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USDA develops a database for flavonoids to assess dietary intakes

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Abstract

The Nutrient Data Laboratory (NDL) of ARS/USDA issued "USDA Database for the Flavonoid Content of Selected Foods, Release 3.1" in 2012. A complementary database for the "USDA Database for the Isoflavone Content of Selected Foods, Release 2" was issued in 2008. To support the assessment of the flavonoids intake these two databases were expanded to comprise approximately 2900 foods from USDA's National Nutrient Database for Standard Reference (SR). Various estimation techniques, long established for calculating unavailable values in SR, were used to complete this expanded flavonoids database for a total of 30 compounds for each of 2900 foods.

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Keywords: monomeric flavonoids; calculation techniques; database expansion

1. Introduction

There is a considerable interest in the scientific community about the potential benefits of flavonoids in reducing the risk of chronic diseases including cardiovascular diseases [1]. Evidence supporting cancer prevention effects of flavonoids is limited and conflicting, but some organ-specific associations have been reported. Lam et al. [2] observed an inverse relationship between quercetin-rich food intake and lung cancer in Italy, while Ekström et al., [3], observed protection against stomach cancer with high intakes of quercetin in a population study in Sweden. Flavonoids, including isoflavones, are secondary plant metabolites and are found mainly in fruits, vegetables, soybeans and some grains. The USDA database for the flavonoid content of selected foods, Release 3.1 (FDB 3.1) [4], contains values for up to 27 monomeric flavonoid compounds in five subclasses of flavonoids for 500 foods. The isoflavones database released by the USDA in 2008 (IDB 2) [5] contains values for three prominent compounds (daidzein, genistein, and glycitein) for 557 foods. The Nutrient Data Laboratory (NDL) developed a new

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database by expanding these two databases to include approximately 2900 food items in the subset of USDA's National Nutrient Database for Standard Reference (SR) used as the foundation to develop USDA Food and Nutrient Database for Dietary Studies (FNDDS).

Fruits and vegetables are the main sources of dietary flavonoids. Some grains like barley and buckwheat contain some catechins and flavonols. Isoflavones are mainly present in soybeans and soybean products such as soy flour, soymilk, tofu etc. Animal products such as meat/poultry do not contain flavonoids, unless flavonoid containing ingredients are added. Every food (fruit or vegetable) does not contain every compound from all subclasses. Quercetin, a flavonol, is the most ubiquitous flavonoid. Most of the foods contain compounds predominantly from one or two subclasses only. For example: citrus fruits contain mainly flavanones, while tea contains mainly flavan 3-ols. The six subclasses of flavonoids and the compounds in the subclasses included in the two USDA databases and some of their food sources are presented below in Table 1.

Table 1.Flavonoid subclasses and major food sources

Subclass	Compounds	Color	Food Sources
Anthocyanidins	Cyanidin, Delphinidin, Malvidin, Pelargonidin, Peonidin, Petunidin	Blue, Red, Violet	Berries (blueberries, Red grapes, Strawberries)
Flavanols (Flavan 3-ols)	Catechin, Epicatechin, Gallocatechin, Epicatechin gallate, Epigallocatechin gallate, Theaflavins, Thearubigins	Colorless	Apples, Tea, Beer
		Yellow	
Flavanones	Hesperetin,	Colorless	Citrus fruits
	Naringenin, Eriodictyol,	Pale Yellow	Oranges, Grapefruit
Flavonols	Quercetin, Kaempferol, Myricetin, Isorhamnetin	Pale Yellow	Onions, Broccoli, Kale, Apple, Tea, Buckwheat
Flavones	Apigenin, Luteolin	Pale Yellow	Herbs, Parsley, Thyme, Celery
Isoflavones	Daidzein, Genistein, Glycitein	Colorless	Legumes (soybeans), soybean products (tofu, soymilk)

Yao et al., Plant Foods for Human Nutrition, 2004, 59:113-122.

2. Method

There are approximately 500 and 550 foods in FDB 3.1 and IDB 2 respectively. The available analytical values for the compounds for each food from these databases were matched by using the Nutrient Data Bank (NDB) number, a five digit numerical code used in the SR for a unique food item. These two databases were used as the foundation to calculate all the unavailable values. The FNDDS requires complete profile for all 30 compounds for each food in the subset of SR. It was, therefore, necessary to calculate values for many flavonoid compounds for which analytical values were not available.

