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Research Article

Comparison of dietary phytochemical intake in adults using different assessment methods

Arife DEMİR[1], **Ayşe Nur KAHVE**[2], **Ebru BAYRAK**[1]

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[1] Selçuk University, Faculty of Health Sciences, Department of Nutrition and Dietetics, Konya, Türkiye

[2] Aksaray University, Project Support Office Coordination, Aksaray, Türkiye

ORCID IDs of the authors:
A.D. 0000-0002-6348-5282
A.N.K. 0000-0001-6960-7204
E.B. 0000-0001-7279-3255

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Correspondence:
Ebru BAYRAK
E-mail: ebayrak@selcuk.edu.tr

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ABSTRACT

This study aims to systematically compare the amount of dietary phytochemicals in adults aged 20-65 years using different calculation methods and dietary assessment tools. Data were collected from a total of 430 individuals using a 24-hour dietary recall and food frequency questionnaire; phytochemical intake was calculated using the USDA, Phenol-Explorer, and Phytochemical Index methods. The findings showed significant and statistically significant differences between the methods and assessment tools ($p<0.001$). The PE method systematically produced higher estimates, while the FI method produced lower estimates, and a very high method × tool interaction was detected. These results highlight the crucial role of methodological choice in estimating phytochemical intake and emphasize that the lack of standardization in inter-study comparisons is a significant limitation. The use of multiple methods and ensuring methodological consistency are critical for future research.

Keywords: Dietary phytochemicals, Phytochemical index, Phenol-Explorer, Diet assessment methods

Introduction

Phytochemicals are naturally occurring bioactive compounds found in plant-based foods such as fruits, vegetables, whole grains, legumes, nuts, and herbs (Liu, 2004). Previously thought to have toxic effects and referred to as anti-nutrients, phytochemicals have later been recognized for their potential health-promoting properties owing to advancements in analytical methods (Leitzmann, 2016). According to Verpoorte (2000), approximately 15% of 250,000 plant species have been studied for their phytochemical properties. Within phytochemicals, 21,000 alkaloids, 22,000 terpenoids, and tens of thousands of different secondary metabolites such as 5,000 flavonoids and tannins have been identified. The chemical structure of these metabolites shows genetic diversity and also varies in quality and quantity within species (Kroymann, 2011). The physicochemical properties of these phytochemicals, extracted from plant roots or extracts, have also been investigated, and a large majority, approximately 11%, of the 252 essential medicines listed by the World Health Organization (WHO) have been used in pharmaceutical chemistry (Ahmad & Ahamad, 2020).

Studies have shown that phytochemicals inhibit ATP synthesis, alter the activation of transcription factors, play a role in the activity of many genes and enzymes, exhibit antioxidant and anti-inflammatory effects, suppress adipocyte proliferation, activate the transient receptor potential (TRP) channel to affect neurological diseases, have neuroprotective, antihypertensive, and anti-aging effects, and prevent carcinogenesis through their antiproliferative effect (Premkumar, 2014; Rodriguez-Casado, 2016; Goktas et al., 2020; Guan et al., 2021). Well-characterized or uncharacterized phytochemicals have shown significant effects against many diseases in scientific research, including dose-response relationships. However, determining and evaluating daily intake of phytochemicals is difficult due to their presence in many foods, their as-yet-undefined chemical structures, their varying amounts depending on many factors of the same type, and their bioavailability (Tsao & Deng, 2004; Probst et al., 2017). Researchers in nutritional science are interested in determining recommended intake amounts for phytochemicals. Increasing awareness of phytochemicals may help promote fruit and vegetable consumption and support the development of nutritional guidelines and food products by nutrition companies (Wallace et al., 2015).

To assess dietary intake of phytochemicals, databases such as the Phytochemical Index (PI), the United States Department of Agriculture (USDA) database, and the Phenol-Explorer (PE) database have been developed. If an untargeted analysis of a sample allows the identification of a novel compound with a sufficiently reliable score, it is added to the database (Savoi et al., 2021). The two major databases used for the analysis of dietary phytochemicals are the PE and USDA databases (La Barbera et al., 2017; Probst et al., 2018). To examine the dietary intake of phytochemicals in the general population or their effects on diet and health, average intake data obtained through Food Frequency Questionnaire (FFQ), 24-hour Dietary Recall (24-h DR), or food consumption record are required (Thompson & Subar, 2017). Following this dietary assessment, the phytochemical values of selected foods are examined in databases. However, the limitations of dietary assessment methods, along with the inadequate documentation of region-specific foods or the lack of equivalent matches in databases, may lead to differences in analysis results. Therefore, analyzing data in countries that do not have their own databases is difficult (Probst et al., 2018).

The first and still leading comprehensive database for phytochemicals is Phenol-explorer 3.6. Last updated in 2015, it contains over 35,000 entries for 500 different polyphenols in more than 400 foods. Including over 60,000 publications, this database critically reviews publications before inclusion and utilizes reliable analyses such as high-performance liquid chromatography (HPLC) (Neveu et al., 2010; Huang et al., 2020).

This study aimed to calculate the dietary phytochemical intake of adults aged 20-65 years using the PI, PE, and USDA-FDB, and to compare this intake with two different dietary assessment tools: a food frequency questionnaire and a 24-hour dietary recall.

Materials and Methods

Study Design

This study is a descriptive study aimed at evaluating the dietary phytochemical intake of adults aged 20-65 years using phytochemical indices and databases. The study population consisted of adults between the ages of 20 and 65 years living in the city center of Konya. The inclusion criteria of the study were being literate, willing to communicate, and being between the ages of 20 and 65 years. The exclusion criteria included having chronic liver and/or kidney disease, mental or psychiatric disorders, cancer, genetic diseases, malabsorption disorders, following a special diet or an ongoing weight-loss program, and being pregnant or lactating.

Power Analysis and Analysis of Variance (ANOVA) were applied to determine the sample size. The parameters entered into the G*Power 3.1.9.2 program were an effect size of 0.15 (medium effect size according to Cohen (2013), a significance level (α) of 0.05, and a statistical power ($1-\beta$) of 0.95. Based

on these parameters, the required sample size was calculated as 430 participants. The independent variables of the study were: age, gender, height, body weight, education level, food supplement use, diet status of the participating adults, and the USDA flavonoid database, Phenol-explorer database, and phytochemical index to be used in the research. The dependent variable in this study was the dietary phytochemical intake of adults. Inclusion criteria for this study included literacy, openness to communication, and being between 20 and 65 years of age. Exclusion criteria included individuals with chronic liver and/or kidney disease, mental and psychiatric illnesses, cancer patients, those following a special diet, those undergoing an ongoing weight loss program, those with genetic diseases, those with malabsorption disorders, and pregnant and breastfeeding individuals.

Data Collection Tools

Individuals who voluntarily participated in the study were interviewed face-to-face. A questionnaire prepared based on a literature review included socio-demographic characteristics, health information, and dietary habits, and a food consumption frequency questionnaire was used to calculate the dietary phytochemical content, along with a 24-hour dietary recall.

Participants' dietary phytochemical intake was calculated using three different methods: USDA, PE, and FI. The demographic information section of the questionnaire included general information about individuals such as age, gender, education level, monthly income, height and weight, chronic disease status, medication, supplement, smoking, alcohol use, and exercise status. The nutritional habits section of the questionnaire included questions about the number of meals, skipping meals, and water consumption. Anthropometric measurements of the participants were based on their own statements. Body Mass Index (BMI) was calculated using anthropometric measurements. BMI was calculated and classified by dividing body weight by the square of height (kg/m²).

24-hour Dietary Recall (24-h DR)

A food consumption record form was collected using a 24-hour reminder method to assess individuals' food consumption status (TBSA, 2019). Data obtained from a one-day food consumption record form were used to determine the intake of macro- and micronutrients using the Computer-Assisted Nutrition Program, Nutrition Information Systems Package Program (BeBIS 8.2) developed for Turkey (BeBIS, 2011). Each food item consumed according to standard recipes was analyzed, and its consumption amount was determined. The consumption amounts of the foods were entered into a dataset created in Excel to calculate the total daily phytochemical consumption.

Food Frequency Questionnaire (FFQ)

A 58-item food consumption frequency questionnaire was created by reviewing the literature and including portion sizes for frequency and quantity analysis, consisting of some foods and classified food groups such as fruits, vegetables, legumes, nuts, grains, spices, milk, eggs, and beverages (Sun et al., 2014; Burkholder-Cooley et al., 2016; Amiot et al., 2021; Ajabnoor et al., 2024).

