.8	1971	12138	5018	34211	1528	482	5507	180	29.3	1259	187	90.1	395
ED41.0	17.7	3.7	97.7	144	85.1	252	267	61.8	2064	12712	5256	35808	1632	515	5873	194	31.4	1348	195	94.0	411
ED42.0	18.8	3.9	103	152	90.1	267	283	64.8	2159	13305	5498	37460	1742	551	6257	208	33.7	1441	203	98.1	427
ED43.0	19.9	4.1	108	161	95.3	282	299	68.0	2256	13918	5747	39172	1858	587	6660	224	36.1	1539	212	102	445
ED44.0	21.1	4.3	114	170	101	298	316	71.2	2355	14553	6003	40920	1980	626	7085	240	38.6	1641	220	106	462
ED45.0	22.3	4.5	120	180	106	315	335	74.4	2457	15209	6265	42738	2108	667	7530	257	41.3	>1693	230	111	480
ED46.0	23.6	4.8	126	190	112	333	354	77.7	2561	15889	6536	44607	2243	710	8000	275	44.1	>1693	239	115	499
ED47.0	24.9	5.0	133	201	118	351	374	81.1	2667	16593	6812	46533	2385	754	8497	295	47.1	>1693	248	120	518
ED48.0	26.3	5.3	140	212	125	371	396	84.5	2775	17323	7096	48533	2534	802	9016	315	50.2	>1693	258	125	537
ED49.0	27.8	5.6	147	223	132	391	419	87.9	2886	18080	7388	50593	2692	851	9564	337	53.5	>1693	269	130	558
ED50.0	29.4	5.9	154	236	138	412	443	91.5	2993	18867	7690	52732	2858	903	10140	360	57.0	>1693	279	135	578
ED51.0	31.1	6.2	162	248	146	434	469	95.1	3048	19684	7999	54946	3032	957	10749	385	60.7	>1693	290	140	600
ED52.0	32.8	6.5	170	262	153	457	496	99.0	3066	20534	8321	57258	3216	1014	11394	411	64.6	>1693	301	145	622
ED53.0	34.6	6.8	179	275	161	481	524	103	>3078	21420	8653	59667	3410	1074	12068	439	68.6	>1693	313	150	644
ED54.0	36.6	7.2	188	290	169	506	555	107	>3078	22342	8996	62195	3614	1137	12779	468	73.0	>1693	324	156	667
ED55.0	38.6	7.5	198	305	178	532	588	112	>3078	23304	9349	64857	3829	1203	13525	499	77.5	>1693	337	162	691
ED56.0	40.8	7.9	208	321	187	560	622	117	>3078	24309	9717	67640	4057	1272	14319	532	82.3	>1693	349	168	716
ED57.0	43.0	8.3	218	338	196	589	659	122	>3078	25359	10095	70585	4296	1344	15159	568	87.4	>1693	362	174	742
ED58.0	45.4	8.8	229	356	206	619	699	127	>3078	26457	10488	73598	4550	1421	16035	605	92.8	>1693	376	180	768
ED59.0	48.0	9.2	241	374	217	651	741	133	>3078	27607	10898	>74351	4817	1501	16965	645	98.4	>1693	390	187	795
ED60.0	50.6	9.7	>244	394	228	685	786	139	>3078	28813	11322	>74351	5100	1585	17947	688	104	>1693	405	193	824

Table S2 - Cumulative dose dataset ED values - continued

ED	Mustard			Peanut			Sesame			Shrimp			Soy			Walnut			Wheat		
		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI		LCI	UCI
ED61.0	53.5	10.2	>244	415	239	720	835	146	>3078	30079	11762	>74351	5400	1674	18985	733	111	>1693	420	200	853
ED62.0	56.5	10.7	>244	436	251	757	887	153	>3078	31409	12225	>74351	5717	1767	20079	782	117	>1693	435	207	883
ED63.0	59.7	11.3	>244	459	264	796	943	161	>3078	32809	12702	>74351	6053	1866	21241	834	124	>1693	451	215	914
ED64.0	63.1	11.8	>244	483	277	837	1003	169	>3078	34284	13200	>74351	6410	1969	22469	889	132	>1693	468	222	946
ED65.0	66.7	12.5	>244	509	292	880	1068	178	>3078	35840	13715	>74351	6788	2078	23769	949	140	>1693	486	230	980
ED66.0	70.5	13.1	>244	535	307	926	1138	187	>3078	37484	14262	>74351	7191	2193	25148	1013	148	>1693	504	238	1014
ED67.0	74.6	13.8	>244	564	323	974	1214	197	>3078	39223	14831	>74351	7619	2315	26497	1081	157	>1693	523	247	1051
ED68.0	79.0	14.5	>244	594	339	1024	1297	208	>3078	41067	15424	>74351	8075	2443	>26504	1155	166	>1693	542	256	1088
ED69.0	83.7	15.3	>244	626	357	1078	1387	220	>3078	43024	16045	>74351	8561	2578	>26504	1234	176	>1693	563	265	1128
ED70.0	88.7	16.2	>244	660	376	1135	1485	233	>3078	45106	16693	>74351	9080	2722	>26504	1319	187	>1693	584	274	1169
