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Abstract: *Phytoestrogens may play a role in hormone-related diseases such as cancer, but epidemiological and clinical data are conflicting in part due to inadequate databases used in intake estimation. A database of nine phytoestrogens in foods relevant to Western diets was developed to more accurately estimate intakes. Foods (*N *= 121) available in Ontario, Canada were prepared as commonly consumed and analyzed for isoflavones (genistein, daidzein, glycitein, formononetin), lignans (secoisolariciresinol, matairesinol, pinoresinol, lariciresinol), and coumestan (coumestrol) using gas chromatography–mass spectrometry methods. Data were presented on an as is (wet) basis per 100 g and per serving. Food groups with decreasing levels of total phytoestrogens per 100 g are nuts and oilseeds, soy products, cereals and breads, legumes, meat products, and other processed foods that may contain soy, vegetables, fruits, alcoholic, and nonalcoholic beverages. Soy products contain the highest amounts of isoflavone, followed by legumes, meat products and other processed foods, cereals and breads, nuts and oilseeds, vegetables, alcoholic beverages, fruits, and nonalcoholic beverages. Decreasing amounts of lignans are found in nuts and oilseeds, cereals and breads, legumes, fruits, vegetables, soy products, processed foods, alcoholic, and nonalcoholic beverages. The richest sources of specific phytoestrogens, including coumestrol, were identified. The database will improve phytoestrogen intake estimation in future epidemiological and clinical studies particularly in Western populations.*

Introduction

Phytoestrogens have gained much interest in recent years because of their potential protective effects against many diseases and conditions including cancer, cardiovascular disease, osteoporosis, and menopausal symptoms (1–7). These plant compounds with estrogenic or antiestrogenic activities comprise three major classes: isoflavones, lignans, and coumestans (1–7). The isoflavones include genistein, daidzein, glycitein, formononetin, biochanin A, and their glycosides. There are many plant lignans but of interest are those that can be metabolized by the intestinal microflora to the mammalian lignans enterolactone and enterodiol, which are more physiologically active than their precursors (8–10). For many years, secoisolariciresinol and matairesinol were considered to be the only mammalian lignan precursors, but recent studies have shown that pinoresinol, lariciresinol, syringaresinol, arctigenin, and 7-hydroxymatairesinol can likewise be converted to mammalian lignans (11). Although the isoflavones are found largely in soy and soy products, mammalian lignan precursors are found in most plant foods, with flaxseed reported to be the richest source (12–14). The main coumestan is coumestrol.

Many epidemiological studies have been conducted to determine the relationship between phytoestrogen intake and the risk of various diseases, particularly breast and prostate cancer, with conflicting results (15–33). However, most studies showed either a negative or no relationship. These conflicting results may in part be related to the food sources or databases used in estimating phytoestrogen intake. In some cases, phytoestrogen intake was estimated based only on the amount of soy products consumed (17–25). Other studies estimated intake using databases produced by compiling published values from phytoestrogen analysis using different methodologies and different sources of foods (13,28,34–38). Compiled phytoestrogen databases on lignans used analytical values largely from European laboratories (13,14,36,37). In some cases, the foods (e.g., legumes, cereals) were analyzed as dry seeds rather than cooked or processed for consumption, or analytic values were reported as dry weight where wet weight (as consumed) needed then to be imputed (34,35,39). The databases often include only genistein, daidzein, and secoisolariciresinol and, occasionally, matairesinol. Sometimes the databases include the mammalian lignans produced from the foods after in vitro fermentation with human fecal inoculum rather than only the food lignans

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(12). Few databases have been reported where both the isoflavones and lignans were analyzed simultaneously in the same food (40). Even then, few lignans were included and analytical methods may not have been ideal. The only study that simultaneously analyzed four major lignans in numerous foods did not analyze the isoflavones (14).

The aim of this study was to develop a database of nine major phytoestrogens simultaneously analyzed in the same foods relevant to Western diets that can be used to estimate their intakes in epidemiological and clinical studies in relation to hormone-related cancers such as of the breast and prostate as well as other hormone-related diseases or conditions. It should help improve the phytoestrogen dietary assessment particularly in the North American population.

Materials and Methods

Food Samples

One hundred twenty one food samples (Table 1) were selected for analysis from those identified as important phytoestrogen sources in the food analysis (12,13,37,38,40–50) and intake literature (26,33,35,39,51–56) and considered relevant to Western populations. Specific food types and brands, when given, were based on those most frequently reported by a sample of population-based controls in our current breast cancer case-control study (Ontario Women's Diet and Health Study). All foods and serving sizes (Table 1) correspond to items on the modified Block food frequency questionnaire (FFQ) used in this study (57). Multiple units or samples of the foods were bought at random primarily in local outlets of a major chain supermarket. Secondary sources included smaller stores, those selling foods in bulk with no brands, and government controlled outlets for alcoholic beverages. Samples were pooled and/or ground to obtain homogeneous representative samples of each food. Only edible portions of the foods were taken and analyzed. If the foods required preparation or heat treatment before consumption, they were first prepared according to commonly used methods or package instructions. Fresh or cooked food samples with high moisture content, including beverages except wine, beer, tea, and coffee, were freeze dried, and those with high fat content such as the nuts, oilseeds, and meat products were defatted with hexane before analysis. Alcoholic, tea and coffee beverages, and low moisture/dry foods were analyzed as is except that beer was first degassed in an ultrasonic bath at room temperature. Moisture content was determined by oven drying according to the Association of Official Analytical Chemists methods (58). All weighings were done accurately to allow later calculation of the phytoestrogen content on an as is (wet) basis. Minimum serving sizes used in the FFQ were weighed in grams and used to calculate the phytoestrogen content per serving. Serving size was measured after foods were prepared or cooked ready for consumption. Weights for beverages were based on standard American volumes.

Chemicals and Standards

For standards, purified daidzein, genistein, glycitein, and formononetin were purchased from Sigma-Aldrich (St. Louis, MO). Coumestrol was purchased from Toronto Research Chemical (Toronto, ON, Canada). Pinoresinol, lariciresinol, and matairesinol were kind gifts from Dr. R. Santti (University of Turku, Turku, Finland). Secoisolariciresinol was obtained from Dr. A. Muir (Agriculture Canada, Saskatoon, SK, Canada). β-glucuronidase (Helix Pomatia) was from Sigma-Aldrich and Tri-sil reagent (hexamethyldisilazane/ trimethylchlorosilane in pyridine, 2:1:10) was from Pierce Co. (Rockford, IL). The other reagents were of analytical grade, and all solvents used were high performance liquid chromatography grade.