In evaluating the frequency of food consumption, a scoring system was used based on the following formula:

Σ P n × F n × G n × S n (P = amount of phenolic compounds in 100 g of food (mg), F = Frequency factor, a multiplier reflecting the frequency of intake (every day = 1, 2-3 times a week = 0.35, once a week = 0.14, every two weeks = 0.07 and once a month = 0.035), G = standard portion size of the food (g) and S = reported portions of the food) (Burkholder-Cooley et al., 2016; Ivey et al., 2016; Amiot et al., 2021).

USDA Flavonoid Database (USDA-FDB)

In this study, the data obtained from dietary assessment tools were entered into relevant databases. The USDA flavonoid database (Release 3.3) includes five subclasses: flavanols (monomers and flavanol-derived compounds), flavanones, flavones, flavonols, and anthocyanidins, and covers 506 food items. The flavonoid content of foods (mg) was obtained from the database file titled "USDA Database for the Flavonoid Content of Selected Foods, Release 3.3."

The USDA database includes only data generated using chromatographic methods and reports flavonoids in their aglycone forms. Mean values in the database are expressed as mg per 100 g of the edible portion on a fresh weight basis. Tea values are reported as mg per 100 g (100 mL) of tea infusion, which is equivalent to one gram of dry tea.

In the USDA flavonoid database, the data for each compound were evaluated for quality using procedures referred to as the Data Quality Evaluation System (DQES), and a confidence code was assigned as an indicator of data quality and the reliability of a given mean value.

Phenol Explorer 3.6 (PE)

To more accurately compare polyphenol content data obtained from Phenol Explorer with USDA data, high-performance liquid chromatography (HPLC) data were used (Witkowska et al., 2015; Lanuza et al., 2022; Siprelle et al., 2024). For data obtained with Phenol-Explorer, retention factors (RFs) were used to convert the polyphenol content in raw foods to that found in processed foods. The polyphenol content in raw food was multiplied by the appropriate RF for culinary techniques

such as boiling, frying, or baking. These polyphenol RFs are applied in the Phenol-Explorer database (Neveu et al., 2010; Huang et al., 2020). Intake values were determined by multiplying the daily consumption of individual food items by their polyphenol/flavonoid content (Neveu et al., 2010; Huang et al., 2020). The total flavonoid content of the food item is expressed as the total conjugated form.

Dietary Phytochemical Index (PI)

Daily intake of all food items in the data obtained from the food consumption frequency questionnaire and the 24-hour dietary recall method was converted to grams and calculated according to the method developed by McCarty (2004).

$$PI = \frac{\text{Energy intake from phytochemical rich foods (kcal)}}{Total\ daily\ energy\ intake\ (kcal)} \text{ x } 100$$

This equation includes phytochemically rich foods such as whole grains, fruits and vegetables, nuts and seeds, legumes, soy products, and olives and olive oil. Potatoes were not included due to their low phytochemical content. Natural fruit and vegetable juices and tomato sauce were considered due to their high phytochemical content.

Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics 27.0. Socio-demographic characteristics and dietary habits were presented as frequency (n) and percentage (%), while continuous variables were expressed as mean ± standard deviation (Mean ± SD) or median (Min–Max), depending on data distribution.

Normality was assessed using skewness and kurtosis coefficients, and values within the acceptable range proposed by Kline (2023) were considered normally distributed. For normally distributed data, independent samples t-test and one-way ANOVA were used for group comparisons, followed by Duncan or Tamhane T2 post hoc tests according to variance homogeneity. For non-normally distributed data, Mann–Whitney U and Kruskal–Wallis H tests were applied, with Dunn's test and Bonferroni correction used for post hoc analyses.

Correlations between FFQ and 24-h DR data obtained from USDA-FDB, PE, and PI methods were evaluated using Pearson or Spearman correlation analyses according to data distribution. Comparisons among phytochemical assessment methods were performed using repeated-measures ANOVA or the Friedman test. Additionally, MANOVA was conducted to evaluate the combined effects of phytochemical assessment methods and dietary assessment tools, using Pillai's Trace statistic. Statistical significance was accepted as $p<0.05$.

Results and Discussion

In the study, which included a total of 430 individuals, 76.5% of the participants were women, and the average age was found to be 35.05 ±12.43 years. 56.0% of the participants were single, 48.6% were high school graduates, and 54.7% had an income above the minimum wage. Regarding lifestyle habits, 23.7% smoked, 2.6% consumed alcohol, 21.4% engaged in regular physical activity, and 19.3% used supplements. Anthropometric measurements showed that the average height, weight, and BMI for women were 162.43 ±6.42 cm, 73.48 ±13.78 kg, and 28.01 ±5.85 kg/m², respectively; while for men they were 176.36 ±5.54 cm, 91.67 ±13.39 kg, and 29.43 ±3.73 kg/m², respectively (Table 1).

Most individuals consume an average of three meals a day. Skipping meals was observed in 51.9% of participants, with women (52%) skipping meals more frequently than men (51.5%). The most commonly skipped meals were breakfast (40.4%) and lunch (38.1%). The most common reasons for skipping meals were lack of time (48.4%) and habit (44.4%). Only 1.9% of participants reported following a diet, with intermittent fasting being the most common diet at 75%. Daily water consumption was approximately 6 glasses, with a significant difference between male and female participants ($p=0.044$). Disease prevalence was higher in women than men ($p=0.023$), and a significant difference was found between genders in terms of disease types ($p<0.001$). Supplement use was higher in women ($p<0.001$), while no significant difference was found between genders in terms of diet and medication use (Table 2). In the present study, disease prevalence and supplement use were significantly higher among women than men, whereas no significant sex difference was observed in diet and medication use. These findings are consistent with previous studies reporting that dietary supplement use is more common among women than men (Stierman et al., 2026; Mishra et al., 2021). Meal skipping was also common in the present study, particularly breakfast and lunch. Previous evidence has shown that breakfast is the most frequently skipped meal and that lack of time is an important reason for meal skipping among adults (Pendergast et al., 2016). Overall, these findings suggest that sex-related differences in dietary habits and lifestyle characteristics should be considered when evaluating dietary phytochemical intake patterns.

When 24-h DR values were examined according to participants' sociodemographic characteristics and lifestyle habits, only PI-24-h DR values were found to be significantly higher in males compared to females ($p<0.001$). According to marital status, married individuals had significantly higher USDA-FDB-24-h DR and PE-24-h DR values than single individuals

($p<0.05$). A significant difference was observed among occupational groups in terms of PE-24-h DR values ($p=0.005$), whereas no significant differences were found according to education level or income status. Individuals who smoked had higher PI-24-h DR values ($p=0.010$), while those who engaged in regular physical activity had significantly lower USDA-FDB-24-h DR, PE-24-h DR, and PI-24-h DR values ($p<0.05$). Additionally, PI-24-h DR values were significantly lower in individuals who followed a diet compared to those who did not ($p=0.006$). No significant differences were observed according to other variables (Table 3). Previous studies evaluating phytochemical intake using PI, USDA-FDB, and PE databases have reported inconsistent findings according to sex and demographic characteristics. In a study conducted in Korea, PI values calculated from dietary records (24-h DR) were found to be significantly higher in older adults and women (Jo & Park, 2022). Similarly, Salehi-Sahlabadi et al. (2022) reported higher PI scores among women, whereas Tirani et al. (2024) found no significant differences according to age and sex distribution. In studies conducted in the United States and the United Kingdom, dietary polyphenol intake assessed using USDA-FDB and PE databases was reported to be higher in women (Ziauddeen et al., 2019; Huang et al., 2020). However, consistent with the present study, the EPIC study reported no significant sex differences in total polyphenol intake assessed using 24-h DR in combination with PE and USDA-FDB databases (Zamora-Ros et al., 2016) n another study conducted in the United Kingdom, total polyphenol intake assessed using 24-h DR together with USDA-FDB and PE databases was higher among overweight/obese women who followed healthy eating recommendations and consumed at least 25 g/day of dietary fiber compared to women who did not follow a diet and had lower physical activity levels (Huang et al., 2020). These inconsistencies suggest that phytochemical intake estimates may vary depending on the dietary assessment method, database characteristics, and population structure.