Estimation techniques for calculating unavailable values:

The NDL estimation techniques for calculating unavailable values [6] were adopted and are described below. Figure 1 illustrates the flow chart of the decision-making procedure. Table 2 explains assignment of "zero" values, while Table 3 explains other techniques used to calculate values.

1. Assumed "0" values were assigned to all the meat/poultry products
2. If compounds from a subclass of flavonoids were not expected in a food, "0" values were assumed for those compounds, e.g. "0" values for flavanones for most of the vegetables.
3. Used flavonoid values from a different, but similar food.
4. Calculated flavonoid values from a different form (raw/cooked or fresh/dry) of the same food using food yield (i.e. weight changes) and "flavonoid compound" retention factors. Due to lack of experimental studies on flavonoid retentions, the NDL consulted with analytical chemists at the Food Composition and Methods Development Laboratory (FCMDL) of ARS/USDA [7] to develop best approximations for the retention factors for flavonoids. The retention factors of 85% for all the subclasses except 50% for anthocyanidins were used whenever necessary (Dr. James Harnly, FCMDL, personal communication, 2012).
5. A yield factor was used to account for the canned foods to adjust for yields of solid foods after draining liquids [8].
6. For multi-ingredient foods, formulations developed by NDL scientists [9] were used to estimate percentages of flavonoid-containing ingredients. If a food ingredient (fruits, vegetables, nuts, soy proteins etc.) contributed <5% by weight to a multicomponent food, "0"values were assumed for that ingredient. But if an ingredient contributed >5% by weight flavonoid values for that ingredient were adjusted according to the % weight. Cocoa powder, regular or alkalinized, soy protein isolate and soy flour were the exceptions to the <5% contribution by weight rule due to their reported high contents.
7. Generic profiles were prepared for common leafy vegetables and for fruits to estimate values when similar vegetable or fruit were not available.
8. Values from other databases such as Phenol-Explorer, Release 2 [10] were used for some foods not available in FDB 3.1. Phenol-Explorer is a database for polyphenols developed at the French National Institute of Agricultural Research in collaboration with AFSSA (French Agency for Food, Environmental and Occupational Health & Safety), the University of Alberta, and the University of Barcelona.