ED71.0	94.1	17.1	>244	695	397	1195	1592	247	>3078	47325	17369	>74351	9636	2873	>26504	1411	198	>1693	607	284	1211
ED72.0	99.8	18.0	>244	734	418	1259	1710	263	>3078	49695	18078	>74351	10232	3035	>26504	1511	210	>1693	630	295	1256
ED73.0	106	19.0	>244	774	441	1327	1839	280	>3078	52232	18826	>74351	10871	3206	>26504	1619	223	>1693	655	305	1302
ED74.0	113	20.1	>244	818	466	1399	1982	298	>3078	54955	19616	>74351	11558	3389	>26504	>1693	237	>1693	681	317	1351
ED75.0	120	21.2	>244	864	492	1477	2140	319	>3078	57884	20444	>74351	12299	3584	>26504	>1693	252	>1693	708	328	1403
ED76.0	128	22.5	>244	914	520	1560	2317	341	>3078	61046	21309	>74351	13099	3792	>26504	>1693	268	>1693	737	341	1457
ED77.0	136	23.8	>244	967	551	1649	2514	367	>3078	64469	22230	>74351	13965	4015	>26504	>1693	285	>1693	768	354	1514
ED78.0	146	25.3	>244	1025	584	1745	2735	394	>3078	68187	23202	>74351	14905	4252	>26504	>1693	303	>1693	800	367	1573
ED79.0	156	26.8	>244	1087	619	1849	2981	426	>3078	72242	24234	>74351	15929	4508	>26504	>1693	323	>1693	834	382	1637
ED80.0	167	28.5	>244	1154	657	1962	3065	461	>3078	>74351	25326	>74351	17047	4782	>26504	>1693	345	>1693	870	397	1704
ED81.0	180	30.3	>244	1226	699	2085	>3078	501	>3078	>74351	26489	>74351	18273	5080	>26504	>1693	368	>1693	909	413	1775
ED82.0	193	32.3	>244	1306	744	2221	>3078	547	>3078	>74351	27726	>74351	19622	5403	>26504	>1693	394	>1693	951	430	1851
ED83.0	209	34.5	>244	1392	792	2371	>3078	598	>3078	>74351	29068	>74351	21114	5752	>26504	>1693	422	>1693	995	448	1932
ED84.0	226	36.9	>244	1487	846	2537	>3078	658	>3078	>74351	30506	>74351	22771	6132	>26504	>1693	452	>1693	1043	468	2019
ED85.0	244	39.6	>244	1592	905	2726	>3078	728	>3078	>74351	32066	>74351	24622	6548	>26504	>1693	486	>1693	1095	488	2113
ED86.0	>244	42.5	>244	1708	969	2940	>3078	808	>3078	>74351	33737	>74351	>26504	7009	>26504	>1693	524	>1693	1152	511	2214
ED87.0	>244	45.8	>244	1838	1041	3187	>3078	904	>3078	>74351	35571	>74351	>26504	7516	>26504	>1693	566	>1693	1214	535	2324
ED88.0	>244	49.5	>244	1984	1121	3475	>3078	1018	>3078	>74351	37597	>74351	>26504	8086	>26504	>1693	613	>1693	1282	561	2445
ED89.0	>244	53.7	>244	2150	1210	3817	>3078	1155	>3078	>74351	39829	>74351	>26504	8729	>26504	>1693	666	>1693	1358	590	2579
ED90.0	>244	58.5	>244	2340	1311	4233	>3078	1324	>3078	>74351	42333	>74351	>26504	9449	>26504	>1693	727	>1693	1444	622	2727
ED91.0	>244	64.0	>244	2561	1427	4746	>3078	1535	>3078	>74351	45150	>74351	>26504	10274	>26504	>1693	797	>1693	1540	658	2894
ED92.0	>244	70.5	>244	2821	1562	5410	>3078	1800	>3078	>74351	48347	>74351	>26504	11233	>26504	>1693	879	>1693	1651	698	3083
ED93.0	>244	78.2	>244	3134	1720	6290	>3078	2143	>3078	>74351	52115	>74351	>26504	12366	>26504	>1693	977	>1693	1781	744	3302
ED94.0	>244	87.5	>244	3520	1910	7538	>3078	2607	>3078	>74351	56522	>74351	>26504	13733	>26504	>1693	1096	>1693	1935	798	3559
ED95.0	>244	99.1	>244	4012	2146	9466	>3078	2997	>3078	>74351	61877	>74351	>26504	15426	>26504	>1693	1245	>1693	2125	863	3870
ED96.0	>244	114	>244	4672	2450	12878	>3078	3066	>3078	>74351	68663	>74351	>26504	17616	>26504	>1693	1441	>1693	2369	943	4260
ED97.0	>244	135	>244	5626	2867	19847	>3078	>3078	>3078	>74351	>74351	>74351	>26504	20620	>26504	>1693	1687	>1693	2701	1048	4777
ED98.0	>244	167	>244	7208	3505	37484	>3078	>3078	>3078	>74351	>74351	>74351	>26504	25196	>26504	>1693	>1693	>1693	3205	1199	5534
ED99.0	>244	226	>244	10843	4726	113627	>3078	>3078	>3078	>74351	>74351	>74351	>26504	>26504	>26504	>1693	>1693	>1693	4171	1464	6902