Analysis

The samples were analyzed in duplicate using a modification of established methods for isoflavone (44) and lignan (59) analysis. Freeze-dried, dry, or defatted foods (0.25–2.00 g) were extracted twice with 25 mL 70% methanol at 60–70°C for 2 h while being shaken in a water bath. One aliquot of the pooled extract or liquid food samples was analyzed for lignan and another aliquot for isoflavone.

For lignan analysis, the sample went through alkaline hydrolysis, solid-phase extraction, β-glucuronidase hydrolysis, and another solid-phase extraction. An aliquot of the extract or liquid sample was evaporated to dryness in a rotary evaporator at 60°C under vacuum and the residue was treated with 5 mL of 1 mol/L sodium hydroxide for 3 hr at room temperature. The alkaline hydrolysate was neutralized with 5 mL of 1mol/L acetic acid and then passed through a C18 solid-phase extraction column (SPE column, Octadecyl C18/14%, 200 mg/3 mL; Applied Separations, Allentown, PA) that was preconditioned with 5 mL of methanol/chloroform (1:1, vol/vol), followed by 5 mL methanol and 5 mL water. The column was then washed with 5 mL water and eluted with 4 mL methanol. The eluent was evaporated to dryness in a rotary evaporator at 60°C under vacuum. To the residue was added 5 mL 0.1 mol/L sodium acetate buffer and 50 μL β-glucuronidase and the dispersion was then incubated overnight at 37°C. The β-glucuronidase hydrolysate was again subjected to solid-phase extraction as described previously. The eluent was evaporated to dryness at 60°C under vacuum and the residue was reconstituted with 1 mL methanol and stored at –20°C until analysis in a gas chromatograph–mass spectrometer (GC-MS). For isoflavone analysis, the method was the same as in the lignan analysis except that the alkaline hydrolysis step was eliminated. When ready for analysis, 100 μL of internal standard solution (5α-androstane-3β, 17β-diol, 50 μg/mL methanol) was added to the above sample in methanol solution. The sample was dried under nitrogen flow, and after adding 300 μL of Tri-Sil Reagent, was incubated for 0.5 h on a 60°C heater block. The silylating agent was then removed under nitrogen gas flow, and the trimethy-

Table 1. Phytoestrogen Content of Foods as Consumed (wet weight) per 100 g and per Serving (µg)[a,b,c]

Food item 100 g serving (g)	FOR	DAI	GEN	GLY	MAT	LAR	PINO	SECO	COU	Total ISO	Total LIG	Total PE
Soy products												
Bacon bits[1]												
100 g	4.1	998.3	4896.7	99.5	nd	nd	nd	35.1	nd	5998.6	35.1	6033.7
1 tbsp (8)	0.3	79.9	391.7	8.0	nd	nd	nd	2.8	nd	479.9	2.8	482.7
Miso paste[2]												
100 g	5.3	4424.4	5901.8	799.5	3.6	24.4	17.0	18.8	2.4	11131.0	63.9	11197.3
1 tbsp (22)	1.2	973.4	1298.4	175.9	0.8	5.4	3.8	4.1	0.5	2448.8	14.1	2463.4
Miso soup[3]												
100 g	0.1	430.2	1009.8	27.6	0.1	1.4	0.6	0.7	0.0	1467.7	2.8	1470.5
½ cup (115)	0.1	494.7	1161.3	31.7	0.1	1.7	0.7	0.8	0.0	1687.8	3.2	1691.0
Soy bean sprouts[4]												
100 g	0.0	268.3	514.6	4.5	0.0	0.7	0.5	0.9	nd	787.5	2.2	789.6
¼ cup (22)	0.0	59.0	113.2	1.0	0.0	0.2	0.1	0.2	nd	173.3	0.5	173.7
Soy beans[5]												
100 g	5.2	56621.4	44213.4	2809.4	1.8	99.6	88.7	79.1	1.5	103649.3	269.2	103920.0
¼ cup (44)	2.3	24913.4	19453.9	1236.1	0.8	43.8	39.0	34.8	0.7	45605.7	118.5	45724.8
Soy milk[6]												
100 g	1.2	921.3	1852.2	169.5	0.2	4.9	1.6	5.7	0.6	2944.2	12.3	2957.2
8.5 oz (251)	3.1	2312.3	4649.1	425.5	0.5	12.2	3.9	14.4	1.5	7390.0	30.9	7422.5
Soy nuts[7]												
100 g	61.6	28351.2	36264.0	3894.8	1.4	60.8	21.7	38.2	37.1	68571.5	122.2	68730.8
¼ cup (31)	19.1	8788.9	11241.8	1207.4	0.4	18.9	6.7	11.9	11.5	21257.2	37.9	21306.6
Soy protein powder[8]												
100 g	16.3	2529.4	5972.6	305.6	0.5	9.3	2.2	4.5	0.5	8823.8	16.5	8840.7
1 scoop (18)	2.9	455.3	1075.1	55.0	0.1	1.7	0.4	0.8	0.1	1588.3	3.0	1591.3
Soy sauce[9]												
100 g	5.8	23.2	100.6	5.4	1.7	nd	2.4	10.3	0.4	135.0	14.3	149.6
1 tbsp (17)	1.0	4.0	17.1	0.9	0.3	nd	0.4	1.7	0.1	23.0	2.4	25.4
Soy yogurt[10]												
100 g	1.5	3364.4	6565.1	296.7	0.3	17.6	3.5	25.3	0.5	10227.8	46.6	10275.0
¼ cup (64)	1.0	2153.2	4201.7	189.9	0.2	11.2	2.2	16.2	0.3	6545.8	29.8	6576.0
Tempeh[11]												
100 g	1.9	6974.8	10729.6	571.4	0.5	11.3	1.7	16.1	0.6	18277.7	29.6	18307.9
¼ cup (35)	0.7	2441.2	3755.4	200.0	0.2	4.0	0.6	5.6	0.2	6397.2	10.4	6407.8
Textured vegetable protein[12]												
100 g	7.7	5427.1	10160.8	526.6	nd	34.5	3.7	61.2	2.4	16122.2	99.4	16223.9
¼ cup (55)	4.2	2984.9	5588.4	289.6	nd	19.0	2.1	33.6	1.3	8867.2	54.7	8923.2
Tofu[13]												
100 g	0.9	9337.5	17050.2	729.9	0.8	9.0	3.0	18.1	0.7	27118.5	30.9	27150.1
¼ cup (32)	0.3	2988.0	5456.1	233.6	0.3	2.9	1.0	5.8	0.2	8677.9	9.9	8688.0

