Expert Collaboration Review of Temkin et al., 2025

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January 12, 2026

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Acronyms and Abbreviations

ADI	Acceptable Daily Intake
AGRICAN	French Agriculture and Cancer Study
AHS	Agricultural Health Study
β	Beta
CDC	Centers for Disease Control and Prevention
CI	Confidence Interval
CNAP	Cancer in the Norwegian Agricultural Population
DAP	Dialkylphosphate
EPA	Environmental Protection Agency
EWG	Environmental Working Group
FNDDS	Food and Nutrient Database for Dietary Studies
NFS	Not Further Specified
NHANES	National Health and Nutritional Examination Survey
NOAEL	No Observed Adverse Effect Level
OP	Organophosphate
PDP	Pesticide Data Program
RfD	Reference Dose
WWEIA	What We Eat in America
U.S.	United States
USDA	U.S. Department of Agriculture

Limitations

This report summarizes work performed to-date and presents the findings resulting from that work. The findings presented herein are made to a reasonable degree of scientific certainty.

Executive Summary

At the request of the Alliance for Food & Farming, Exponent assembled a group of experts to review the study titled “A cumulative dietary pesticide exposure score based on produce consumption is associated with urinary pesticide biomarkers in a U.S. biomonitoring cohort” (Temkin et al., 2025). The group included Dr. Carl Winter, a Professor Emeritus of Food Science and Technology at University of California, Davis, and Dr. Joan Salge Blake, a Clinical Professor of Nutrition at Boston University.

Utilizing data from the U.S. Department of Agriculture (USDA) Pesticide Data Program (PDP) and the United States Centers for Disease Control and Prevention (CDC) National Health and Nutritional Examination Survey (NHANES), the study alleges that produce consumption weighted by pesticide contamination is associated with higher levels of urinary pesticide metabolites, after excluding potatoes.

Given the application of pesticides to produce to control pests and disease, an association between produce consumption and urinary pesticide metabolites would not be surprising. However, Temkin et al. (2025) did not find a statistically significant association, except for an analysis that excludes one type of produce: potatoes. The study mentions the importance of utilizing pesticide toxicity values to assess health risk is mentioned, yet a risk assessment is not carried out, despite containing all the necessary data.

Our review identified several errors made in the selection of representative food codes using NHANES and using older survey data. Despite the singular association between dietary pesticide exposure score and higher pesticide load when excluding one of the 43 produce types, the study concludes that consumption of produce may lead to higher urinary pesticide metabolite levels and should be used to inform future research and tools for consumers. The data provided in the publication does not support this conclusion and, in fact, refutes it.

Introduction

In September 2025, the study titled "A cumulative dietary pesticide exposure score based on produce consumption is associated with urinary pesticide biomarkers in a U.S. biomonitoring cohort" was published in the *International Journal of Hygiene and Environmental Health* (Temkin et al., 2025). Utilizing data from the U.S. Department of Agriculture (USDA) Pesticide Data Program (PDP) and the United States Centers for Disease Control and Prevention (CDC) National Health and Nutritional Examination Survey (NHANES), the study alleges that produce consumption is associated with higher levels of urinary pesticide metabolites, after excluding potatoes. This report provides a review of Temkin et al., 2025 by Exponent and a group of experts, including Dr. Carl Winter, a Professor Emeritus of Food Science and Technology at University of California, Davis, and Dr. Joan Salge Blake, a Clinical Professor of Nutrition at Boston University.

The study authors work for, or previously worked for, the Environmental Working Group (EWG), and it is expected that EWG will utilize this study to support the scientific validity of its Dirty Dozen media campaign.

Review of publication

Possible correlation between produce consumption and urinary pesticide metabolite levels

Pesticides are utilized to control specific pests and disease carriers and therefore reduce health risks caused by such pests, such as mosquitoes transmitting West Nile virus and birds spreading avian flu (U.S. EPA, 2025). Because pesticides are distributed amongst crops throughout their growth, it is not surprising that they remain on the crop as it is transported, purchased, and consumed. Therefore, the conclusion of Temkin et al. (2025) that pesticide levels on consumed produce may correlate with higher urinary pesticide metabolite levels is not surprising. The findings of this study, however, do not show a true correlation between produce consumption and urinary pesticide metabolite levels, highlighting the flaws in the arbitrary ranking system of pesticide "load".

Biased presentation of results

The abstract displays a biased interpretation of results:

> "Increasing dietary pesticide exposure scores were not associated with average pesticide biomarker rank (β [95 % CI] = 0.02 [-0.34, 0.38]) and were consistent across scores that utilized the different indices. Matching pesticides in food and urine, results in a slightly stronger association (β [95 % CI] = 0.09 [-0.32, 0.51])."

Given the wide confidence intervals that include the null value, the results provide no evidence of an association. Therefore, describing the second model as showing a "slightly stronger association" is misleading.

Weak correlation analysis

Temkin et al. (2025) found no statistically significant association between dietary pesticide exposure and urinary pesticide metabolite levels in all analyses except when excluding potatoes.