When food frequency questionnaire (FFQ) values were examined according to participants' demographic characteristics, only USDA-FDB-FFQ values were found to be significantly higher in women compared to men ($p=0.003$). According to marital status, married individuals had significantly higher USDA-FDB-FFQ and PE-FFQ values than single individuals ($p<0.01$). Significant differences in USDA-FDB-FFQ values were observed according to education level and occupational groups ($p<0.01$), while PI-FFQ values differed significantly according to education level ($p=0.003$). No significant differences were found according to income status ($p>0.05$).

Table 1. Sociodemographic characteristics of the participants (n = 430).

Variable	Subgroup	n (%)
Gender	Female	329 (76.5)
	Male	101 (23.4)
Marital Status	Single	189 (56.0)
	Married	241 (44.0)
Education Level	Primary School	39 (9.1)
	Middle School	44 (10.2)
	High School	209 (48.6)
	Associate/ Bachelor's Degree	106 (24.7)
	Master's Degree	32 (7.4)
Occupation	Housewife	132 (30.7)
	Civil Servant	46 (10.7)
	Self-Employed	48 (11.2)
	Other	204 (47.4)
Income Status	Below Minimum Wage	99 (23.0)
	Minimum Wage	96 (22.3)
	Above Minimum Wage	235 (54.7)
Age (year) ± SD	35.05 ± 12.43	
Lifestyle Habits		
Smoking Status	Yes	102 (23.7)
	No	328 (76.3)
Alcohol Consumption	Yes	11 (2.6)
	No	419 (97.4)
Physical Activity Status	Yes	92 (21.4)
	No	338 (78.6)
Supplement Use Status	Yes	83 (19.3)
	No	347 (80.7)
Anthropometric Measurements	**X ± SD**	
Height (cm)	Female (n=329)	162.43 ±6.42
	Male (n=101)	176.36 ±5.54
Body Weight (kg)	Female (n=329)	73.48 ±13.78
	Male (n=101)	91.67 ±13.39
BMI (kg/m²)	Female (n=329)	28.01 ±5.85
	Male (n=101)	29.43 ±3.73

Table 2. Meal Patterns and Dieting Status of the Participants

		Female (n=329) n (%)	Male (n=101) n (%)	Total (n=430) n (%)	x^2/t	p
Number of Meals		3.36 ±0.939	3.08 ±0.891	3.29 ±0.935	t=-2.797	**0.005***
Meal Skipping	Yes	171 (52.0)	52 (51.5)	223 (51.9)	0.007	0.931
	No	158 (48.0)	49 (48.5)	207 (48.1)		
Most Frequently Skipped Meal (n=223)	Breakfast	67 (39.4)	23 (43.4)	90 (40.4)	16.346	**0.006***
	Mid-morning Snack	16 (9.4)	6 (11.3)	22 (9.9)		
	Lunch	72 (42.4)	13 (24.5)	85 (38.1)		
	Afternoon Snack	13 (7.6)	5 (9.4)	18 (8.1)		
	Dinner	1 (0.6)	5 (9.4)	6 (2.7)		
	Late-night Snack	1 (0.6)	1 (1.6)	2 (0.9)		
Reason for Skipping Meals	Lack of Time	87 (51.2)	21 (39.6)	108 (48.4)	14.562	**0.002***
	Habit	75 (44.1)	24 (45.3)	99 (44.4)		
	For Weight Loss	-	4 (7.5)	4 (1.8)		
	Other	8 (4.7)	4 (7.5)	12 (5.4)		
Dieting Status	Yes	7 (2.1	1 (1.0)	8 (1.9)	0.548	0.459
	No	322 (97.9)	100 (99.0)	422 (98.1)		
Type of Diet Followed (n=8)	Weight Gain	2 (28.6)	-	2 (25.0)	0.381	0.537
	Intermittent Fasting	5 (71.4)	1 (100.0)	6 (75.0)		
Water Intake (number of glasses) (SD)		6.24 ±3.130	5.66 ±3.296	6.11 ±3.176	t= -2.017	**0.044***
Presence of Disease	Yes	69 (21.0)	11 (10.9)	80 (18.6)	5.187	**0.023***
	No	260 (79.0)	90(89.1)	350 (81.4)		
Disease	Diabetes	12 (17.4)	6 (54.5)	18 (22.5)	24.996	**0.000***
	Hypertension	8 (11.6)	2 (18.2)	10 (12.5)		
	Cardiovascular Diseases	13 (18.8)	-	13 (16.3)		
	Obesity	8 (11.6)	-	8 (10.0)		
	Gastrointestinal Diseases	12 (17.4)	1 (9.1)	13 (16.3)		
	Respiratory Diseases	-	2 (18.2)	2 (2.5)		
	Other	16 (23.2)	-	16 (20.0)		
Medication Use	Yes	21 (6.4)	7 (6.9)	28 (6.5)	0.038	0.845
	No	308 (93.6)	94 (93.1)	402 (93.5)		
Supplement Use	Yes	76(23.1)	7 (6.9)	83 (19.3)	12.971	**0.000***
	No	253(76.9)	94 (93.1)	347 (80.7)		

Table 3. Comparison of dietary records across USDA-FDB, PE, and PI methods according to participants' demographic characteristics