(continued)

Veggie burger[14]												
100 g	1.9	461.5	1111.5	81.2	0.7	2.3	1.6	10.6	0.2	1656.0	15.2	1671.5
¼ cup (29)	0.6	133.8	322.3	23.5	0.2	0.7	0.5	3.1	0.1	480.2	4.4	484.7
Mean (per 100 g)	**8.1**	**8580.9**	**10453.1**	**737.3**	**0.8**	**19.7**	**10.6**	**23.2**	**3.3**	**19779.3**	**54.3**	**19837.0**
SD (per 100 g)	**15.4**	**15080.3**	**13073.4**	**1116.6**	**1.0**	**27.5**	**22.6**	**22.4**	**9.4**	**28851.9**	**68.8**	**28920.6**
Mean (per serving)	**2.6**	**3484.4**	**4194.7**	**291.3**	**0.3**	**8.7**	**4.4**	**9.7**	**1.2**	**7973.0**	**23.0**	**7997.2**
SD (per serving)	**4.7**	**6342.3**	**5191.5**	**399.0**	**0.3**	**11.7**	**9.8**	**11.1**	**2.9**	**11789.7**	**30.9**	**11819.5**
Legumes												
Baked beans[15]												
100 g	0.5	0.1	0.6	0.0	0.2	0.8	1.1	13.3	0.0	1.3	15.3	16.6
¼ cup (64)	0.3	0.1	0.4	0.0	0.1	0.5	0.7	8.5	0.0	0.8	9.8	10.6
Black bean sauce[16]												
100 g	1.7	2304.0	2486.6	526.9	0.4	0.9	0.6	8.7	0.6	5319.2	10.5	5330.3
1 tbsp (21)	0.4	483.8	522.2	110.7	0.1	0.2	0.1	1.8	0.1	1117.0	2.2	1119.4
Black beans[17]												
100 g	2.9	0.2	0.2	0.1	0.1	1.4	0.2	4.6	0.0	3.4	6.3	9.7
¼ cup (48)	1.4	0.1	0.1	0.0	0.0	0.7	0.1	2.2	0.0	1.6	3.0	4.6
Broad beans[18]												
100 g	0.1	0.1	0.2	0.1	0.1	6.2	4.2	1.2	0.0	0.5	11.7	12.3
¼ cup (41)	0.1	0.0	0.1	0.0	0.1	2.6	1.7	0.5	0.0	0.2	4.8	5.1
Chick peas[19]												
100 g	0.5	0.1	1.1	0.0	0.1	1.8	0.5	0.6	0.1	1.7	2.9	4.7
¼ cup (42)	0.2	0.1	0.5	0.0	0.0	0.8	0.2	0.2	0.0	0.7	1.2	2.0
Hummus[20]												
100 g	3.4	0.8	9.3	0.1	15.5	123.7	837.7	2.5	0.0	13.6	979.4	993.0
¼ cup (61)	2.1	0.5	5.7	0.1	9.5	75.4	511.0	1.5	0.0	8.3	597.4	605.8
Kidney beans[21]												
100 g	0.2	0.8	0.6	0.0	1.1	1.8	0.4	3.2	0.0	1.6	6.5	8.1
¼ cup (45)	0.1	0.3	0.3	0.0	0.5	0.8	0.2	1.5	0.0	0.7	2.9	3.7
Lentils[22]												
100 g	7.0	1.3	1.1	0.1	0.2	16.3	9.0	1.2	0.3	9.5	26.6	36.5
¼ cup (36)	2.5	0.5	0.4	0.0	0.1	5.9	3.2	0.4	0.1	3.4	9.6	13.1
Lima beans[23]												
100 g	0.1	0.4	1.4	0.1	0.1	3.9	0.5	10.1	0.0	2.0	14.6	16.6
½ cup (41)	0.0	0.2	0.6	0.0	0.0	1.6	0.2	4.1	0.0	0.8	6.0	6.8
Mung bean sprouts[24]												
100 g	2.0	91.4	135.2	1.2	0.1	18.5	13.1	97.0	136.6	229.8	128.7	495.1
¼ cup (19)	0.4	17.4	25.7	0.2	0.0	3.5	2.5	18.4	26.0	43.7	24.5	94.1
Mung beans[25]												
100 g	0.5	1.5	2.1	0.2	0.4	12.5	0.9	29.9	0.0	4.3	43.7	48.0
¼ cup (47)	0.3	0.7	1.0	0.1	0.2	5.9	0.4	14.1	0.0	2.0	20.5	22.6
Red beans[26]												
100 g	0.2	2.7	2.1	0.1	0.3	2.2	0.3	2.4	0.1	5.0	5.2	10.4
¼ cup (43)	0.1	1.1	0.9	0.0	0.1	1.0	0.1	1.0	0.1	2.2	2.2	4.5
Soup, pea[27]												
100 g	0.1	0.1	0.3	0.0	0.0	1.1	0.5	0.2	0.0	0.5	1.8	2.3
½ cup (124)	0.1	0.1	0.4	0.1	0.0	1.4	0.7	0.2	0.0	0.6	2.3	2.9

(continued)

Table 1. (*Continued*)

