Flavonoid Database Based on Indonesian Foods

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(Received June 3, 2019)

Summary
Background and objectives. The prevalence of NCDs (Non-communicable Diseases) was increasing in Indonesia. The antioxidants have been known as a potential nutrient that prevent and reduce the risk of the NCDs. Flavonoid is the most abundant antioxidant in plant-source diet and commonly consumed in Indonesia. In other side, there was not a flavonoid database based on various Indonesian foods. The aim of this study was to build a flavonoid database based on Indonesian foods. Methods. The selected food items used food items of Indonesian Total Diet Survey 2014 (SDT 2014). We did not determine the flavonoids contents in the laboratories, we compiled its content by using the United States Department of Agriculture Database and related references. The estimation for calculating flavonoid content used USDA Database technique. The total flavonoid content for each food items were summarized into six flavonoid subclasses (anthocyanidine, flavan-3-ols, flavanone, flavone, flavonols, dan isoflavone). The total flavonoid content was presented by mg/100 gram of each food items. Results. There were 13 food groups and 1,203 food items in this database. There were 654 food items had flavonoid content. The highest mean of flavonoid content was legumes (45.36 mg/100 g). The vegetables and products were the food group with the most foods containing flavonoid (120 food items). Conclusion. There were 654 food items in Indonesian foods contained flavonoid. The highest mean of flavonoid content were legumes. This findings can provide valuable information for Indonesian people to increase dietary flavonoid intake.

Key Words flavonoid, content, Indonesian food, database, descriptive

Non-communicable diseases (NCDs) were chronic diseases that develop over a long time in adult and elderly people. Types of NCDs that cause death that often occur include coronary heart disease (CHD) (46.4%), cancer (21.7%), hypertension (12.8%) and diabetes (4.0%) (1). According to the Indonesia Basic Healthy Research 2013 (RISKEDESAS 2013), the increase of prevalence from year 2007 compared to 2013 were in diabetes mellitus (DM) from 1.1% to 1.5%, hypertension from 7.6% to 9.4%, and stroke from 6.0 to 7.0‰ (2). A 26% death before the age of 70 (premature deaths) due to NCDs in Indonesia (3).

Lifestyle and unhealthy eating habits were the risk factors that be able to be changed for the prevention of PTM¹. A behaviour potentially reduced NCDs risks was an increase in vegetable and fruit consumption. An increase in one portion/d of vegetable and fruit consumption reduced 4% the risk of CHD (4). The last report showed that the consumption of vegetables and fruits of Indonesian people is still low (5).

Flavonoids represent one of the phytochemical subgroups that widespread in plant and plant products, such as vegetables, fruits, tea and spices (6). Flavonoids are mostly present as glycosides in which one or more sugar groups are bound to phenolic groups by glycosidic linkages. There are for about 11 and 26 classes of flavonoids and over 4,000 compounds. Six classes and 20–30 compounds are especially common in foods and the most consumed subclass of phytoneutrients with beneficial biological effects by its antioxidants properties (7).

Flavonoid potentially improve health status in human body. The research on subjects aged ≥19 y showed that flavonoid intake was able to reduce 41% the risks of cancer, 18% the risks of CHD, 9% the risks of hypertension, 8% the risks of DM, 19% the risks of heart failure, and 10% the risks of stroke (8–13). Recently, meta-analysis of cohort studies showed that high consumption of total flavonoids was associated with decreased risk of all-cause mortality (14, 15). While a 100-mg/d increment in intake led to a (linear) decreased risk of 6% and 4% of all-cause and CVD mortality (14).

The research for assessing the health impact of flavonoids requires a database that provides quantitative information on specific compounds of foods. The Nutrient Data Laboratory (NDL) of U.S. Department of Agriculture have developed a flavonoid database based on USA food items—Iowa State University Database on the Isoflavone Content of Selected Foods in 1999 and the USDA Database for the Flavonoid Content of Selected

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Foods in 2003—. In 2015, the Release 3 of updated database included source documents citing research conducted in the U.S. and also in 50 other countries (16). Andarwulan et al. also developed the flavonoid database for West Java foods (17). Although these are useful tools to estimate flavonoid intake, coverage of foods containing these flavonoids remains incomplete for Indonesian foods. In general, the data from each source were for a limited number of compounds for locally collected samples and cultivars.

Indonesia have 1,340 ethnic in 34 provinces. Natural resources in each region in Indonesia are influenced by their natural conditions. The Research and Development Agency of Health Ministry of Indonesia conducted Survei Konsumsi Makanan Individu/SKMI 2014 (Survey of Individual Food Consumption 2014) in 34 provinces. SKMI 2014 was a part of Total Diet Study 2014 and was the very first national study which described food consumption patterns of Indonesian (5). To study dietary flavonoid intake, particularly in Indonesian populations, we created a flavonoid database using SKMI 2014 food items. To improve the comprehensiveness of flavonoid coverage in foods and beverages, additional sources of literature were reviewed and incorporated into the USDA databases.