Variable	USDA- 24-h DR Descriptive statistics	PE-24-h DR Descriptive statistics	Fİ- 24-h DR Descriptive statistics
Female	230.7 ±301.65	328.54 (0 - 2223.79)	74.22 ±31.35
Male	201.58 ±245.84	319.01 (33.24 - 2486.94)	93.02 ±38.39
Test Statistic, p-value	0.884, 0.377[t]	-1.028, 0.304[m]	-4.483, **<0.001**[t]
Marital Status			
Married	109.06 (0 - 1582.24)	372.97 (0 - 2223.79)	80.35 ±33.37
Single	79.27 (0 - 1983.69)	282.15 (0 - 2486.94)	76.46 ±34.84
Test ist., p	-2.435, **0.015**[m]	-3.420, **0.001**[m]	1.177, 0.240[t]
Education Level			
Primary School	124.04 (0.11 - 1049.42)	445.05 (79.48 - 1301.67)	89.22 ±41.11
Middle School	86.52 (0 - 1241.86)	297.69 (0 - 1136.6)	77.38 ±27.22
High School	79.27 (0 - 1238.78)	346.61 (0 - 1569.62)	78.39 ±34.56
Associate /Bachelor's Degree	89.83 (0 - 1983.69)	313.53 (0 - 2486.94)	76.94 ±33.91
Master's Degree	96.16 (3.81 - 1551.31)	295.26 (2.85 - 1948.12)	74.68 ±29.23
Test Statistic, p-value	3.281, 0.512[h]	6.279, 0.179[h]	1.137, 0.339[f]
Occupation			
Housewife	98.55 (0 - 1582.24)	491.51 ±375.54[a]	79.41 ±33.83
Civil Servant	139.91 (0 - 868.68)	502.01 ±444.13[a]	82.81 ± 7.67
Self-Employed	120.28 (0 - 978.64)	472.49 ±363.19[ab]	87.58 ±38.69
Other	72.24 (1.5 - 1983.69)	368.28 ±308.49[b]	75.09 ±31.83
Test Statistic, p-value	6.159, 0.104[h]	4.297, **0.005**[f]	2.112, 0.098[f]
Income Status			
Below Minimum Wage	225.1 ±312.05	432.78 ±362.18	72.61 ±29.49
Minimum Wage	291.37 ±348.91	471.78 ±365.42	77.26 ±31.4
Above Minimum Wage	195.76 ±246.54	415.51 ±350.29	81.74 ±36.52
Test Statistic, p-value	3.054, 0.051[f]	0.849, 0.428[f]	2.903, 0.057[f]
Smoking Status			
Yes	203.14 ±240.3	459.01 ±394.71	86.18 ±37.77
No	230.3 ±303.22	423.67 ± 343.74	76.29 ±32.5
Test Statistic, p-value	-0.827, 0.409[t]	0.875, 0.382[t]	2.580, **0.010**[t]
Alcohol Consumption			
Yes	246.84 ±221.22	460.38 ±312.39	89 ±42.51
No	223.26 ± 291.26	431.31 ±357.71	78.36 ±33.81
Test Statistic, p-value	0.266, 0.790[t]	0.267, 0.790[t]	1.023, 0.307[t]
Physical Activity Status			
Yes	154.16 ±219.37	280.2 (0 - 2486.94)	71.3 ± 33.34
No	242.83 ±303.33	350.59 (0 - 2223.79)	80.63 ± 34
Test Statistic, p-value	-3.145, **0.002**[t]	-2.427, **0.015**[m]	-2.344, **0.020**[t]
Disease Status			
Yes	255.19 ±304.66	453.33 ±335.43	80.5 ±36.76
No	216.7 ±285.89	427.18 ±361.22	78.21 ±33.43
Test Statistic, p-value	1.073, 0.284[t]	0.592, 0.554[t]	0.543, 0.587[t]
Disease Type			
Diabetes	67.34 (5.39 - 1050.37)	237.18 (94.29 - 1468.69)	94.76 (43.83 - 157.03)
Hypertension	107.18 (14.39 - 1049.42)	350.39 (93.94 - 1124.29)	71.88 (34.87 - 213.4)
Cardiovascular Diseases	180.57 (0 - 1241.86)	491.88 (0 - 949.27)	72.81 (12.76 - 115.67)
Obesity	161.75 (13.83 - 779.77)	371.35 (70.14 - 1015.68)	76.16 (42.96 - 120.48)
Gastrointestinal Diseases	79.45 (1.62 - 614.04)	321.79 (111.55 - 679.63)	75.84 (28.4 - 108.34)
Respiratory Diseases	124.15 (124.04 - 124.26)	769.5 (237.32 - 1301.67)	99.71 (34.94 - 164.48)
Other Diseases	199.95 (16.58 - 959.95)	457.29 (107.59 - 1322.55)	74.14 (35.84 - 221.79)
Test Statistic, p-value	4.097, 0.664[h]	5.266, 0.510[h]	5.017, 0.542[h]
Medication Use			
Yes	255.25 ±302.4	440.84 ± 299.32	86.29 ± 38.49
No	221.67 ±288.84	431.44 ± 360.27	78.1 ± 33.69
Test Statistic, p-value	0.593, 0.554[t]	0.135, 0.893[t]	1.232, 0.281[t]
Supplement Use			
Yes	223.61 ±307.93	465.51 ± 391.64	73.54 ± 31.15
No	223.92 ±285.38	424.05 ± 347.48	79.86 ± 34.62
Test Statistic, p-value	-0.009, 0.993[t]	0.952, 0.341[t]	-1.521, 0.129[t]
Skipping Meals			
Yes	229.31 ± 292.87	409.45 ± 319.29	77.09 ± 32.75
No	217.98 ± 286.42	456.39 ± 391.66	80.3 ± 35.38
Test Statistic, p-value	0.405, 0.686[t]	-1.366, 0.173[t]	-0.976, 0.329[t]
Most Frequently Skipped Meal			
Breakfast	93.2 (3.81 - 1983.69)	315.72 (33.24 - 1858.83)	77.02 (1.2 - 213.4)
Mid-Morning Snack	56.48 (3.2 - 778.21)	269.26 (43.67 - 1010.19)	87.92 (28.4 - 131.24)
Lunch	92.67 (0 - 1241.86)	369.55 (0 - 1540.93)	72.64 (12.76 - 185.06)
Afternoon Snack	106.86 (1.5 - 644.3)	344.42 (37.99 - 782.49)	64.65 (30.7 - 138.28)
Dinner	18.72 (3.78 - 421.97)	282.55 (43.31 - 522.71)	56.4 (32.69 - 90.01)
Late-night Snack	353.26 (155.8 - 550.73)	645.62 (606.26 - 684.98)	72.75 (48.52 - 96.99)
Test Statistic, p-value	5.086, 0.405[h]	5.432, 0.365[h]	6.857, 0.231[h]
Reason for Skip-ping Meals			
Lack of Time	212.49 ±270.78	403.87 ±328.41	76.29 ±34.71
Habit	246.23 ±322.11	437.98 ±336.42	78.09 ±31.15
Weight Loss	200.09 ±301.81	389.9 ±314.39	92.07 ±18.22
Other	310.47 ± 57.27	460.88 ±278.41	73.79 ±31.42
Test Statistic, p-value	0.534, 0.660[f]	0.255, 0.858[f]	0.369, 0.776[f]
Dieting Status			
Yes	365.13 ±381.5	657.24 ±512.86	45.65 ±23.36
No	221.18 ±287.39	427.78 ±352.17	79.26 ±33.92

Test Statistic, p-value	1.395, 0.164[t]	1.809, 0.071[t]	-2.789, **0.006**[t]

t: Independent samples t-test; f: One-way ANOVA; m: Mann–Whitney U test; h: Kruskal–Wallis H test; a–b: Groups sharing the same letter are not significantly different (Duncan test); Normally distributed variables are presented as mean ± standard deviation, whereas non-normally distributed variables are presented as median (minimum–maximum).

Previous studies evaluating dietary polyphenol and phytochemical intake according to demographic characteristics have reported inconsistent findings. A population-based study using the PE database reported higher polyphenol intake in individuals with lower education levels and smokers (Miranda et al., 2016). In contrast, Karam et al. (2018) found higher polyphenol intake among individuals with higher income and education levels and those who were physically active. Similarly, Wisnuwardani et al. (2019) reported significantly higher intake among adolescents whose fathers had higher education levels and who consumed alcohol. In another study, smoking and alcohol consumption were negatively associated with phytochemical index levels (Im et al., 2020), which was partially consistent with the present findings regarding smoking behavior. In contrast, Delshad Aghdam et al. (2021) found no significant associations between demographic characteristics, lifestyle factors, and dietary phytochemical index scores. These inconsistencies across studies may be related to differences in study populations, dietary assessment tools, and phytochemical calculation methods.

Individuals who smoked had lower USDA-FDB-FFQ and PE-FFQ values (p=0.010), while those who engaged in regular physical activity had lower USDA-FDB-FFQ values (p=0.001). Participants who skipped meals exhibited lower USDA-FDB-FFQ and PE-FFQ values, but higher PI-FFQ values ($p<0.05$). Additionally, individuals who followed a diet had significantly lower USDA-FDB-FFQ and PI-FFQ values compared to those who did not ($p<0.001$). No significant differences were observed according to other variables ($p>0.05$) (Table 4). The associations observed between lifestyle-related factors and FFQ-based phytochemical intake in the present study were partially consistent with previous findings. Previous studies have reported that smoking and unhealthy lifestyle behaviors may be associated with lower phytochemical intake, whereas physically active individuals tend to exhibit healthier dietary patterns and higher consumption of phytochemical-rich foods (Im et al., 2020; Karam et al., 2018). However, inconsistent findings across studies indicate that these associations may vary depending on the dietary assessment tool and characteristics of the study population.

Table 4. Comparison of Food Frequency (FFQ) Data Across USDA-FDB, PE, and PI Methods by Participants' Demographic Characteristics

Variable	USDA- FFQ Descriptive statistics	PE-FFQ Descriptive statistics	Fİ- FFQ Descriptive statistics
Female	724.21 ± 345.27	1437.46 (252.49 -14653.23)	82.26 ±8.69
Male	610.26 ± 308.22	1240.81 (329.42 -14653.23)	83.96 ±8.15
Test Statistic, p-value	2.973, **0.003**[t]	-1.663, 0.096[m]	-1.749, 0.081[t]
Marital Status			
Married	798.30 ±329.46	1457.09 (460.50- 14653.23)	82.6 ±8.72
Single	568.83 ±309.23	1240.81 (252.49- 14653.23)	82.73 ±8.44
Test ist., p	7.364, **<0.001**[t]	-3.481, **0.001**[m]	-0.149, 0.882[t]
Education Level			
Primary School	810.13 ±353.30[c]	1579.57 (675.98 -14653.23)	82.87 ±8.42[ab]
Middle School	968.92 ±382.23[b]	1690.49 (565.58- 4760.13)	83.15 ±7.47[ab]
High School	672.77±338.57[ac]	1339.51 (252.51- 14653.23)	84.06 ±8.23[a]
Associate/ Bachelor's Degree	591.07 ±274.32[a]	1337.00 (252.49- 14653.23)	80.37 ±8.83[b]
Master's Degree	700.31 ±239.01[ac]	1504.14 (561.92 -11198.08)	80.13 ±10.01[b]
Test Statistic, p-value	10.285, **<0.001**[f]	12.932, 0.051[h]	4.121, **0.003**[f]
Occupation			
Housewife	795.84 ±326.02[a]	1454.29 (460.55- 11198.07)	83.4 ±8.04
Civil Servant	669.43 ±270.94[b]	14.09 65.58- 11198.08)	82.76 ±9.92
Self-Employed	682.78 ±295.31[b]	1141.40 (675.98- 10967.24)	81.86 ±8.99
Other	643.54 ±360.36[b]	1403.47 (252.49- 14653.23)	82.34 ±8.55
Test Statistic, p-value	5.709, **0.001**[f]	2.316, 0.510[h]	0.557, 0.643[f]
Income Status			
Below Minimum Wage	706.33 ±348.72	1395.82 (2525.12-14653.23)	82.92 ±8.55
Minimum Wage	732.73 ±384.37	1435.74 (464.97 -11198.07)	82.35 ±6.95
Above Minimum Wage	679.28 ±316.55	1422.33 (252.49- 14653.23)	82.67 ±9.22
Test Statistic, p-value	0.886, 0.413[f]	0.005, 0.998[h]	0.139, 0.870[f]
Smoking Status			
Yes	631.85 ±269.38	1306.95 (252.49- 14653.23)	83.82 ±8.46
No	717.84±357.11	1454.29 (329.42- 14653.23)	82.29 ±8.61
Test Statistic, p-value	-2.592, **0.010**[t]	-2.569, **0.010**[m]	1.575, 0.116[t]
Alcohol Consumption			
Yes	605.68 ±149.58	973.14 (559.46 -5644.27)	77.97 ±6.33
No	699.85 ±343.38	1428.64 (252.49- 14653.23)	82.78 ±8.61