Food item 100 g serving (g)	FOR	DAI	GEN	GLY	MAT	LAR	PINO	SECO	COU	Total ISO	Total LIG	Total PE
White beans[28]												
100 g	0.4	13.2	25.3	0.1	0.2	2.8	0.6	29.9	0.1	39.1	33.5	72.7
¼ cup (61)	0.3	8.1	15.4	0.1	0.1	1.7	0.4	18.3	0.1	23.8	20.4	44.3
Mean (per 100 g)	**1.4**	**172.6**	**190.5**	**37.8**	**1.3**	**13.8**	**62.1**	**14.6**	**9.9**	**402.2**	**91.9**	**504.0**
SD (per 100 g)	**1.9**	**591.6**	**637.8**	**135.7**	**3.9**	**31.0**	**215.1**	**24.8**	**35.2**	**1364.9**	**248.1**	**1365.3**
Mean (per serving)	**0.6**	**36.6**	**41.0**	**8.0**	**0.8**	**7.3**	**37.3**	**5.2**	**1.9**	**86.1**	**50.5**	**138.5**
SD (per serving)	**0.8**	**124.1**	**133.7**	**28.5**	**2.4**	**19.0**	**131.4**	**6.5**	**6.7**	**286.2**	**151.9**	**312.0**
Nuts and oil seeds												
Almonds[29]												
100 g	0.8	2.1	14.4	0.6	0.3	32.2	9.0	70.3	1.5	18.0	111.7	131.1
¼ cup (37)	0.3	0.8	5.3	0.2	0.1	11.9	3.3	26.0	0.5	6.7	41.3	48.5
Cashews[30]												
100 g	10.0	1.4	10.3	0.4	0.3	60.5	1.1	37.5	0.4	22.1	99.4	121.9
¼ cup (34)	3.4	0.5	3.5	0.1	0.1	20.6	0.4	12.8	0.1	7.5	33.8	41.5
Chestnuts[31]												
100 g	1.7	2.8	16.4	0.3	0.5	7.8	5.6	172.7	2.4	21.2	186.6	210.2
¼ cup (32)	0.6	0.9	5.2	0.1	0.2	2.5	1.8	55.3	0.8	6.8	59.7	67.2
Flaxseed[32]												
100 g	34.1	58.2	173.2	56.0	153.3	2807.5	729.6	375321.9	46.8	321.4	379012.3	379380.4
¼ cup (43)	14.7	25.0	74.5	24.1	65.9	1207.2	313.7	161388.4	20.1	138.2	162975.3	163133.6
Hazelnuts[33]												
100 g	1.2	3.6	24.8	0.5	1.2	14.3	1.1	60.5	0.3	30.2	77.1	107.5
¼ cup (34)	0.4	1.2	8.4	0.2	0.4	4.9	0.4	20.6	0.1	10.3	26.2	36.6
Peanut butter[34]												
100 g	0.7	3.3	38.2	0.2	0.1	8.8	0.2	28.6	0.1	42.4	37.6	80.1
1 tbsp (19)	0.1	0.6	7.3	0.0	0.0	1.7	0.0	5.4	0.0	8.0	7.2	15.2
Peanuts[35]												
100 g	0.3	1.7	4.9	0.4	0.1	0.9	0.8	25.3	0.1	7.3	27.1	34.5
¼ cup (34)	0.1	0.6	1.7	0.1	0.0	0.3	0.3	8.6	0.0	2.5	9.2	11.7
Pecans[36]												
100 g	0.7	1.6	0.9	0.3	0.6	8.4	1.2	14.8	0.3	3.5	25.0	28.8
¼ cup (28)	0.2	0.5	0.2	0.1	0.2	2.4	0.3	4.2	0.1	1.0	7.0	8.1
Pistachios[37]												
100 g	0.2	73.1	103.3	0.4	0.1	123.0	31.2	44.6	6.7	176.9	198.9	382.5
¼ cup (33)	0.1	24.1	34.1	0.1	0.0	40.6	10.3	14.7	2.2	58.4	65.6	126.2
Sesame seed[38]												
100 g	3.8	2.6	2.2	2.0	123.1	1052.4	6814.5	7.3	0.4	10.5	7997.2	8008.1
¼ cup (34)	1.3	0.9	0.7	0.7	41.8	357.8	2316.9	2.5	0.1	3.6	2719.0	2722.8
Sunflower seed[39]												
100 g	0.7	2.4	2.0	0.5	0.5	149.7	33.9	26.2	0.1	5.7	210.3	216.0
¼ cup (33)	0.2	0.8	0.7	0.2	0.2	49.4	11.2	8.7	0.0	1.9	69.4	71.3

(continued)

Walnuts[40]												
100 g	0.9	35.2	16.4	0.8	0.2	7.2	0.2	78.0	0.6	53.3	85.7	139.5
¼ cup (26)	0.2	9.2	4.3	0.2	0.1	1.9	0.1	20.3	0.2	13.9	22.3	36.3
Mean (per 100 g)	**4.6**	**15.7**	**33.9**	**5.2**	**23.4**	**356.1**	**635.7**	**31324.0**	**5.0**	**59.4**	**32339.1**	**32403.4**
SD (per 100 g)	**9.3**	**24.3**	**49.9**	**15.3**	**51.7**	**791.1**	**1873.6**	**103719.3**	**12.7**	**91.0**	**104548.5**	**104639.9**
Mean (per serving)	**1.8**	**5.4**	**12.2**	**2.2**	**9.1**	**141.8**	**221.6**	**13463.9**	**2.0**	**21.6**	**13836.3**	**13859.9**
SD (per serving)	**4.0**	**8.9**	**20.7**	**6.6**	**20.6**	**335.3**	**637.6**	**44600.9**	**5.5**	**38.2**	**44973.2**	**45013.7**
Vegetables												
Alfalfa sprouts[41]												
100 g	384.3	1.7	7.5	0.6	0.1	24.1	18.4	2.2	2.5	394.1	44.8	441.4
¼ cup (10)	38.4	0.2	0.8	0.1	0.0	2.4	1.8	0.2	0.3	39.4	4.5	44.1
Broccoli[42]												
100 g	0.1	0.0	0.1	0.0	0.1	82.0	6.1	5.8	0.0	0.2	93.9	94.1
¼ cup (20)	0.0	nd	0.0	0.0	0.0	16.4	1.2	1.2	0.0	0.0	18.8	18.8
Cabbage[43]												
100 g	0.1	0.2	0.6	0.1	0.1	32.3	44.2	2.6	0.0	0.9	79.1	80.0
¼ cup (17)	0.0	0.0	0.1	0.0	0.0	5.5	7.5	0.4	nd	0.2	13.5	13.6
Carrots, cooked[44]												
100 g	0.1	0.0	0.0	0.0	0.1	0.9	0.6	2.1	0.0	0.2	3.6	3.8
¼ cup (34)	0.0	0.0	0.0	0.0	0.0	0.3	0.2	0.7	nd	0.1	1.2	1.3
Carrots, raw[45]												
100 g	0.1	0.0	0.1	0.1	0.0	2.1	0.1	4.1	0.0	0.2	6.4	6.7
¼ cup (33)	0.0	0.0	0.0	0.0	0.0	0.7	0.1	1.4	nd	0.1	2.1	2.2
Collards[46]												
100 g	0.0	0.4	1.5	0.0	0.4	66.7	24.8	5.9	1.5	1.9	97.8	101.3
¼ cup (19)	nd	0.1	0.3	0.0	0.1	12.7	4.7	1.1	0.3	0.4	18.6	19.3
Corn[47]												
100 g	0.1	1.5	3.4	0.1	0.0	0.5	0.2	3.2	0.0	5.1	3.9	9.0
¼ cup (38)	0.1	0.6	1.3	0.0	0.0	0.2	0.1	1.2	0.0	1.9	1.5	3.4
French fries[48]												
100 g	0.3	0.1	0.2	0.1	0.1	1.6	0.1	0.7	0.1	0.7	2.4	3.2
¼ cup (26)	0.1	0.0	0.1	0.0	0.0	0.4	0.0	0.2	0.0	0.2	0.6	0.8
Garlic[49]												
100 g	0.8	5.0	14.3	0.2	4.8	54.4	481.9	42.0	0.1	20.3	583.2	603.6
1 tbsp (17)	0.1	0.9	2.4	0.0	0.8	9.3	81.9	7.2	0.0	3.5	99.2	102.6
Green beans[50]												
100 g	0.2	5.9	32.9	0.1	0.6	32.8	2.6	30.9	0.0	39.0	66.8	105.8
¼ cup (27)	0.0	1.6	8.9	0.0	0.2	8.9	0.7	8.3	0.0	10.5	18.0	28.6
Lettuce[51]												
100 g	0.1	0.1	0.5	0.1	1.0	2.4	0.6	4.9	0.1	0.7	9.0	9.7
¼ cup (10)	0.0	0.0	0.1	0.0	0.1	0.2	0.1	0.5	0.0	0.1	0.9	1.0
Olive oil[52]												
100 g	0.6	8.1	28.2	1.1	0.3	1.7	139.7	1.0	0.1	38.0	142.6	180.7
1 tbsp (13)	0.1	1.1	3.7	0.2	0.0	0.2	18.2	0.1	0.0	5.0	18.5	23.5