**MATERIALS AND METHODS**

Determination of flavonoid content of Indonesian foods in this study used the United States Department of Agriculture (USDA) Database for Flavonoid Content from 3.2 Selected Food Releases in 2015, USDA Database for Isoflavone Content from Selected Food Release 2 in 2008, and other previous studies. The USDA Database for the Flavonoid Content of Selected Foods contains values for five classes of flavonoids: flavonols, flavones, flavanones, flavan-3-ols, and anthocyanidins. Twenty-six individual flavonoids comprise these classes. Values are reported as milligrams per 100 g of fresh weight of edible portion of food (16).

Some values in the USDA Database for Isoflavone Content from Selected Food Release 2 were updated when the Nutrient Data Laboratory (NDL) of U.S. Department of Agriculture received new values for certain foods from the industry or recognized the need for other changes in 2008. Values in the database are reported as mg/100 g of fresh weight of edible portion of food. Values expressed on a dry weight basis were converted to wet weight basis by using either published moisture content or by moisture content. Values for beverages were adjusted by their respective specific gravities and are reported as mg/100 g (18, 19). The total flavonoid content in this present study was the amount of 6 subclasses of flavonoids (anthocyanidins, flavan-3-ols, flavanones, flavones, flavonol, and isoflavones).

Both the SKMI 2014 and the USDA used raw weight as a reference for calculating nutrient intake. Figure 1 illustrates the flow chart of the decision-making procedure.

Some estimation technique was used for this study based on USDA Flavonoid Database were adopted and described below: 1) Flavonoid levels are assumed to be zero, if food is in the form of meat from livestock, poultry, or marine products (without additional ingredients); 2) If a food is not expected to contain a type of flavonoid subclasses, then the level of the subclass of food flavonoids is assumed to be zero; 3) If data on the flavonoid content of a food item cannot be found, then data on other food flavonoid content can be used that have similarities or similarities with these food ingredients; 4) Calculation of the content of flavonoids in different forms (raw/cooked or fresh/dry) of a food using food yield (i.e. weight changes) and retention factor of flavonoids (the retention factor for the anthocyanidine is 80% and the other subclasses is 85%); 5) Yield factor was used to calculate canned foods by adjusting the yield of solid food after removing the liquid part; 6) For composite foods, the estimation of flavonoid content using the percentages of flavonoid-containing ingredients. Food with a proportion of < 5% is assumed not to contribute to the content of food flavonoids (considered to be zero), except for certain ingredients such as cocoa powder, soy protein isolates and soy flour because the levels of flavonoids are quite high; 7) There are certain foods which are assumed to be zero in value, the attachments to the names of these foods are in the USDA Database for Isoflavones Contents of Selected Food Release 2.0 (18, 19).

The selection of food items from the reference adjusted to SKMI 2014. In this process, SKMI 2014 food items in English or its species is translated, for example “green tea” was assumed to be the same as “Beverages, tea, green, brewed, regular” (code 14278 in the USDA database) and “kokosan” was calculated as *Lansium domesticum*. There were 13 food groups from 17 food groups of SKMI 2014 described in this study. The re-
spective groups are cereals and products, tubers and products, legumes, vegetables, fruit and fruit juices, fish-seafood and products, egg and products, dairy products, fats and oils, sweets, spices, beverages and composite foods.

For food items that included into multi-ingredients food, especially composite foods, we used previous flavonoid database by Andarwulan et. al. (2016). Their study was conducted in Bandung and Bogor, it represented the flavonoid content of West Java foods. Their database used the standard recipe to determine food item components of each dish. Furthermore, in this paper we called it with “Previous Flavonoid Database”.

In addition, we also used the scientific journals for certain SKMI 2014 food items which was not included in USDA Flavonoid Database or the selection of scientific journals was chosen based on their flavonoid analysis methods. They used the USDA Flavonoid Database analysis methods. The USDA Flavonoid Database does not use the results of research using thin layer/paper chromatography, radioimmunoassay, pH differential methods, and spectrophotometric quantitation. We only use data from analytical studies that used acceptable procedures defined as those which lead to good separation of flavonoid compounds, such as column chromatography or high-performance liquid chromatography. This was to avoid differences in content due to the diversity of the results of calculating the content. Zero values that reported in the database indicated that analysis attempted to measure the compound/s in that food and did not find it and reported as not detected. All analyses were conducted by using Ms. Excel 2016 and SPSS version 16.

**RESULTS**

This present study covered 1,203 food items from 13 food groups (Table 1). It was more than Previous Flavonoid Database (18). There were 549 food items (46.0%) did not contain flavonoids. From this number, only 50 food items were unknown values. There were 4 food groups of SKMI 2014 that not include in this database. They were water, meat, offals and supplements.