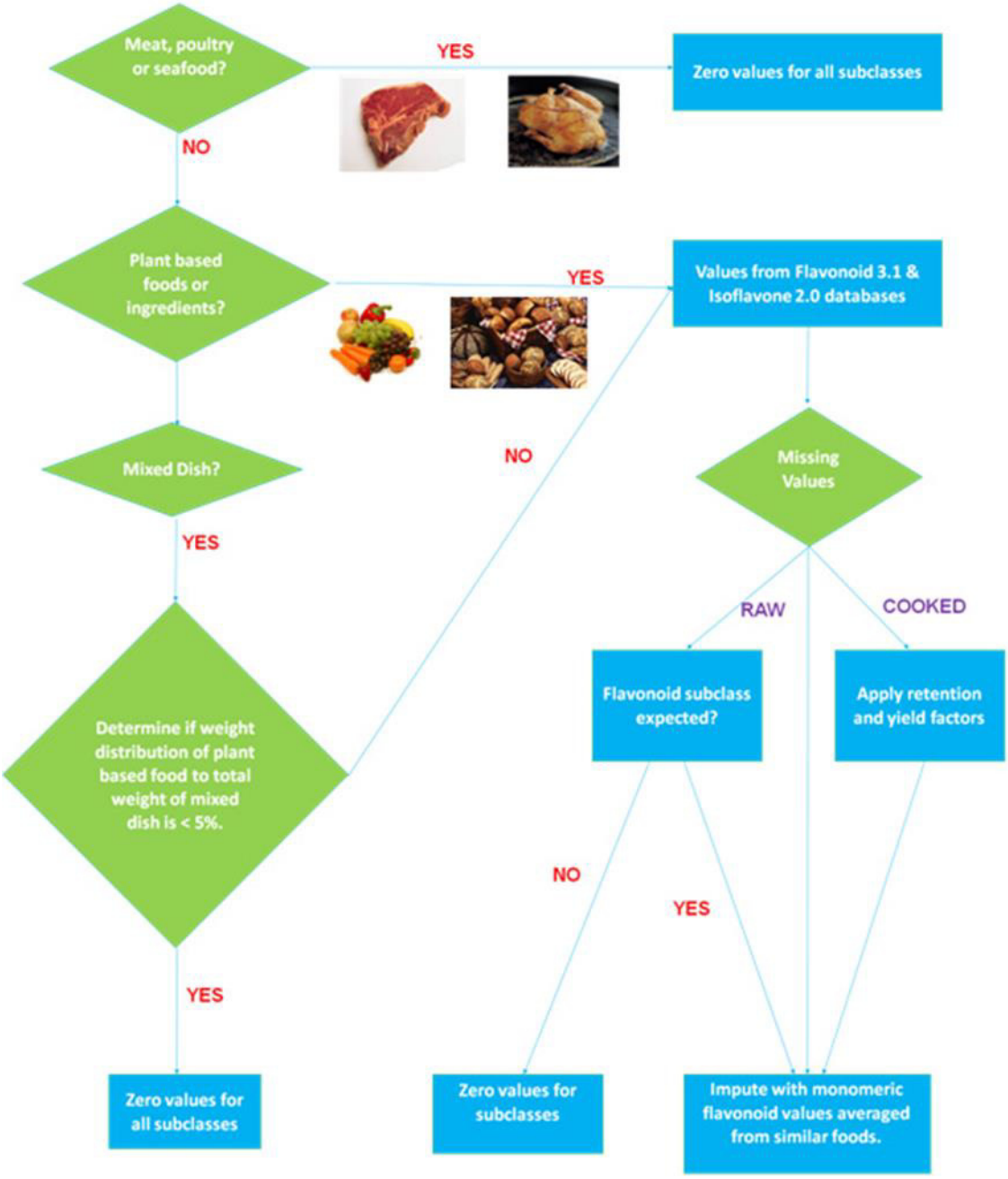

Fig. 1.Decision making procedure

Table 2.Assignment of "zero" values

Food Group (USDA Food Group Code)	Flavonoid Subclass
Dairy and Egg Products (01)	Flavones, Flavanones, Anthocyanidins
Spices and herbs (02)	Anthocyanidins, Flavan 3-ols
Nuts and Seeds (12)	Flavones, Flavanones
Legumes and Products (16)	Flavones, Flavanones
Poultry (05), Sausages and Luncheon meats (07)	Flavonols, Flavones, Flavanones, Flavan 3-ols, Anthocyanidins
Pork Products (10), Beef Products (13)	
Finfish and Shellfish Products (15),	
Lamb, Veal, Game (17)	

Table 3.Examples of Estimation Techniques

NDB No. (Flavonoid values unavailable)	Food Description	Source NDB No. (FDB 3.1) for Calculation	Food Description	Factor used for Estimation (Reason)
11012	Asparagus, cooked, boiled, drained	11011	Asparagus, raw	0.85 (Flavonoid Retention), 0.99 (cooking Yield)
09374	Pear, canned, heavy syrup, drained	09252	Pears raw	0.67 (solids left after draining)
09110	Mulberries, raw,	09042	Blackberries, raw	No adjustment (similar food)
02027	Oregano, dried	99115	Oregano, fresh	6.23 (Moisture loss)
06025	Soup, chicken vegetable, canned, condensed	11357	Potatoes, white, flesh and skin, baked	0.12 (12% by wt. per Formulation)
		11125	Carrots, cooked, boiled, drained, w/o salt	0.12 (12% by wt. per Formulation)
		11530	Tomatoes, red, ripe, cooked	0.12 (12% by wt. per Formulation)

3. Results

The database for a subset of about 2900 foods with a complete profile for 30 flavonoids compounds was completed and provided to the Food Surveys Research Group (FSRG) of ARS/USDA.

The FSRG will expand this database to provide flavonoid profiles for about 7000 foods in the FNDDS 4.1 [11] which will then be used to estimate intakes of these compounds in the U.S. population participating in the What We Eat in America (WWEIA) component of National Nutrition and Health Examination Survey (NHANES) 2007-2008. The collaborators will then assess the relationship of flavonoid intake to levels of various indicators of health status.

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