(continued)

Table 1. (*Continued*)

Food item 100 g serving (g)	FOR	DAI	GEN	GLY	MAT	LAR	PINO	SECO	COU	Total ISO	Total LIG	Total PE
Olives[53]												
100 g	1.2	1.4	1.9	1.7	0.1	0.6	1.9	30.6	0.2	6.2	33.2	39.5
¼ cup (39)	0.5	0.5	0.7	0.7	0.0	0.2	0.8	11.9	0.1	2.4	12.9	15.4
Onions[54]												
100 g	0.0	0.0	0.0	0.1	9.0	0.3	0.8	21.7	0.0	0.2	31.8	32.0
¼ cup (31)	0.0	0.0	0.0	0.0	2.8	0.1	0.3	6.7	nd	0.1	9.9	9.9
Pumpkin[55]												
100 g	0.0	0.1	0.2	0.0	0.2	3.7	0.2	0.9	0.0	0.3	4.9	5.3
¼ cup (44)	0.0	0.0	0.1	0.0	0.1	1.7	0.1	0.4	0.0	0.1	2.2	2.3
Seaweed[56]												
100 g	0.7	0.8	1.1	0.4	0.3	1.7	4.2	0.7	0.1	3.0	7.0	10.0
¼ cup (2)	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	nd	0.1	0.1	0.2
Soup, vegetable[57]												
100 g	0.0	0.0	0.0	0.0	0.0	1.2	1.5	1.7	0.0	0.1	4.5	4.6
½ cup (120)	0.0	0.0	0.0	0.0	0.0	1.5	1.8	2.1	0.0	0.1	5.4	5.6
Spinach, cooked[58]												
100 g	0.1	0.0	0.1	0.2	0.1	3.1	0.3	0.2	0.0	0.4	3.8	4.2
¼ cup (37)	0.0	0.0	0.0	0.1	0.0	1.2	0.1	0.1	0.0	0.1	1.4	1.5
Spinach, raw[59]												
100 g	0.1	0.3	0.2	0.1	0.1	10.5	1.9	1.3	0.0	0.8	13.8	14.6
¼ cup (7)	0.0	0.0	0.0	nd	0.0	0.7	0.1	0.1	nd	0.1	1.0	1.0
Sweet potatoes[60]												
100 g	0.1	0.1	0.1	0.0	16.6	14.4	1.1	4.1	0.0	0.4	36.3	36.7
¼ cup (38)	0.1	0.1	0.1	0.0	6.3	5.5	0.4	1.6	nd	0.2	13.8	13.9
Tomatoes[61]												
100 g	0.1	0.1	0.3	0.0	0.0	6.0	1.9	1.2	0.0	0.5	9.1	9.6
¼ cup (41)	0.0	0.0	0.1	0.0	0.0	2.4	0.8	0.5	nd	0.2	3.7	3.9
White potatoes[62]												
100 g	0.1	0.0	0.1	0.0	0.0	0.6	0.2	0.4	0.0	0.2	1.2	1.4
¼ cup (35)	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.1	0.0	0.1	0.4	0.5
Winter squash[63]												
100 g	0.1	0.1	0.2	0.0	0.1	91.1	8.8	13.4	0.0	0.3	113.3	113.7
¼ cup (35)	0.0	0.0	0.1	0.0	0.0	31.9	3.1	4.7	0.0	0.1	39.7	39.8
Zucchini[64]												
100 g	0.0	0.0	0.0	nd	0.1	2.7	0.5	1.8	0.0	0.1	5.1	5.1
¼ cup (42)	0.0	nd	0.0	nd	0.0	1.1	0.2	0.8	0.0	0.0	2.1	2.1
Mean (per 100 g)	**16.2**	**1.1**	**3.9**	**0.2**	**1.4**	**18.2**	**31.0**	**7.6**	**0.2**	**21.4**	**58.2**	**79.8**
SD (per 100 g)	**76.8**	**2.1**	**8.7**	**0.4**	**3.7**	**27.1**	**98.3**	**11.3**	**0.6**	**78.5**	**116.7**	**143.4**
Mean (per serving)	**1.7**	**0.2**	**0.8**	**0.1**	**0.4**	**4.3**	**5.2**	**2.1**	**0.0**	**2.7**	**12.1**	**14.8**
SD (per serving)	**7.7**	**0.4**	**1.9**	**0.1**	**1.4**	**7.2**	**16.5**	**3.1**	**0.1**	**8.0**	**20.4**	**22.1**

