Modeling Excess Dietary Exposure

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Introduction

Assessment of total aggregate exposure necessitates consideration of the important role that the dietary route contributes to overall exposure. For young children, by virtue of their unique activities, the dietary exposure contribution may actually be the dominant contributor. However, unlike dietary exposures of adults, where the contribution to the total intake predominantly arises directly from the food, children's dietary exposure includes indirect pathways. Contaminated hands and surfaces are also significant sources of exposure during eating, particularly for younger children where hand-to-food and surface-to-hand-to-food frequencies are relatively high.

A linear deterministic model, termed the Children's Dietary Intake Model (CDIM), was developed to identify the various input parameters needed to assess total dietary exposure. The parameters included not only the pesticide residue concentration of the food or surface, but also the frequency and duration of transfer (e.g., surface-to-food), including the transfer efficiencies between the surfaces, and transfers between contaminated hands and foods (e.g., surface-to-hand-to-food). The deterministic model evaluations concluded that indirect ingestion activities were significant to overall exposure.

Important research is still ongoing by EPA/NERL to model pesticide residues on foods. Residue data, along with food consumption information, have already been compiled into national databases and have been modeled with the Stochastic Human Exposure and Dose Simulation (SHEDS) modeling system. CDIM is now being evaluated as a probabilistic model to facilitate prediction of dietary intake of young (i.e., < 6 yrs.) children. CDIM evaluations focus on the increased dietary exposure due to surface-to-food and surface-to-hand-to-food contacts in connection with SHEDS dietary module.

CDIM

$$I = \underbrace{R \bullet FT}_{\text{Term 1}} + \underbrace{\left[CS \bullet FS \bullet TSF \bullet ASF\right]}_{\text{Term 2}} + \underbrace{\left[(CS \bullet SHR \bullet TSH \bullet ASH)(THF \bullet AHF \bullet FH)\right]}_{\text{Term 3}}$$

Where

- I = total dietary intake (μg) of pesticide
- R = pesticide residue (μg/g food) in food item
- FT = total amount (g) of the contaminated single piece of food consumed
- CS = pesticide residue on the contacted surface (μg/cm^2 of hardwood floor)
- FS = total food surface area in contact with surface (cm^2)
  = product of the portion of food surface area in contact with the contaminated portion of the surface (***PS***) and the total food surface area (***Q***)
- TSF = surface-to-food transfer efficiency (dimensionless)
- ASF = surface-to-food contact frequency (dimensionless)
- SHR = factor to account for surface area contacted by hand (=1 if no wiping effect; >1 otherwise)
- TSH = surface-to-hand transfer efficiency (dimensionless)
- ASH = surface-to-hand contact frequency (dimensionless)
- THF = hand-to-food transfer efficiency (dimensionless)
- AHF = hand-to-food transfer frequency (dimensionless)
- FH = total food surface area in contact with contaminated portion of hand (cm^2)
  = product of the portion of food surface area in contact with the contaminated portion of the hand (***PH***) and (***Q***)

Objectives

The overall objective was to stochastically evaluate the deterministic CDIM.

Specifically,

- To carefully select and use input variables to determine the impacts on each parameter within the model
- To determine the range of dietary values using national database information, in-house dietary data, and published dietary data with varied input parameters
- To determine the impact of reasonable ranges for activity factors
- To estimate total dietary intake for selected pesticides in selected foods

Approach

Identify relevant data sources
- →Data distributions were created
- →Data distributions were synthesized or otherwise derived from other data

Incorporate SHEDS data
- →Several datasets received from EPA to support creation of the distributions for Term 1
- →USDA-sponsored pesticide analysis results for specific food items
- →Food consumption data by age and gender

Create Bridges
- →Between food items in the pesticide residue and food consumption databases
- →Between food items in the food consumption database and food diary data for selected studies