The study failed to demonstrate an association between dietary pesticide exposure scores and average pesticide biomarker rank, which remained consistent in all scenarios applied to calculate the pesticide load index, such as using the No Observed Adverse Effect Level (NOAEL), using the reference dose/acceptable daily intake (RfD/ADI), removing the toxicity indicator altogether, and limiting to a subset of pesticides. Further, when broadly applying the NOAEL as the toxicity metric for all sensitivity analyses and including additional precision variables in the sensitivity analysis model, results were still null.

After various combinations of dietary consumption data, pesticide concentration data, toxicity reference values, and urinary pesticide metabolite levels, the study applied a “leave-one-out” sensitivity analysis for each of 44 produce types. When 43 produce types were individually removed from the calculation of the dietary pesticide exposure score, the association between dietary pesticide exposure score and average pesticide biomarker rank did not meaningfully change, with β estimates ranging from -0.16 to 0.02 (see **Figure 6 in Temkin et al., 2025**). However, the singular statistically significant association from Temkin et al. (2025) resulted from excluding potatoes from the analysis. Excluding potatoes leads to a large, and perhaps questionable, shift in correlations relative to other produce types, producing a β estimate 35 times the maximum for all other “leave-one-out” analyses (β [95% CI] = 0.70 [0.30, 1.10]). The study utilized this singular result to justify excluding potatoes from the remaining analyses, one of which yielded a significant estimate for high residue fruits and vegetables and average pesticide biomarker rank (β [95% CI] = 59.9 [25.9, 93.9]).

If the purpose of the study was to demonstrate that “the dietary pesticide exposure score developed and validated in this study can be utilized to assess the impact of dietary pesticide exposure on health outcomes”, the exclusion of a single produce type from the analyses, in fact, invalidates the method (Temkin et al., 2025). Potatoes had the fourth highest pesticide load index and the largest number of samples overall with at least one pesticide residue. Potatoes were also highly consumed, as “the average number of servings of all 4 included fruits and vegetables consumed per day was 1.7, compared to 1.4 servings when excluding potatoes” (Temkin et al., 2025). Not only is it inappropriate to exclude any of the 43 produce types, but it is especially concerning to exclude potatoes given their impact on exposure and consumption estimates.

Many sources of urinary metabolites

Temkin et al. (2025) utilized urinary metabolite levels from the National Health and Nutrition Examination Survey (NHANES) conducted in 2015-2016 and pesticide concentration data from the Pesticide Data Program (PDP) from 2013-2018. NHANES 2015-2016 includes a total of 17 urinary metabolites, but the analysis was narrowed down to 15 urinary metabolites, as 2,4-D and glyphosate were not available in the PDP data. Nine out of the 15 urinary metabolites were dialkylphosphates (DAPs), which originate from organophosphate (OP) pesticides (see **Supplemental Table 9 in Temkin et al., 2025**). Five of the DAPs were generic hydrolysis products (i.e., dimethylphosphate, diethylphosphate) with non-specific OP parent compounds, while the remaining four DAPs were from specific OPs.

The four DAPs with specific OP parent compounds included oxypyrimidine (metabolite of diazinon), malathion diacid (metabolite of malathion), paranitrophenol (metabolite of methyl-parathion and ethyl-parathion), and 3,5,6-trichloropyridinol (metabolite of chlorpyrifos). Since DAPs are also environmental metabolites of OPs, in addition to *in vivo* metabolites, DAPs are present on produce itself. Produce consumption results in exposure to DAPs, which subsequently may appear in urine even when there is not direct OP exposure. Based on a study that measured 12 insecticides among 153 produce samples, produce specifically treated with diazinon, malathion, and chlorpyrifos always had higher concentrations of DAPs than OP pesticides (Zhang et al., 2008). When treated with diazinon, malathion, and chlorpyrifos, produce contained an average of 0.54, 0.79, and 0.60 mole fractions of DAPs from the environment, respectively. Therefore, the main source of DAPs is from direct ingestion of DAPs, not of an OP itself. Many pesticide metabolites are both environmental and *in vivo* metabolites.

Correlation of pesticides with each other

It is difficult to distinguish between the effects of individual pesticides due to their correlation with each other. Analysis of pesticide concentration data from agricultural cohort studies such as the U.S. Agricultural Health Study (AHS), French Agriculture and Cancer Study (AGRICAN), and Cancer in the Norwegian Agricultural Population (CNAP) provides evidence for correlations between pesticides (Brouwer et al., 2016). In addition, studies that utilize data from these cohorts to assess the effect of pesticides on health outcomes adjust for correlated pesticides in their statistical analyses, which demonstrates the potential for correlated exposures to obscure analyses (Andreotti et al., 2018; Parks et al., 2025).