(continued)

Fruits												
Apples[65]												
100 g	0.2	0.2	1.6	0.1	0.4	1.4	0.8	0.3	0.0	2.1	2.9	4.9
1 medium (164)	0.2	0.4	2.6	0.2	0.6	2.3	1.3	0.5	0.0	3.4	4.7	8.1
Bananas[66]												
100 g	0.3	0.1	0.2	0.2	0.1	1.0	0.2	0.6	0.0	0.8	1.8	2.6
1 medium (124)	0.4	0.1	0.2	0.3	0.1	1.2	0.2	0.7	0.0	0.9	2.2	3.2
Black currants[67]												
100 g	0.4	0.9	1.2	0.1	0.1	4.6	0.1	13.3	0.0	2.6	18.1	20.8
¼ cup (38)	0.2	0.4	0.5	0.0	0.0	1.7	0.1	5.1	0.0	1.0	6.9	7.9
Blueberries[68]												
100 g	0.9	0.4	0.7	0.2	0.7	2.0	4.1	8.4	0.2	2.1	15.2	17.5
¼ cup (35)	0.3	0.1	0.2	0.1	0.3	0.7	1.4	2.9	0.1	0.7	5.3	6.1
Cantaloupe[69]												
100 g	0.2	0.0	0.1	0.1	0.0	1.8	0.3	4.7	0.0	0.3	6.8	7.1
1/8 large (200)	0.3	0.1	0.2	0.1	0.0	3.7	0.5	9.4	0.0	0.7	13.6	14.3
Cranberries[70]												
100 g	0.3	0.6	6.1	0.1	0.3	0.9	0.9	25.6	0.0	7.2	27.7	34.9
¼ cup (43)	0.1	0.3	2.6	0.1	0.1	0.4	0.4	11.0	0.0	3.1	11.9	15.0
Dried apricots[71]												
100 g	12.5	6.4	19.8	1.1	0.6	62.1	190.1	147.6	4.2	39.8	400.5	444.5
¼ cup (37)	4.6	2.4	7.3	0.4	0.2	23.0	70.4	54.6	1.6	14.7	148.2	164.4
Dried currants[72]												
100 g	0.6	2.2	10.0	0.2	1.1	5.8	3.0	10.9	0.1	13.1	20.9	34.1
¼ cup (38)	0.2	0.8	3.8	0.1	0.4	2.2	1.2	4.2	0.0	5.0	7.9	12.9
Dried dates[73]												
100 g	0.4	1.2	3.4	0.2	0.3	116.9	100.2	106.2	0.8	5.1	323.6	329.5
¼ cup (31)	0.1	0.4	1.0	0.1	0.1	36.3	31.1	32.9	0.3	1.6	100.3	102.1
Dried prunes[74]												
100 g	0.5	2.6	0.2	0.9	0.2	2.1	71.5	103.8	1.8	4.2	177.5	183.5
¼ cup (38)	0.2	1.0	0.1	0.4	0.1	0.8	27.2	39.4	0.7	1.6	67.5	69.7
Dried raisins[75]												
100 g	0.4	1.5	5.2	1.0	0.4	9.2	0.8	11.5	0.2	8.1	22.0	30.2
¼ cup (35)	0.2	0.5	1.8	0.3	0.2	3.2	0.3	4.0	0.1	2.8	7.7	10.6
Grapefruit[76]												
100 g	0.2	0.1	0.1	0.0	0.0	2.9	0.4	2.3	0.2	0.4	5.6	6.2
½ medium (205)	0.4	0.1	0.2	0.1	0.1	5.8	0.8	4.7	0.4	0.8	11.5	12.6
Grapes[77]												
100 g	0.1	0.3	0.2	0.1	0.2	6.2	0.8	1.6	0.1	0.8	8.7	9.6
¼ cup (36)	0.0	0.1	0.1	0.1	0.1	2.2	0.3	0.6	0.0	0.3	3.1	3.4
Oranges[78]												
100 g	1.1	0.8	0.5	0.0	1.8	9.2	3.1	2.5	0.2	2.4	16.5	19.0

(continued)

Table 1. (*Continued*)