Construct SAS Datasets
- →Each data source was compiled in Excel at the sample matrix level
- →Relevant variables were extracted and standardized to create a single SAS dataset for each parameter type
- →Where needed, measurements were converted to ensure compatibility between all parameters and terms in the model

Parametric Distributions of Raw Data
- →Variables were coded to specified categories to maintain consistency across studies
- →Analyses were conducted on cis-permethrin, trans-permethrin, chlorpyrifos, and diazinon
- →THF and AHF were examined across food groups
- →TSF and ASF were examined across surface types and food groups
- →Normal, lognormal, beta, exponential distributions were used for model parameter values
- →Goodness-of-fit statistics were used to determine the distribution that best fit the data
- →All pesticide data were used as a surrogate to obtain the distribution shape when specific pesticide information was lacking

Monte Carlo Analysis
- →Used to obtain distributions of total dietary intake of one pesticide
- →Terms 1, 2 and 3 values were randomly drawn from corresponding distributions
- →N = 5000 children in a given age class was used
- →Combinations of pesticides, surfaces and foods were used

Sensitivity Analysis
- →Compare results using an F-statistic and graphic display to measure the amount of variation in the model attributed to each parameter
- →Assess the sensitivity of the parameter to the intake model by the partial F-test statistic, i.e., the ratio of the variation in pesticide intake attributed to a particular model parameter when it's fixed at low, medium, and high values over the variation in pesticide intake that is not attributed to the particular model parameter

Results

Table 1: Pesticide Intakes For Selected Food Diary Items

Diary Food Item	Food Amount (g) (USDA)	Food Amount (Diary)	No. of Pieces of Food	Mass (g)/ Piece	Food Code	Pesticide ID.	Intake/ piece (μg)	Total Intake (μg)	Pesticide Name
Bread	90	1 slice	1	90.0	51000180	024	0.79	0.79	Diazinon
Bread	90	1 slice	1	90.0	51000180	160	0.39	0.39	Chlorpyrifos
Bread	90	1 slice	1	90.0	51000180	222	0.71	0.71	cis-Permethrin
Bread	90	1 slice	1	90.0	51000180	223	0.77	0.77	trans-Permethrin
Soft Taco	50		1	50.0	52215350	024	0.38	0.38	Diazinon
Soft Taco	50		1	50.0	52215350	160	0.06	0.06	Chlorpyrifos
Soft Taco	50		1	50.0	52215350	222	0.18	0.18	cis-Permethrin
Soft Taco	50		1	50.0	52215350	223	0.33	0.33	trans-Permethrin

Figure 1: Variation in Partial F-Statistic with Model Parameter by Pesticide, Surface Type, and Selected Food Type

