Supplemental Material

Supplemental Figure 1. Flavonoid intakes (mg/ day) regressed on the dietary share of ultra-processed foods using restricted cubic splines. US population aged 0 + years (NHANES 2017-2018) (n=7,481)

The values shown on the x-axis correspond to the 5th, 27.5th, 50th, 72.5th, and 95th centiles for percentage of total energy from ultra-processed foods (knots).



Total flavonoids (mg per day): Wald test for linear term p=0.630; Wald test for all non-linear terms p<0.001.

ΣIsoflavones (mg per day): Wald test for linear term p=0.105; Wald test for all non-linear terms p=0.0256.



ΣAnthocyanidins (mg per day): Wald test for linear term p=0.080; Wald test for all non-linear terms p=0.8399.

ΣFlavan-3-ols (mg per day): Wald test for linear term p=0.223; Wald test for all non-linear terms p=0.0005.



ΣFlavanones (mg per day): Wald test for linear term p=0.667; Wald test for all non-linear terms p=0.0124.

ΣCatechin [Flavan-3-ols] (subtotal) (mg per day): Wald test for linear term p=0.109; Wald test for all non-linear terms p=0.0019.



ΣFlavanones (mg per day): Wald test for linear term p=0.667; Wald test for all non-linear terms p=0.0124.

ΣFlavonols (mg per day): Wald test for linear term p=0.338; Wald test for all non-linear terms p=0.0002.

Supplemental Material – Flavonoid Database

The Flavonoid Database for USDA Food Codes is largely based on the USDA’s Expanded Flavonoid Database for the Assessment of Dietary Intakes 1.1 (1), also known as FDB-EXP, which provides 29 flavonoid values (in mg/100 edible ingredient code grams) for 1,789 of the 2,332 unique ingredient codes used in FNDDS 2017-2018. Flavonoid values for the remaining 23% unique ingredient codes (not contemplated in FDB-EXP) were assigned via imputation (using the same logic applied to develop the FDB-EXP) or obtained from the scientific literature (2). For the most part, flavonoid values in the Flavonoid Database for USDA Food Codes were calculated using the same recipes (ingredient codes and weights) that had been used to create the FNDDS remaining nutrient values. In some cases, however, it was necessary to modify some existing FNDDS recipes (ingredient codes and/or weights) to calculate food code flavonoid values, to assure more representative flavonoid values or to ensure the consistency of flavonoid values across related food codes (2).

Because analytic data were available for a very limited number of foods, a systematic approach was used to assign flavonoid values in the FDB-EXP. For example, for exclusively animal-based products, flavonoid content was assumed to be zero, whereas for tomatoes, isoflavones were set to zero as they do not contain soy. Among the flavonoid values that were not assumed to be zero, about 10% were analytical values and the remaining 90% were imputed based on data for similar foods. The foods/beverages that do have analytical values account for a large proportion of overall flavonoid intake (2).

In FDB-EXP, any ingredient accounting for less than five percent of the weight of the food was not accounted for when calculating flavonoid values of each ingredient code, except when the ingredient was high in flavonoids and likely to be a major contributor of flavonoid intake, such as cocoa powder (alkalinized or regular), soy protein isolate, or soy flour. The same rule and exceptions were applied in the Flavonoid Database for USDA Food Codes, though two additional exceptions to the 5-percent rule were made. In the Flavonoid Database for USDA Food Codes, minor ingredients that accounted for less than five percent of an item’s total weight, were also accounted for (not omitted) if (a) were concentrated sources of at least one of the flavonoids of interest and (b) were asked about in the What We Eat in America (WWEIA), NHANES 2017-2018 dietary interview and/or were common recipe ingredients used consistently in many foods in the FNDDS (2).

The predominant source of isoflavones is soy-based foods/beverages (e.g., soy milk, soy-based protein powders, and tofu) while most of the remaining isoflavone intake comes from functional ingredients (e.g., soy additives that serve as stabilizers or emulsifiers). The Flavonoid Database for USDA Food Codes retained the isoflavone values provided by the FDB-EXP for items in which soy was a principal ingredient, conservatively setting to zero isoflavone non-zero values if provided by a functional ingredient because the presence/absence of the functional ingredient may depend on the brand name. Only for doughnuts (nearly all of which contain soy-based functional ingredients) and soy-containing nutrition bars (brand name collection during the dietary intake allowed assigning bars that contained soy to different food codes from those that did not contain soy) that non-zero values were retained (not set to zero) (2).

Retention factors based on cooking method and subclass flavonoid were consistently applied in both Flavonoid Database for USDA Food Codes and FDB-EXP. Briefly, for moist-heat cooking methods, a loss of 15% was applied to flavan-3-ols, flavanones, flavones, and flavanols and a loss of 50% was applied to anthocyanidins. No loss was assumed for dry heat cooking methods such as baking. No retention factors were applied to isoflavones, because analytical values were available for both raw and cooked/processed versions of most foods that contain isoflavones (2).

**REFERENCES**

1. U.S. Department of Agriculture, Methods and Application of Food Composition Laboratory [Internet]. USDA Special Interest Databases on Flavonoids [includes USDA Database for the Flavonoid Content of Selected Foods Release 3.1 and 3.3, and USDA's Expanded Flavonoid Database for the Assessment of Dietary Intakes Release 1.1); updated 2021 Mar 31; cited 2022 May 13]. Available from: <http://www.ars.usda.gov/Services/docs.htm?docid=24953>.
2. U.S. Department of Agriculture, Agricultural Research Service. 2022. Flavonoid Values for USDA Survey Foods and Beverages 2017-2018. Food Surveys Research Group Home Page, http://www.ars.usda.gov/nea/bhnrc/fsrg