Test Statistic, p-value	-1.957, 0.072[t]	-1.659, 0.097[m]	-1.838, 0.067[t]
Physical Activity Status			
Yes	591.18 ±312.07	1346.69 (283.77- 11198.08)	81.7 ±10.58
No	726.36 ±342.02	1437.46 (252.49- 14653.23)	82.92 ±7.96
Test Statistic, p-value	-3.423, **0.001[t]**	-0.371, 0.710[m]	-1.025, 0.307[t]
Disease Status			
Yes	729.53 ±313.40	1477.42 (252.49- 14653.23)	83.03 ±9.5
No	690.10 ±345.85	1375.22 (252.51 -14653.23)	82.57 ±8.38
Test Statistic, p-value	0.936, 0.350[t]	-1.706, 0.088[m]	0.431, 0.667[t]
Disease Type			
Diabetes	765.86 (367.46 -1140.70)	1569.40 (849.18- 14653.23)	86.98 (79.1 - 97.96)
Hypertension	914.62 (455.37 -1140.65)	1516.93 (818.88- 6009.62)	83.62 (77.39 - 95.68)
Cardiovascular Diseases	835.88 (323.42 -1650.73)	1505.62 (565.58- 2725.09)	79.85 (70.61 - 89.99)
Obesity	714.42 (490.50 -967.55)	1244.44 (785.53- 1834.64)	88.77 (64.37 - 97.96)
Gastrointestinal Diseases	592.88 (86.14 -1015.19)	880.54 (252.49 -9101.99)	86.95 (78 - 98.14)
Respiratory Diseases	452.25 (449.14 -455.36)	834.35 (818.95- 849.76)	95.46 (95.24 - 95.68)
Other Diseases	542.38 (251.18 -1650.73)	2300.05 (696.44- 4361.21)	79.09 (59.08 - 92.6)
Test Statistic, p-value	15.069, 0.051[h]	14.451, 0.051[h]	18.402, 0.051[h]
Medication Use			
Yes	651.71 ±387.00	1698.80 (464.97 -14653.23)	86.11 ±8.41
No	700.63 ±336.84	1393.91 (252.49- 14653.23)	82.42 ±8.56
Test Statistic, p-value	-0.736, 0.462[t]	-1.195, 0.232[m]	2.213, **0.027[t]**
Supplement Use			
Yes	664.19 ±343.80	1454.29 (252.49 -9101.99)	80.43 ±10.58
No	705.39 ±339.16	1389.65 (283.77 -14653.23)	83.19 ±7.97
Test Statistic, p-value	-0.992, 0.322[t]	-0.864, 0.387[m]	-2.227, **0.028[t]**
Skipping Meals			
Yes	591.64 ±326.96	1228.77 (252.49 -14653.23)	83.5 ±8.64
No	811.41 ±316.90	1466.55 (561.91- 11198.08)	81.75 ±8.46
Test Statistic, p-value	-7.068, **<0.001[t]**	-3.919, **<0.001[m]**	2.113, **0.035[t]**
Most Frequently Skipped Meal			
Breakfast	484.45 (176.29 -1788.08)[a]	1163.79 (252.49- 14653.23)	83.93 (58.52 - 96.29)[a]
Mid-morning Snack	729.40 (86.14 -1251.34)[ab]	1480.97 (464.97- 6009.67)	85.05 (71.37 - 97.06)[a]
Lunch	639.04 (96.32 -1618.03)[ab]	1372.80 (460.55- 14653.23)	81.89 (66.78 - 98.32)[a]
Afternoon Snack	335.73 (234.46 -1135.03)[ab]	1079.94 (559.46- 2872.40)	85.27 (67.82 - 97.67)[a]
Dinner	170.69 (105.78 -1013.04)[b]	750.15 (329.42- 3562.07)	72.51 (59.55 - 74.95)[b]
Late-night Snack	703.59 (703.59 -703.59)[ab]	1160.00 (1159.99 - 1160.00)	74.4 (74.4 - 74.4)[ab]
Test Statistic, p-value	17.684, **0.003[h]**	3.177, 0.673[h]	18.627, **0.002[h]**
Reason for Skipping Meals			
Lack of Time	619.63 ±365.84	1190.47 (506.54- 14653.23)	83.79 ±9.69[b]
Habit	602.84 ±315.96	1338.81 (252.49- 14653.23)	82.7 ±6.36[b]
Weight Loss	302.72 ±42.13	1066.61 (658.57- 1066.61)	91.79 ±1.68[a]
Other	754.40 ±432.27	1676.76 (329.42- 2725.09)	77.95 ±11.06[b]
Test Statistic, p-value	1.785, 0.151[f]	1.607, 0.658[h]	26.084, **<0.001[f]**
Dieting Status			
Yes	497.04 ±85.58	1.61 (3.3 -9.78)	68.08 ±14.28
No	701.24 ±341.95	8.8 (0 -19.83)	82.93 ±8.23
Test Statistic, p-value	-5.913, **<0.001[t]**	-0.968, 0.333[m]	-4.977, **<0.001[t]**

t: Independent samples t-test; f: One-way ANOVA; h: Kruskal–Wallis H test; a–b: Groups sharing the same letter are not significantly different (Duncan test, Tamhane's T2 test, Bonferroni-adjusted Dunn test); Normally distributed data are presented as mean ± standard deviation, whereas non-normally distributed data are presented as median (minimum–maximum).

When 24-h DR and FFQ data were compared across different methods, statistically significant differences were observed among the methods for both 24-h DR and FFQ values ($p<0.001$). For 24-h DR values, the highest mean was obtained with the PE method, while the lowest mean was observed with the PI method. Similarly, for FFQ values, the highest mean was found using the PE method, whereas the lowest mean was obtained with the PI method. Post hoc multiple comparisons revealed that all methods differed significantly from each other ($p<0.001$) (Table 5).