Food item 100 g serving (g)	FOR	DAI	GEN	GLY	MAT	LAR	PINO	SECO	COU	Total ISO	Total LIG	Total PE
1 medium (334)	3.7	2.5	1.6	0.1	5.9	30.7	10.2	8.2	0.6	7.9	55.0	63.4
Peaches[79]												
100 g	0.5	1.1	1.0	0.0	1.6	9.5	37.1	13.6	0.1	2.6	61.8	64.5
1 medium (165)	0.8	1.8	1.7	0.1	2.7	15.7	61.2	22.4	0.1	4.3	102.0	106.4
Raspberries[80]												
100 g	1.1	3.2	4.8	0.2	0.3	8.2	17.7	11.6	0.5	9.3	37.7	47.6
¼ cup (32)	0.4	1.0	1.5	0.1	0.1	2.6	5.7	3.7	0.2	3.0	12.1	15.2
Strawberries[81]												
100 g	0.0	0.3	2.1	0.0	0.1	22.9	20.8	5.1	0.3	2.4	48.9	51.6
¼ cup (28)	0.0	0.1	0.6	0.0	0.0	6.4	5.8	1.4	0.1	0.7	13.7	14.5
Watermelon[82]												
100 g	0.0	0.0	0.0	0.0	0.0	1.1	0.3	1.4	0.0	0.1	2.9	2.9
¼ cup (35)	0.0	nd	0.0	nd	0.0	0.4	0.1	0.5	nd	0.0	1.0	1.0
Mean (per 100 g)	**1.1**	**1.2**	**3.2**	**0.3**	**0.5**	**14.9**	**25.1**	**26.2**	**0.5**	**5.7**	**66.6**	**72.8**
SD (per 100 g)	**2.8**	**1.6**	**4.8**	**0.3**	**0.5**	**28.4**	**48.4**	**42.9**	**1.0**	**9.0**	**112.3**	**119.7**
Mean (per serving)	**0.7**	**0.7**	**1.4**	**0.1**	**0.6**	**7.7**	**12.1**	**11.5**	**0.2**	**2.9**	**31.9**	**35.1**
SD (per serving)	**1.3**	**0.8**	**1.8**	**0.1**	**1.4**	**10.8**	**21.0**	**15.2**	**0.4**	**3.5**	**42.6**	**45.4**
Cereals and breads												
Bread, flax[83]												
100 g	1.7	85.0	212.3	1.8	0.2	29.2	1.6	7208.3	0.6	300.8	7239.3	7540.6
1 slice (50)	0.9	42.5	106.1	0.9	0.1	14.6	0.8	3604.2	0.3	150.4	3619.6	3770.3
Bread, multigrain[84]												
100 g	4.7	0.8	4.2	3.0	1.2	9.8	4.1	4770.4	0.5	12.6	4785.6	4798.7
1 slice (46)	2.2	0.4	1.9	1.4	0.6	4.5	1.9	2194.4	0.2	5.8	2201.4	2207.4
Bread, oat bran[85]												
100 g	0.4	0.2	0.5	0.2	0.3	3.5	1.1	7.0	0.1	1.3	11.8	13.2
1 slice (48)	0.2	0.1	0.2	0.1	0.1	1.7	0.5	3.3	0.0	0.6	5.7	6.3
Bread, rye[86]												
100 g	0.1	0.3	2.8	0.2	0.2	11.4	9.4	122.0	0.0	3.4	142.9	146.3
1 slice (58)	0.1	0.2	1.6	0.1	0.1	6.6	5.5	70.8	0.0	1.9	82.9	84.8
Bread, sesame[87]												
100 g	0.1	0.8	1.3	0.3	0.3	7.7	42.0	2.6	0.0	2.5	52.6	55.1
1 slice (58)	0.1	0.5	0.8	0.2	0.2	4.5	24.4	1.5	0.0	1.4	30.5	32.0
Bread, white[88]												
100 g	0.6	0.3	0.5	0.3	0.0	2.0	0.5	1.3	0.1	1.7	3.9	5.7
1 slice (34)	0.2	0.1	0.2	0.1	0.0	0.7	0.2	0.5	0.0	0.6	1.3	1.9
Bread, whole wheat[89]												
100 g	0.3	0.2	0.2	0.2	0.1	5.1	0.9	2.8	0.1	0.9	8.8	9.8
1 slice (35)	0.1	0.1	0.1	0.1	0.0	1.8	0.3	1.0	0.0	0.3	3.1	3.4
Cereal, high-fibre[90]												
100 g	0.5	1.0	1.3	0.6	0.3	17.2	1.1	14.5	0.2	3.3	33.1	36.6
½ cup (26)	0.1	0.3	0.3	0.2	0.1	4.5	0.3	3.8	0.0	0.9	8.6	9.5
Cereal, regular[91]												
100 g	2.9	0.4	2.4	0.5	1.3	3.2	0.3	8.9	0.2	6.3	13.6	20.0

(continued)

½ cup (14)	0.4	0.1	0.3	0.1	0.2	0.4	0.0	1.2	0.0	0.9	1.9	2.8
Cooked cereal[92]												
100 g	0.2	0.7	1.3	0.1	0.1	3.8	2.1	0.8	0.1	2.3	6.7	9.1
½ cup (111)	0.2	0.8	1.5	0.1	0.1	4.2	2.3	0.9	0.1	2.6	7.4	10.1
Couscous[93]												
100 g	0.3	5.0	0.8	0.2	nd	0.3	nd	1.6	0.1	6.3	2.0	8.3
¼ cup (34)	0.1	1.7	0.3	0.1	nd	0.1	nd	0.6	0.0	2.1	0.7	2.8
Doughnuts[94]												
100 g	0.7	1054.8	1780.6	36.3	0.1	7.2	4.6	19.6	0.1	2872.3	31.4	2903.8
1 whole (54)	0.4	569.6	961.5	19.6	0.1	3.9	2.5	10.6	0.1	1551.0	17.0	1568.1
Granola bar[95]												
100 g	0.4	1.7	3.9	0.1	1.5	8.3	14.1	3.0	0.0	6.3	26.9	33.2
1 bar (23)	0.1	0.4	0.9	0.0	0.3	1.9	3.3	0.7	0.0	1.4	6.2	7.6
Rice[96]												
100 g	0.1	0.7	0.9	0.2	0.1	3.4	0.5	0.3	0.0	1.9	4.2	6.2
¼ cup (31)	0.0	0.2	0.3	0.1	0.0	1.0	0.2	0.1	0.0	0.6	1.3	1.9
Mean (per 100 g)	**0.9**	**82.3**	**143.8**	**3.2**	**0.4**	**8.0**	**5.9**	**868.8**	**0.2**	**230.1**	**883.1**	**1113.3**
SD (per 100 g)	**1.3**	**270.6**	**457.2**	**9.2**	**0.5**	**7.3**	**10.8**	**2140.9**	**0.2**	**736.8**	**2145.1**	**2251.9**
Mean (per serving)	**0.4**	**44.1**	**76.9**	**1.7**	**0.1**	**3.6**	**3.0**	**421.0**	**0.1**	**122.9**	**427.7**	**550.6**
SD (per serving)	**0.5**	**146.2**	**246.9**	**5.0**	**0.1**	**3.6**	**6.1**	**1046.4**	**0.1**	**397.9**	**1048.7**	**1112.0**
Meat products & other processed foods												
Black licorice[97]												
100 g	398.8	22.3	21.6	1.1	1.3	39.6	32.7	341.5	3.8	443.8	415.1	862.7
¼ cup (30)	119.6	6.7	6.5	0.3	0.4	11.9	9.8	102.4	1.1	133.1	124.5	258.8
Breakfast sausage[98]												
100 g	0.2	0.0	0.2	0.0	0.1	0.3	0.1	0.3	0.0	0.4	0.8	1.2
1 whole (23)	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.1	nd	0.1	0.2	0.3
Cake[99]												
100 g	0.2	0.1	0.4	0.1	0.1	0.4	0.4	0.6	0.1	0.7	1.5	2.2
¼ cup (18)	0.0	0.0	0.1	0.0	0.0	0.1	0.1	0.1	0.0	0.1	0.3	0.4
Cookies[100]												
100 g	0.6	0.1	0.2	0.4	0.0	0.6	0.1	1.2	0.8	1.2	1.9	3.9
1 whole (16)	0.1	0.0	0.0	0.1	0.0	0.1	0.0	0.2	0.1	0.2	0.3	0.6
Ham, sliced[101]												
100 g	0.3	0.8	0.6	0.1	0.1	0.2	0.2	0.1	0.1	1.8	0.5	2.3
1 slice (25)	0.1	0.2	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.1	0.6
Hot dog[102]												
100 g	0.6	0.1	0.5	0.1	0.1	0.6	0.1	1.1	0.1	1.2	1.8	3.1
1 whole (37)	0.2	0.0	0.2	0.0	0.0	0.2	0.0	0.4	0.0	0.4	0.7	1.1
Lasagna[103]												
100 g	0.3	0.1	0.2	0.1	0.0	0.4	0.1	0.3	0.0	0.6	0.8	1.4
¼ cup (45)	0.1	0.0	0.1	0.0	0.0	0.2	0.0	0.1	0.0	0.3	0.3	0.6
Pancakes[104]												
100 g	0.8	0.2	0.9	0.1	0.1	0.3	0.5	1.0	0.1	2.0	1.8	3.9
1 whole (44)	0.4	0.1	0.4	0.1	0.1	0.1	0.2	0.4	0.0	0.9	0.8	1.7