Comparing with the number of food items in the food groups, the highest number of food groups containing flavonoids was the vegetables (Table 1). Meanwhile, the food group containing the lowest amount of flavonoids was egg and products. The food group based on fish, egg and processed foods was still recorded to contain flavonoids, this is caused by the content of other ingredients flavonoids or spices added to these animal-based foods.

We found that legumes was the food group with the highest mean of flavonoid content, 45.36 mg/100 g (Table 2). The second one is vegetables with 38.41 mg/100 g.
Table 3 were an overview of some foods items with high flavonoids content. They were also the food items that commonly consumed by Indonesian people. Table 3 also showed that the vegetables that easily to be found in every district, “köl merah kol putih”, have high content of flavonoid, 210.6 mg/100 g of fresh weight.

**DISCUSSION**

The content of total flavonoids in each food group was based on the composition of flavonoids the subclasses that composed. There were at least one of flavonoids subclasses dominated and became a specific character of flavonoids which was often found in species the food. For example, in the group of vegetables, the flavonoids subclasses that are often found was flavonol (20).

The content of flavonol in food groups for fish and poultry products are found in the most amount high among other sub-classes, due to some spices were added to animal-based foods during the processing. In the legumes, the flavonoids subclass that dominant was isoflavones. The egg and products only contains flavonoids from the sub-class of isoflavones. The flavonoids subclasses which was often found in cereals and products were isoflavones, flavonols and flavones; as well as food, spices and spices oil. In the group of fruits and fruit juices, the sub-class of flavonoids are found in the highest number are flavonone and anthocyanidin, while at the beverage group is dominated by the anthocyanidin sub class. Besides anthocyanidin, at the beverage group was also found to contain catechins (flavonoids included in this) sub class of flavonol) which is widely contained by drinks such as tea and coffee (21).

The accumulation of analytic data on the expansion of flavonoid databases has facilitated the comprehensive studies in relation to health and disease (22). Flavonoids are antioxidants and thus may reduce the oxidation of LDL cholesterol. Epidemiologic data suggest that dietary flavonoids may have beneficial cardiovascular effects in human populations (8).

The potential of flavonoid intake for preventing and reducing the risk of NCD was still controversial. Zamora-Ros et al. found that subject consumed vegetables 217.7 g/d and fruits 281.7 g/d had median of total flavonoid intake 199.6 mg/d (IQR: 128.9–298.4 mg/d). They potentially reduced 41% colorectal cancer of the subjects. This study used case-control design with total of subjects 825 (424 cases with incident colorectal cancer and 401 hospital-based controls) (23). A 14 y of cohort study also provide the evidence of flavonoid in NCDs prevention, with 8% reduction risk of hypertension. Inversely, meta-analysis studies showed that there was not significant association between total flavonoid intake with gastric cancer and breast cancer (24, 25). Oxidative stress is a situation when there is a significant imbalance between free radicals and the antioxidant defense system. It will develope oxidative damage that occurs to DNA, proteins, lipids and small molecules in the living system, then damage body’s tissue. At this point, flavonoids have beneficial effect as anti-oxidant, anti-inflammatory, and anti-cancer. Flavonoids are free-radical scavenger that neutralizes free-radical in the human body. In addition, flavonoids were found as a phytochemical that repairing DNA due to free radical, and inhibit cancer cell proliferation (26). The molecular mechanisms of flavonoid may underlie their abilities to be linked to modulate enzyme activity (kinases, phospholipases, ATPases, lipo-oxygenases, cyclo-oxygenases) (27).

Flavonoids are polyphenolic compounds with a C6-C3-C6 backbone. They can be subdivided into five structural categories: flavones, flavonols, flavanones, flavan-3-ols (catechins), and anthocyanidins. These compounds (aglycones) are commonly glycosylated (at one or more sites with a variety of sugars) and may also be alkoxylated or esterified. As a result, over 5,000 different flavonoids have been identified in plant materials (28).

The lack of comprehensive data is due to the large number of foods that contain flavonoids, the large number of glycosylated flavonoids, and the lack of analytical standards for most of these glycosylated compounds.
Total flavonoid content of all databases be able to be various, because “total flavonoids” will vary depending on the number of compounds quantified, and data sources used. several factors such as geography, cultivar, climate, agricultural techniques, processing and storage can affect variations in the content of flavonoids in food. Flavonoid estimation will also differ because of true differences in dietary habits across populations (20).

In summary, this study as the first step toward generating data of flavonoid content for various Indonesian foods. These descriptive data provide a platform to further investigate the role of flavonoid, for either reducing or preventing NCDs’s risks.

Disclosure of state of COI
No conflicts of interest to be declared.

Acknowledgments
The authors thank to National Institute of Health Research and Development, Health Ministry of Indonesia that conducted SKMI 2014.

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