In the present study, PE-derived intake values were consistently higher than USDA-FDB-derived values for both 24-h DR and FFQ data, whereas PI values were substantially lower compared to the other methods. In addition, FFQ-based intake estimates were markedly higher than 24-h DR-based estimates. Similar differences according to dietary assessment tools and phytochemical databases have been reported in previous studies. The main dietary sources of polyphenols were coffee, tea, vegetables, and fruits (Yahya et al., 2016). In another study conducted in the United Kingdom, polyphenol intake was assessed using a 7-day dietary record in combination with PE, and the mean total polyphenol intake was reported as 1536 mg/day (Dryer-Beers et al., 2024), which was lower than the PE-FFQ values observed in the present study. In the Portuguese population, total flavonoid intake was estimated at 107.3 mg/day using a database developed based on USDA-

FDB and PE (Martins et al., 2025), which was considerably lower than the intake values obtained in the present study. In a study conducted among Polish adults using a one-day dietary record (24-h DR), total polyphenol intake was evaluated using USDA-FDB and PE and was found to be 525 mg/day and 989 mg/day, respectively (Witkowska et al., 2015). Similarly, in another study conducted in Poland using FFQ, polyphenol intake was assessed using PE, and the mean intake of polyphenols was reported as 1756.5 ±695.8 mg/day (Grosso et al., 2014), which was comparable to the PE-FFQ values observed in the present study. In a study conducted among older adults in Australia, Ivey et al. (2016) reported mean flavonoid intakes of 834 mg/day using USDA-FDB and 487 mg/day using PE, and a strong agreement was observed between the two methods. In a population-based study, flavonoid intake was estimated using a validated FFQ across four different databases. In this study, which utilized USDA-FDB, PE, eBASIS, and the Indian Food Composition Table (IFCT), flavonoid intakes were reported as 426.67 mg/100 g, 596.06 mg/100 g, 934.33 mg/100 g, and 486.18 mg/100 g, respectively. Despite these substantial differences, low-to-moderate agreement was observed among the databases (Alemayohu et al., 2024).

Table 5. Comparison of 24-h DR and FFQ Data Across Different Methods

Methods	Descriptive statistics	Test Statistic	p
USDA-24-h DR	223.86 ±289.5[b]		
PE-24-h DR	432.05 ±356.33[a]	313.572	**<0.001[z]**
Fİ-24-h DR	78.64 ±34.04[c]		
USDA- FFQ	655.34 (86.14-1788.08)[b]		
PE- FFQ	1414.78 (252.49-14653.23) [a]	860.000	**<0.001[y]**
Fİ- FFQ	82.57 (58.52-98.45)[c]		

y: Friedman test; z: Repeated-measures ANOVA; a–c: Methods sharing the same letter are not significantly different. Normally distributed data are presented as mean ± standard deviation, whereas non-normally distributed data are presented as median (minimum–maximum).

In the present study, while similarity was observed between PE and USDA-FDB data, the lack of agreement in PI values may be attributed to the exclusion of foods containing little or no energy from the PI calculation. Additionally, discrepancies observed in studies using PI may be related to differences in study design, population characteristics, and the inherent limitations of the dietary assessment methods employed. The PI values calculated in the present study were higher than those reported in some previous studies. In Switzerland, the median PI value assessed using a validated FFQ was reported as 25.5 (Gamba et al., 2023). In a study conducted among adults in Iran using an FFQ, the highest mean PI value was reported as 36.08 (Vasmehjani et al., 2021). In a case–control study conducted in China, PI was evaluated using a validated semi-quantitative FFQ, and women with polycystic ovary syndrome (PCOS) had significantly lower PI scores compared to the control group (32.42 vs. 43.87) (Chi et al., 2024). In a study assessing PI using 24-h DR among Korean children, the mean PI values were 15.43 ±1.07 and 16.49 ±0.45 for boys and girls, respectively (Han et al., 2023). In another study conducted among 200 individuals diagnosed with diabetes, 24-h DR data were collected, and the mean PI score was reported as 16.7 ± 10.7 (Pehlivan, 2024). As a result of these evaluations, this study also supports the recommendation reported by Probst et al. (2018). Accurate estimation of dietary phytochemical consumption requires flexible, searchable, geographically diverse, data-inclusive tools that are compatible with regionally used terminology for the analytics of phytochemical compounds. This necessitates a global effort and regional databases (Probst et al., 2018).

A multivariate analysis of variance using Pillai's Trace revealed a significant main effect of method on phytochemical intake estimates ($F(2, 428) = 931.57$, $p<0.001$, partial $\eta^2=0.813$). A significant main effect of dietary assessment tool was also observed ($F(1, 429) = 633.11$, $p <0.001$, partial $\eta^2 =0.596$), indicating that phytochemical intake estimates differed substantially between the two assessment methods. Importantly, a significant method × tool interaction was found ($F(2, 428) = 925.36$, $p<0.001$, partial $\eta^2=0.812$), demonstrating that the differences between phytochemical estimation methods varied depending on whether dietary intake was assessed using the 24-hour dietary recall (24-h DR) or the food frequency questionnaire (FFQ) (Table 6). The significant effect of dietary assessment tool ($\eta^2=0.596$) further highlights that intake estimates vary considerably depending on how dietary data are collected. Contemporary evidence shows that FFQs and short-term methods such as 24-hour dietary recall capture different dimensions of intake, often resulting in only moderate or even poor agreement for several phytochemical subclasses. (Li et al., 2024). This discrepancy is largely explained by the inability of standard tools to comprehensively capture all phytochemical-rich foods and episodically consumed items. Additionally, recent observational studies continue to rely on repeated 24-hour dietary recall for detailed intake estimation, emphasizing methodological heterogeneity in current research (Wilson et al., 2024). Importantly, the strong method × tool interaction ($\eta^2=0.812$) suggests that these effects are interdependent rather than additive. Recent literature highlights that combining different dietary assessment tools with different phytochemical databases can amplify measurement error and limit comparability across studies (Li et al., 2024). Furthermore, variations in tools (e.g., FFQ vs. recall) across studies have been explicitly identified as a key source of inconsistency in phytochemical intake research (Jazinaki et al., 2026).

Table 6. Multivariate test results for the effects of method and dietary assessment tool on phytochemical intake

Effect	Test	F (df1, df2)	p	Partial η^2
Method	Pillai's Trace	931.57 (2, 428)	<0.001	0.813
Tool	Pillai's Trace	633.11 (1, 429)	<0.001	0.596
Method × Tool	Pillai's Trace	925.36 (2, 428)	<0.001	0.812

Method refers to phytochemical estimation approaches, including the USDA database, Phenol-Explorer (PE), and the Phytochemical Index (FI). Tool refers to dietary assessment methods, including 24-hour dietary recall (24 h DR) and food frequency questionnaire (FFQ). Results are based on Pillai's Trace from multivariate analysis.

Overall, these findings indicate that methodological factors account for a substantial proportion of variability in phytochemical intake estimates. This underscores the need for standardized approaches, improved tool validation, and, where possible, integration of biomarkers to enhance accuracy and comparability in contemporary nutritional epidemiology.

Conclusion

The findings of the present study clearly demonstrate that estimates of phytochemical intake are influenced not only by individuals' demographic and lifestyle characteristics, but also substantially by the calculation method (USDA-FDB, PE, PI) and the dietary assessment tool (24-h DR, FFQ) used. In comparisons across methods, the systematic tendency of PE to yield higher values and PI to produce lower values indicates that differences in databases and calculation approaches play a decisive role in shaping the results.

However, the presence of significant differences between 24-h DR and FFQ methods indicates that short-term and long-term dietary assessment tools capture phytochemical intake from different perspectives. The results of multivariate analyses further support this finding, demonstrating that, in addition to the independent effects of method and assessment tool, the interaction between these two factors is also substantial. Although certain sociodemographic and lifestyle variables (e.g., marital status, physical activity, and meal patterns) were found to produce significant differences within specific methods, their overall contribution to the total variation appears to be limited.

In conclusion, the findings indicate that the method and dietary assessment tool used are critical in interpreting estimates of phytochemical intake; therefore, methodological differences must be carefully considered in cross-study comparisons. These results underscore the importance of standardization in future research and, where possible, the use of multiple methods for validation.

The strengths of this study include its adequate sample size and the comprehensive evaluation of dietary phytochemical intake using three different methods (USDA-FDB, PE, and PI) in combination with two dietary assessment tools (24-h DR and FFQ). In addition, the application of a multivariate analytical approach to examine the interaction between methods and assessment tools enhances the robustness of the methodological interpretation of the findings.

However, the study also has some limitations. The cross-sectional design restricts causal inference. The reliance on self-reported dietary data may introduce recall bias, while the use of self-reported anthropometric measurements increases the risk of measurement error. Furthermore, differences in the content and coverage of the phytochemical databases used may contribute to variability in the results.

Compliance with Ethical Standards

Conflict of interest: The author(s) declare that they have no actual, potential, or perceived conflicts of interest related to this article.

Ethics committee approval: The study was conducted following the Declaration of Helsinki Principles. To carry out the research, the approval of the Selçuk University Faculty of Health Sciences Ethics Committee for Non-Interventional Clinical Investigations was obtained (2023/645).

Data availability: The data will be made available upon request by the author(s).