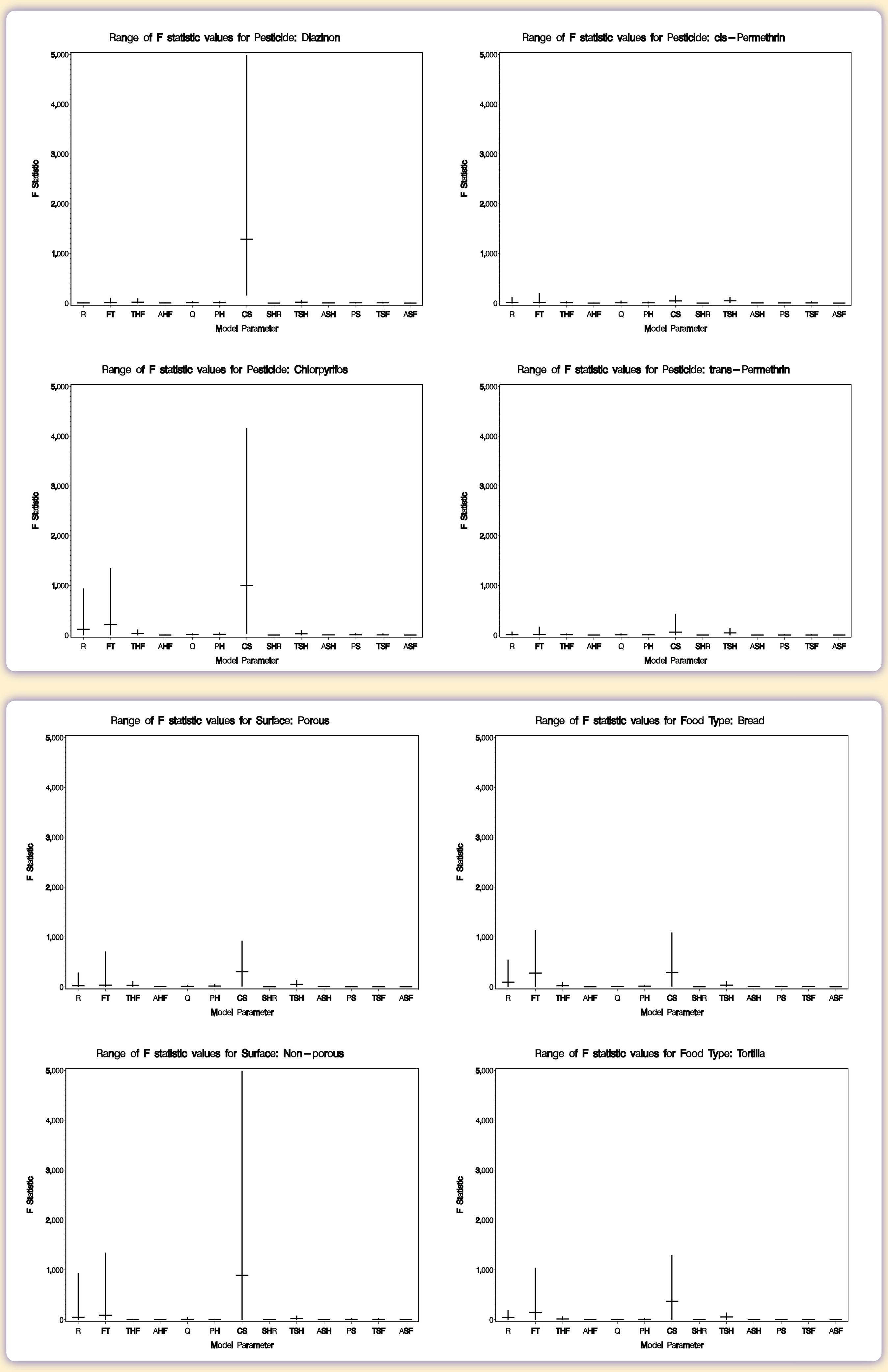
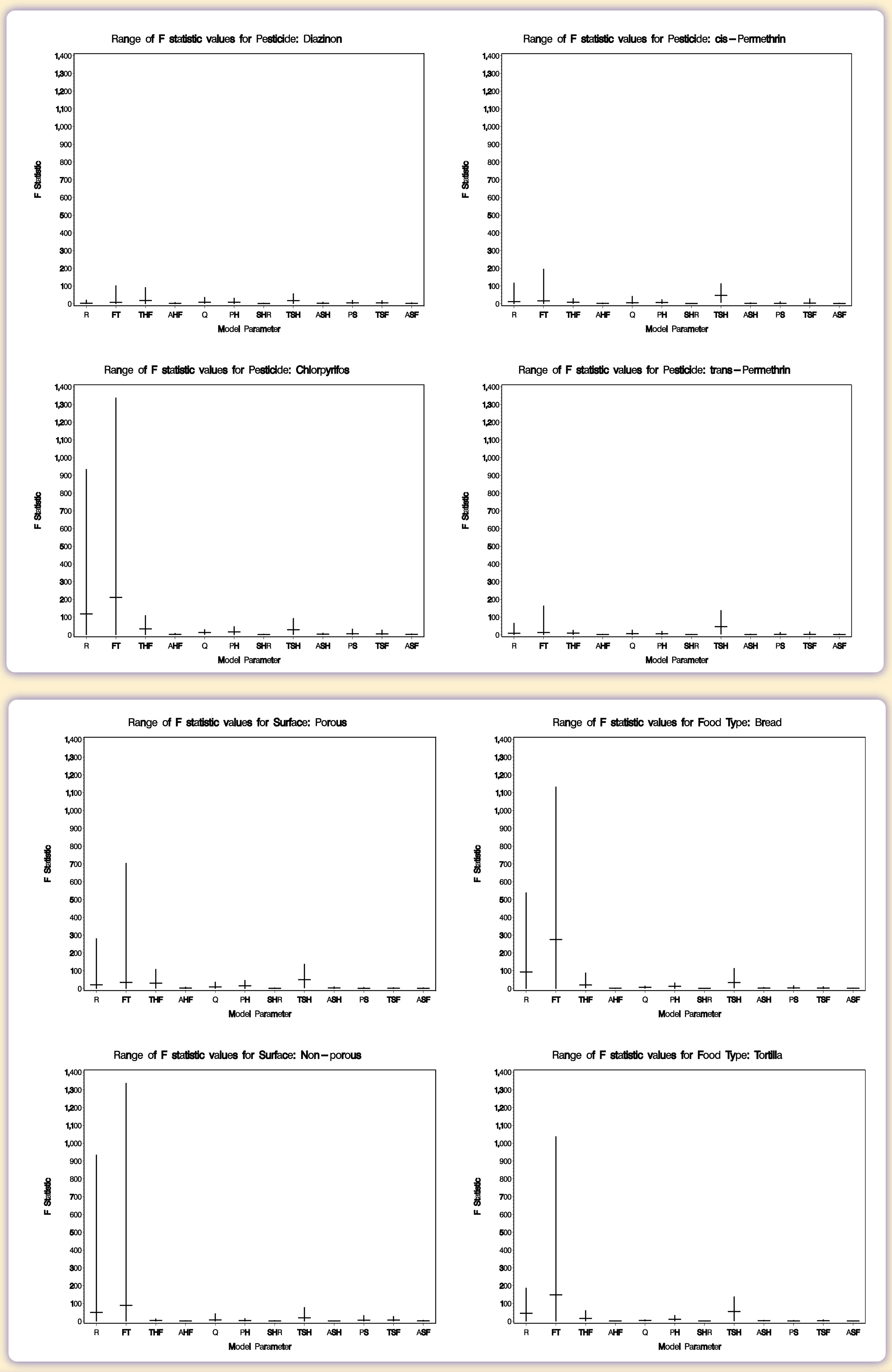


Figure 2: Variation in Partial F-Statistic with Model Parameter by Pesticide, Surface Type, and Selected Food Type; Surface Concentration Excluded



Conclusions

1. Surface concentration (CS) is the dominating influence when calculating total dietary exposure, for most of the combinations of pesticide, food type, and surface.
2. Pesticide residue (R) and amount consumed (FT) are also influential for many combinations of pesticide, surface type, or food type; in one case, more influential than surface concentration (CS).
3. In general, transfer efficiencies TSH and THF are modestly influential within pesticide, surface type, and food type. Conversely, TSF does not appear to have as much effect. This may reflect a lack of data as opposed to little influence.
4. No other parameter, with the possible exception of the food surface area, appears to be influential.
5. Parameters AHF, SHR, ASH, and ASF are rarely, if ever, influential. This may be a result of the sparcity of information for these parameters, incorrect assumptions on data interpretation, or possibly may suggest the existence of parameter interactions or confounding terms.
6. Surface concentration (CS) appears to be more influential for foods with higher transfer efficiencies. This suggests that the intra-term parameters are not truly independent in the model.

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