Failure to conduct a proper risk assessment

The study did not investigate health risks associated with the pesticides of interest, although it contained the data needed to do so. The publication states that “the addition of pesticide toxicity is particularly relevant when using this pesticide exposure score to assess the relationship with health risks” (Temkin et al., 2025). However, the authors developed statistical analyses to examine correlations to very imprecise measurements of pesticide exposure such as urinary pesticide metabolite levels rather than relying upon “gold standard” risk assessment methods using food residues, food consumption, and toxicity metrics, already available to them through the PDP, NHANES, and authoritative government agencies, to estimate risk. Risk estimates for specific produce types derived from this approach could have could have been utilized to more accurately determine if risk estimates correlated with pesticide “loads” on specific fruits and vegetables. The study failed to provide the analyses necessary to make informative conclusions about health risks.

Use of older PDP data when more recent data is available

The study utilized data from PDP 2013-2018 although more recent data up to 2024 were available at the time of publication. Data for all but one of the 44 commodities were available in PDP 2024, alone, which would have provided more recent pesticide levels that may have changed since 2018. Matching consumption data could be provided from NHANES, with the most recent survey cycle being August 2021-August 2023, but the study analyzed PDP and NHANES data from nearly a decade ago instead.

Incorrect inclusion of NHANES food codes

The study stated that the “FNDDS codes linked to WWEIA Food Categories” spreadsheet was utilized to search the list of NHANES food codes using keywords corresponding to produce. To ensure a high coverage of preparations for each produce type, 85 percent of all reported preparations were captured, which is an arbitrary percentage with no explanation nor scientific basis. The sole attempt to refine the captured food codes consisted of dropping produce mismatches such as “pineapple” and “grapefruit” for search terms such as “apple” and “grape”. The stated search strategy was inappropriate for the complex and detailed review required when selecting relevant food codes in the NHANES database. It resulted in the exclusion of relevant food codes in NHANES 2015-2016 such as 91512010 Danish dessert pudding, which consists of “Apples, raw, without skin” according to FNDDS, and 75440200 Vegetable tempura, which consists of “Sweet potato, raw, unprepared”. However, these food codes were not included in the analysis because they do not contain the keywords “apple” and “sweet potato” in the food description.

Using NHANES consumption data, the authors assigned attributable percentages and therefore gram amounts for the component of the food represented by the produce type of interest. There is no further explanation or refinement of their percentage assignment for each food code. Many of the food codes matched to commodities measured in the PDP cannot be used “as is” without further consideration of the impact of processing on the pesticide level in the food and therefore, any measured association with urinary levels. For example, 71200110 Potato chips, barbecue flavored; 71501035 Potato, mashed, from dry mix, NFS; and 74406100 Steak sauce, tomato-base may contain potatoes and tomatoes, respectively, but these are highly processed forms of the produce in which the pesticide was measured. The attributable percents assigned to food codes are not representative of the true percentages according to FNDDS (USDA, 2018). For example, 27345010 Chicken or turkey, rice, and vegetables including carrots, broccoli, and/or dark-green leafy; no sauce was included at 20% for carrots compared to 11% in FNDDS, and 71704000 Stewed potatoes with tomatoes was included at 90% for potatoes compared to 62%. Also, the 449 captured food codes include repeats of the same food code for the same commodity. For example, 53360000 Pie, sweet potato was included twice at 25% for sweet potatoes. The food codes selected and percentages assigned in the NHANES database are not representative of produce types that may expose consumers to pesticides. The exclusion of relevant foods and inclusion of foods at incorrect percentages and without considering processing factors show a lack of knowledge about NHANES dietary data and a disregard for detail and may affect the strength and directionality of the association concluded by the authors.

Flawed conclusions

Temkin et al. (2025) concludes that consumption of produce may lead to higher urinary pesticide metabolite levels, which is inappropriate given the findings. The singular statistically significant association between consumption and pesticide levels is generated by excluding one of the produce types of greatest concern (i.e., potatoes) and therefore is unjustified. Using the association between dietary pesticide exposure score and higher pesticide load, excluding potatoes, the study encourages the approach to be used in future research and to educate consumers on ways to reduce pesticide exposure. The publication claims to prove the proposed pesticide exposure method, which is untrue, given a portion of the exposure variable (i.e., potatoes) was removed in order to make the conclusion. This study shows a lack of association between consumption of produce and urinary pesticide metabolite levels and should not be used to inform future actions, as the research does not add meaning to the scientific literature.

Professional associations of the authors

The authors of Temkin et al. (2025) are affiliated with the Environmental Working Group (EWG) with the exception of one of the authors, Elvira Fleury, who is associated with Brown University. Elvira Fleury was enrolled in a one-year Master's in Public Health program through Brown University while simultaneously serving as an intern for EWG, and no faculty representative from Brown University is referenced in the study. Therefore, it would be misleading to associate Brown University with the study.

Conclusion

Temkin et al. (2025) is not justified in asserting that dietary pesticide exposure scores are associated with urinary pesticide metabolite levels, given that the findings contradict this conclusion. The analyses contained flaws including, but not limited to removing an unjustified singular type of produce out of 43 types and including irrelevant foods to assess dietary consumption. The methodology utilized to develop the dietary pesticide exposure score and support the alleged conclusion should not be applied to assess impact on health outcomes, to inform future research, or to educate consumers, as the study does not meaningfully add to the scientific literature.

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