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References

Ahmad, J. & Ahamad, J. (2020). Bioactive phytochemicals: Drug discovery to product development. Amsterdam: Elsevier.
https://doi.org/10.2174/9789811464485120010l

Ajabnoor, S.M., Jambi, H. & Bahijri, S. (2024). Development and validation of a food frequency questionnaire in adult Saudi subjects in Jeddah city. *BMC Public Health*, 24, 9. https://doi.org/10.1186/s12889-023-17511-9

Alemayohu, M.A., Zanolin, M.E., Cazzoletti, L., Chamitava, L., de Castro Mendes, F., Mattioli, V. & Garcia-Larsen, V. (2024). Flavonoid content of selected foods – A comparison of four international composition tables. *Journal of Food Composition and Analysis*, 134, 106539. https://doi.org/10.1016/j.jfca.2024.106539

Amiot, M.-J., Latgé, C., Plumey, L. & Raynal, S. (2021). Intake estimation of phytochemicals in a French well-balanced diet. *Nutrients*, 13(10), 3628. https://doi.org/10.3390/nu13103628

BEBİS (Beslenme Bilgi Sistemi) (2011). Türkçe Sürüm 8. Stuttgart, Almanya: Ebispro. for Windows, Stuttgart, Germany; Turkish version (BeBiS 8), Version 8; databases: Bundeslebensmittelschlüssel (BLS) 11.3 and other sources. Available at: www.bebis.com.tr (Accessed 25 September 2026).

Burkholder-Cooley, N., Rajaram, S., Haddad, E., Fraser, G.E. & Jaceldo-Siegl, K. (2016). Comparison of polyphenol intakes according to distinct dietary patterns and food sources in the Adventist Health Study-2 cohort. *British Journal of Nutrition*, 115(12), 2162–2169 https://doi.org/10.1017/S0007114516001331

Chi, Y., Yue, R., Lv, Y., Li, H., & Liao, W. (2024). The dietary phytochemical index and its relation to polycystic ovary syndrome: a case-control study. *Journal of Ovarian Research*, 17(1), 228. https://doi.org/10.1186/s13048-024-01540-y

Cohen, J. (2013). *Statistical power analysis for the behavioral sciences*. New York, NY: Routledge. ISBN: 978-0-203-77158-7 https://doi.org/10.4324/9780203771587

Delshad Aghdam, S., Siassi, F., Nasli Esfahani, E., Qorbani, M., Rajab, A., Sajjadpour, Z. & Sotoudeh, G. (2021). Dietary phytochemical index associated with cardiovascular risk factor in patients with type 1 diabetes mellitus. *BMC Cardiovascular Disorders*, 21(1), 293. https://doi.org/10.1186/s12872-021-02106-2

Dryer-Beers, E.R., Griffin, J., Matthews, P.M. & Frost, G.S. (2024). Higher dietary polyphenol intake is associated with lower blood inflammatory markers. *The Journal of Nutrition,* 154(8), 2470–2480. https://doi.org/10.1016/j.tjnut.2024.05.005

Gamba, M., Roa-Diaz, Z.M., Raguindin, P. F., Glisic, M., Bano, A., Muka, T. & Marques-Vidal, P. (2023). Association between dietary phytochemical index, cardiometabolic risk factors and metabolic syndrome in Switzerland. *Nutrition, Metabolism and Cardiovascular Diseases*, 33(11), 2220–2232. https://doi.org/10.1016/j.numecd.2023.07.018

Goktas, Z., Zu, Y., Abbasi, M., Galyean, S., Wu, D., Fan, Z. & Wang, S. (2020). Recent advances in nanoencapsulation of phytochemicals to combat obesity and its comorbidities. *Journal of Agricultural and Food Chemistry,* 68(31), 8119–8131. https://doi.org/10.1021/acs.jafc.0c00131

Grosso, G., Stepaniak, U., Topor-Mądry, R., Szafraniec, K. & Pająk, A. (2014). Estimated dietary intake and major food sources of polyphenols in the Polish arm of the HAPIEE study. *Nutrition,* 30(11), 1398–1403. https://doi.org/10.1016/j.nut.2014.04.012

Guan, R., Van Le, Q., Yang, H., Zhang, D., Gu, H., Yang, Y. & Peng, W. (2021). A review of dietary phytochemicals and their relation to oxidative stress and human diseases. *Chemosphere*, 271, 129499. https://doi.org/10.1016/j.chemosphere.2020.129499

Han, Y.J., Baek, J.H., Jung, S.K., Yang, J.S., Shin, N.R. & Park, M.Y. (2023). Association between the dietary phytochemical index and lower prevalence of obesity in Korean preschoolers. *Nutrients*, 15(11). https://doi.org/10.3390/nu15112439

Huang, Q., Braffett, B.H., Simmens, S.J., Young, H.A. & Ogden, C.L. (2020). Dietary polyphenol intake in US adults and 10-year trends: 2007–2016. *Journal of the Academy of Nutrition and Dietetics,* 120(11), 1821–1833. https://doi.org/10.1016/j.jand.2020.06.016

Im, J., Kim, M. & Park, K. (2020). Association between the phytochemical index and lower prevalence of obesity/abdominal obesity in Korean adults. *Nutrients,* 12(8). https://doi.org/10.3390/nu12082312

Ivey, K.L., Croft, K., Prince, R.L. & Hodgson, J.M. (2016). Comparison of flavonoid intake assessment methods. *Food & Function*, 7(9), 3748–3759. https://doi.org/10.1039/C4FO00234B

Jazinaki, M.S., Barghchi, H., Aali, Y. & Safarian, M. (2026). Association between dietary phytochemical index adherence and hypertension: A systematic review and meta-analysis of observational studies. *BMC Nutrition*, 12(1), 35. https://doi.org/10.1186/s40795-026-01242-2

Jo, U. & Park, K. (2022). Phytochemical index and hypertension in Korean adults using data from the Korea National Health and Nutrition Examination Survey in 2008–2019. *European Journal of Clinical Nutrition*, 76(11), 1594–1599. https://doi.org/10.1038/s41430-022-01155-w

Karam, J., Bibiloni, M.D.M. & Tur, J.A. (2018). Polyphenol estimated intake and dietary sources among older adults from Mallorca Island. *PLoS One,* 13(1), e0191573. https://doi.org/10.1371/journal.pone.0191573

Kline, R.B. (2023). Principles and practice of structural equation modeling. (5th ed.). Guilford Press. ISBN 978-1-4625-5191-0

Kroymann, J. (2011). Natural diversity and adaptation in plant secondary metabolism. *Current Opinion in Plant Biology,* 14(3), 246–251. https://doi.org/10.1016/j.pbi.2011.03.021

La Barbera, G., Capriotti, A.L., Cavaliere, C., Montone, C.M., Piovesana, S., Samperi, R. & Laganà, A. (2017). Liquid chromatography-high resolution mass spectrometry for the analysis of phytochemicals in vegetal-derived food and beverages. *Food Research International*, 100, 28–52. https://doi.org/10.1016/j.foodres.2017.07.080

Lanuza, F., Bondonno, N.P., Zamora-Ros, R., Rostgaard-Hansen, A.L., Tjønneland, A., Landberg, R. & Andres-Lacueva, C. (2022). Comparison of flavonoid intake assessment methods using USDA and Phenol-Explorer databases: Subcohort Diet, Cancer and Health-Next Generations-MAX study. Frontiers in Nutrition, 9, 873774.Leitzmann C, 2016. Characteristics and Health Benefits of Phytochemicals. *Complementary Medicine Research*, 23(2), 69-74. https://doi.org/10.3389/fnut.2022.873774

Li, Y., Xu, Y., Le Sayec, M., Kamarunzaman, N.N.Z., Wu, H., Hu, J., Li, Shan., Gibson, Rachel., Rodriguez-Mateos, A. (2024). Development of a food frequency questionnaire for the estimation of dietary (poly) phenol intake. *Food & function*, *15*(20), 10414-10433. https://doi.org/10.1039/D4FO03546A

Liu, R.H. (2004). Potential synergy of phytochemicals in cancer prevention: Mechanism of action. *The Journal of Nutrition, 134*(12 Suppl), 3479S–3485S. https://doi.org/10.1093/jn/134.12.3479S

Martins, S., Meireles, M., Caetano, E., Correia, D., Carvalho, C., Campos Silva, C. & Torres, D. (2025). Estimated dietary flavonoid intake and major food contributors in the Portuguese population. *British Journal of Nutrition*, 1–27.

