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# Sources of variability in the flavonoid content of foods

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**Abstract**

In 2012, USDA prepared Release 3.1 of the "USDA Database for the Flavonoid Content of Selected Foods", which contained data on 508 food items collected from 308 published sources. Flavonoids are secondary metabolites produced by plants in response to various environmental stresses such as climate and ultraviolet radiation. Other sources of variability include cultivar, growing location, agricultural practices, processing techniques and preparation methods, as well as analytical variability. The objective of this manuscript is to examine and report on variability in the flavonoid content of foods. While the required information needed to assess variability is not available for all foods, data for a number of foods was analyzed using analysis of variance for cultivar, location and other factors. For orange juice, data for 247 samples representing 109 mean values, i.e., different cultivars and location, were analyzed. The overall range for hesperetin was 1-39mg/100g; samples from the United States 5-30mg/100g; samples from Brazil 5-25mg/100g; and samples from Corsica (France) 12-26mg/100g. For strawberries, data for 148 samples representing 98 mean values were analyzed. The overall range for pelargonidin was 8-58 mg/100g. The range of quercetin values in raw yellow onions is 0-91mg/100g, and represents 96 mean values for 402 samples from the U.S., Japan, Spain, and other countries. The flavonoid content of foods is extremely variable and is influenced by both location and cultivar, which account for 25 to 33 percent of the variability as well as by numerous other factors, which were not examined in this analysis.



*Keywords:* Flavonoids, variability

## 1. Introduction

Flavonoids are secondary plant metabolites and are found mainly in fruits, vegetables, and some grains. The quantity of a specific flavonoid can vary considerably depending on a number of factors, such as diseases, insect/pest attack, climate stress, ultraviolet radiation, and others [1, 2]. Other sources of variability can include cultivar, growing location, agricultural practices, harvesting and storage conditions, and processing and preparation methods [3, 4, 5, 6].

Several properties exhibited by flavonoids include inhibition of lipid peroxidation, anticarcinogenic activity, and antioxidant capacity [7]. The potential to reduce the risks of chronic diseases due to these properties has motivated the scientific community to conduct epidemiological studies to observe the intakes of flavonoids and possible associations with risk reduction for various diseases. To address the needs of the research community, the Nutrient Data Laboratory/USDA (NDL) has developed three separate databases: 1) Flavonoid content of selected foods, Release 3.1, 2012, with values for 26

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individual flavonoids (Table 1) for over 500 foods; 2) Isoflavone content of selected foods, Release 2, 2008, with values for 549 foods; and 3) Proanthocyanidin content of selected foods, 2004, with values for over 200 foods. Table 1 shows the list of subclasses of flavonoids as well as the individual aglycone compounds within each subclass. The subclasses are determined by the chemical structure or characteristics of that group of compounds. All of these compounds do not occur together in any one type of food or group of similar foods. Rather, a specific flavonoid subclass or one or more individual flavonoids within that class will predominate in a specific food or type of food.

Table 1.Flavonoid subclasses [8]

| | |
|---|---|
| Anthocyanidins | |
| | Cyanidin, delphinidin, malvidin, pelargonidin, peonidin, petunidin |
| Flavonols | |
| | Quercetin, kaempferol, myricetin, isorhamnetin |
| Flavones | |
| | Apigenin, luteolin |
| Flavanones | |
| | Hesperetin, naringenin, eriodictyol |
| Flavan-3-ols | |
| | Catechin, epicatechin, epicatechin3-gallate, epigallocatechin, epigallocatechin 3-gallate, gallocatechin, theaflavin, theaflavin 3-3'-digallate, theaflavin 3'-gallate, theaflavin 3-gallate, thearubigins |
| Isoflavones | |
| | Daidzein, genistein, glycitein |

The national and international scientific community recently used these NDL databases to study associations of flavonoid intakes with various disorders such as stroke [9] cardiovascular disease [10] diabetes [11], and colorectal cancer [12]. The objective of this paper is to discuss the mean values and variability for selected flavonoid compounds in three foods from the flavonoid database.

## 2. Methods

As part of the process of developing special interest food composition databases, NDL collects articles from the scientific literature. For Release 3.1 of the flavonoid database, data were obtained from 308 articles [8]. These articles contain varying amounts of information about the food item and related data. The documentation may include the detailed food description and other information about many, but not all of the factors influencing flavonoid contents listed above. However cultivar and sampling location, though not necessarily growing location, were frequently provided.

The flavonoid compounds which are predominant in three selected foods were studied for the effects of cultivar and growing locations. They were hesperetin (a flavanone) in orange juice, pelargonidin (an anthocyanidin) in strawberries, and quercetin (a flavonol) in onions. The flavonoid content for all foods examined was analyzed by HPLC. The variability of quercetin in onions was examined only in different cultivars. The orange juice values for hesperetin were available from Brazil, France, Italy, Spain and the United States and for navel, pera and valencia cultivars. Pelargonidin values were available from the United States, Brazil and Spain and for Allstar, Honeoye, and Camarosa cultivars. Values for quercetin were available for yellow, red, white, and sweet onion cultivars.

The data were analyzed using SAS 9.2 (SAS Institute, Inc. Cary, NC). Descriptive statistics were used to characterize the data overall and across factors. To identify statistical differences in flavonoids content between factors, ANOVA methods were employed.