McCarty, M.F. (2004). Proposal for a dietary "phytochemical index". *Medical Hypotheses,* 63(5), 813–817. https://doi.org/10.1016/j.mehy.2002.11.004

Miranda, A.M., Steluti, J., Fisberg, R.M. & Marchioni, D.M. (2016). Dietary intake and food contributors of polyphenols in adults and elderly adults of Sao Paulo. *British Journal of Nutrition,* 115(6), 1061–1070. https://doi.org/10.1017/S0007114515005061

Mishra, S., Stierman, B., Gahche, J. J., & Potischman, N. (2021). Dietary supplement use among adults: United States, 2017–2018. https://doi.org/10.15620/cdc:101131

Neveu, V., Pérez-Jiménez, J., Vos, F., Crespy, V., du Chaffaut, L., Mennen, L., Knox, C., Eisner, R., Cruz, J., Wishard, D., Scalbert, A. (2010). Phenol-Explorer: an online comprehensive database on polyphenol contents in foods. *Database,* 2010. https://doi.org/10.1093/database/bap024

Pehlivan, M. (2024). Examining the relationship between Mediterranean diet adherence, nutritional profile, and phytochemical index in type 2 diabetes patients. *Clinical Nutrition ESPEN*, 63, 1273. https://doi.org/10.1016/j.clnesp.2024.07.927

Pendergast, F.J., Livingstone, K.M., Worsley, A., McNaughton, S.A. (2016). Correlates of meal skipping in young adults: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity,* 13, 125 https://doi.org/10.1186/s12966-016-0451-1

Premkumar, L.S. (2014). Transient receptor potential channels as targets for phytochemicals. *ACS Chemical Neuroscience*, 5(11), 1117–1130. https://doi.org/10.1021/cn500094a

Probst, Y., Guan, V. & Kent, K. (2018). A systematic review of food composition tools used for determining dietary polyphenol intake in estimated intake studies. *Food Chemistry*, 238, 146–152. https://doi.org/10.1016/j.foodchem.2016.11.010

Probst, Y.C., Guan, V.X. & Kent, K. (2017). Dietary phytochemical intake from foods and health outcomes: A systematic review protocol and preliminary scoping. *BMJ Open*, 7(2), e013337. https://doi.org/10.1136/bmjopen-2016-013337

Rodriguez-Casado, A. (2016). The health potential of fruits and vegetables phytochemicals: Notable examples. *Critical Reviews in Food Science and Nutrition*, 56(7), 1097–1107. https://doi.org/10.1080/10408398.2012.755149

Salehi-Sahlabadi, A., Teymoori, F., Mokhtari, E., Taghiyar, M., Hekmatdoost, A. & Mirmiran, P. (2022). Dietary phytochemical index and the risk of non-alcoholic fatty liver disease: A case-control study among Iranian adults. *Complementary Therapies in Medicine*, 71, 102881. https://doi.org/10.1016/j.ctim.2022.102881

Savoi, S., Arapitsas, P., Duchêne, É., Nikolantonaki, M., Ontañón, I., Carlin, S. & Mattivi, F. (2021). Grapevine and wine metabolomics-based guidelines for FAIR data and metadata management. *Metabolites,* 11(11). https://doi.org/10.3390/metabo11110757

Siprelle, K., Kennedy, A.J., Hill, E.B., Hinton, A., Shi, N., Madril, P. & Roberts, K.M. (2024). An improved assessment method to estimate (poly)phenol intake in adults with chronic pancreatitis. *Digestive Diseases and Sciences*, 69(8), 2996–3007. https://doi.org/10.1007/s10620-024-08417-6

Sun, L.N., Yang, Z.Y., Lv, S.S., Liu, X.C., Guan, G.J. & Liu, G. (2014). Curcumin prevents diabetic nephropathy against inflammatory response via reversing caveolin-1 Tyr14 phosphorylation influenced TLR4 activation. *International Immunopharmacology*, 23(1), 236-246. https://doi.org/10.1016/j.intimp.2014.08.023

Stierman, B., Couch, C.A., & Mishra, S. (2026). Dietary Supplement Use: United States, August 2021–August 2023. (561), 1-11. https://doi.org/10.15620/cdc/252445

Thompson, F.E. & Subar, A.F. (2017). Dietary assessment methodology. In A.M. Coulston, C.J. Boushey, M.G. Ferruzzi & L.M. Delahanty (Eds.), *Nutrition in the prevention and treatment of disease* (4th ed., pp. 5–48). Academic Press. https://doi.org/10.1016/B978-0-12-802928-2.00001-1

Tirani, S.A., Lotfi, K., Shahdadian, F., Hajhashemy, Z., Rouhani, P. & Saneei, P. (2024). Dietary phytochemical index in relation to metabolic health status, serum adropin, and brain-derived neurotrophic factor levels in adults. *Current Developments in Nutrition*, 8(3), 102103. https://doi.org/10.1016/j.cdnut.2024.102103

Tsao, R. & Deng, Z. (2004). Separation procedures for naturally occurring antioxidant phytochemicals. *Journal of Chromatography B*, 812(1), 85–99. https://doi.org/10.1016/S1570-0232(04)00764-0

T.C. Sağlık Bakanlığı Halk Sağlığı Genel Müdürlüğü. (2019). Türkiye Beslenme ve Sağlık Araştırması (TBSA) 2017. Sağlık Bakanlığı Yayın No:1132, Ankara. ISBN: 978-975-590-722-2.

Vasmehjani, A.A., Darabi, Z., Nadjarzadeh, A., Mirzaei, M. & Hosseinzadeh, M. (2021). The relation between dietary phytochemical index and metabolic syndrome and its components in a large sample of Iranian adults: A population-based study. *BMC Public Health,* 21(1), 1587. https://doi.org/10.1186/s12889-021-11590-2

Verpoorte, R. (2000). Pharmacognosy in the new millennium: Leadfinding and biotechnology. *Journal of Pharmacy and Pharmacology,* 52(3), 253–262. https://doi.org/10.1211/0022357001773931

Wallace, T.C. & Giusti, M.M. (2015). Anthocyanins. *Advances in Nutrition*, 6(5), 620–622. https://doi.org/10.3945/an.115.009233

Wilson, S.M., Oliver, A., Larke, J.A., Naveja, J.J., Alkan, Z., Awika, J.M. & Lemay, D.G. (2024). Fine-scale dietary polyphenol intake is associated with systemic and gastrointestinal inflammation in healthy adults. *The Journal of Nutrition*, 154(11), 3286–3297. https://doi.org/10.1016/j.tjnut.2024.08.010

Wisnuwardani, R.W., De Henauw, S., Androutsos, O., Forsner, M., Gottrand, F., Huybrechts, I. & Michels, N. (2019). Estimated dietary intake of polyphenols in European adolescents: The HELENA study. *European Journal of Nutrition*, 58(6), 2345–2363. https://doi.org/10.1007/s00394-018-1787-x

Witkowska, A.M., Zujko, M.E., Waśkiewicz, A., Terlikowska, K.M. & Piotrowski, W. (2015). Comparison of various databases for estimation of dietary polyphenol intake in the population of Polish adults. *Nutrients*, 7(11), 9299–9308. https://doi.org/10.3390/nu7115464

Yahya, H.M., Day, A., Lawton, C., Myrissa, K., Croden, F., Dye, L. & Williamson, G. (2016). Dietary intake of 20 polyphenol subclasses in a cohort of UK women. *European Journal of Nutrition*, 55(5), 1839–1847. https://doi.org/10.1007/s00394-015-1001-3

Zamora-Ros, R., Knaze, V., Rothwell, J.A., Hémon, B., Moskal, A., Overvad, K. & Scalbert, A. (2016). Dietary polyphenol intake in Europe: The European Prospective Investigation into Cancer and Nutrition (EPIC) study. *European Journal of Nutrition*, 55(4), 1359–1375. https://doi.org/10.1007/s00394-015-0950-x

Ziauddeen, N., Rosi, A., Del Rio, D., Amoutzopoulos, B., Nicholson, S., Page, P. & Mena, P. (2019). Dietary intake of (poly)phenols in children and adults: Cross-sectional analysis of UK National Diet and Nutrition Survey Rolling Programme (2008–2014). *European Journal of Nutrition,* 58(8), 3183–3198. https://doi.org/10.1007/s00394-018-1862-3