(continued)

Table 1. (*Continued*)

Food item 100 g serving (g)	FOR	DAI	GEN	GLY	MAT	LAR	PINO	SECO	COU	Total ISO	Total LIG	Total PE
Pizza[105]												
100 g	0.2	6.5	7.7	0.1	0.2	5.9	0.5	5.8	0.1	14.6	12.4	27.0
1 slice (131)	0.3	8.5	10.1	0.2	0.3	7.7	0.6	7.6	0.1	19.1	16.2	35.4
Protein bar[106]												
100 g	0.8	788.7	1913.4	0.7	0.4	12.9	1.3	5.0	0.2	2703.6	19.6	2723.3
1 bar (56)	0.5	441.7	1071.5	0.4	0.2	7.2	0.7	2.8	0.1	1514.0	11.0	1525.0
Pumpkin pie[107]												
100 g	0.3	0.2	0.3	0.2	0.2	2.3	0.7	1.6	0.1	1.1	4.8	5.9
1 slice (114)	0.4	0.2	0.4	0.3	0.2	2.7	0.8	1.8	0.1	1.2	5.5	6.8
Soup, chicken noodle[108]												
100 g	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.2	0.2	0.4
½ cup (118)	0.1	0.0	0.1	0.0	0.0	0.1	0.1	0.0	0.0	0.2	0.2	0.5
Tuna, canned[109]												
100 g	0.2	0.1	0.1	0.0	0.1	0.5	0.2	0.2	0.0	0.4	0.9	1.3
¼ cup (40)	0.1	0.0	0.0	0.0	0.0	0.2	0.1	0.1	0.0	0.2	0.4	0.5
Mean (per 100 g)	**31.0**	**63.0**	**149.7**	**0.2**	**0.2**	**4.9**	**2.8**	**27.6**	**0.4**	**244.0**	**35.5**	**279.9**
SD (per 100 g)	**106.2**	**209.6**	**509.2**	**0.3**	**0.3**	**10.6**	**8.6**	**90.6**	**1.0**	**719.7**	**109.7**	**741.3**
Mean (per serving)	**9.4**	**35.2**	**83.8**	**0.1**	**0.1**	**2.3**	**1.0**	**8.9**	**0.1**	**128.5**	**12.3**	**141.0**
SD (per serving)	**31.8**	**117.4**	**285.1**	**0.1**	**0.1**	**3.8**	**2.6**	**27.1**	**0.3**	**401.5**	**32.7**	**405.3**
Beverages, nonalcoholic												
Coffee, decaf[110]												
100 g	0.2	0.1	0.1	0.2	0.2	1.1	0.1	3.4	0.0	0.7	4.8	5.5
10 oz (287)	0.7	0.3	0.3	0.6	0.4	3.2	0.3	9.9	0.1	1.9	13.8	15.8
Coffee, regular[111]												
100 g	0.2	0.1	0.1	0.0	0.1	0.9	0.2	4.7	0.0	0.4	5.9	6.3
10 oz (287)	0.5	0.3	0.2	0.1	0.2	2.8	0.4	13.6	0.0	1.1	16.9	18.1
Cranberry cocktail[112]												
100 g	1.0	0.2	0.3	0.0	0.0	2.1	0.2	3.6	0.0	1.5	5.9	7.5
8.5 oz (251)	2.6	0.5	0.7	0.1	0.1	5.3	0.6	9.0	0.1	3.8	14.9	18.7
Juice, orange[113]												
100 g	0.1	0.1	0.1	0.0	0.0	0.2	0.1	8.0	0.0	0.3	8.4	8.6
8.5 oz (254)	0.2	0.2	0.2	0.1	0.1	0.6	0.3	20.4	0.1	0.7	21.4	22.2
Juice, V-8[114]												
100 g	0.3	2.1	5.5	0.2	0.3	2.1	1.0	5.4	0.1	8.0	8.8	16.9
8.5 oz (249)	0.7	5.1	13.8	0.4	0.6	5.3	2.5	13.4	0.4	19.9	21.8	42.1
Milk, cow[115]												
100 g	0.1	0.0	0.1	0.0	0.1	0.3	0.2	0.4	0.0	0.3	0.9	1.2
8.5 oz (251)	0.3	0.1	0.2	0.1	0.1	0.7	0.4	1.0	0.0	0.7	2.2	3.0
Milkshake, instant[116]												
100 g	0.5	0.2	0.6	0.1	0.0	0.8	0.3	0.6	0.1	1.4	1.8	3.2
8.5 oz (199)	1.1	0.5	1.1	0.2	0.1	1.5	0.7	1.2	0.1	2.8	3.5	6.4

(continued)

Tea, black[117]												
100 g	0.1	0.4	0.1	0.1	0.1	0.2	4.0	3.8	0.2	0.6	8.1	8.9
8.5 oz (244)	0.1	1.1	0.1	0.2	0.2	0.6	9.7	9.4	0.4	1.5	19.8	21.7
Tea, green[118]												
100 g	0.1	0.4	0.2	0.0	0.1	0.1	1.4	10.4	0.3	0.7	12.0	13.0
8.5 oz (244)	0.2	0.9	0.4	0.1	0.4	0.2	3.2	25.4	0.8	1.7	29.2	31.6
Mean (per 100 g)	**0.3**	**0.4**	**0.8**	**0.1**	**0.1**	**0.9**	**0.8**	**4.5**	**0.1**	**1.5**	**6.3**	**7.9**
SD (per 100 g)	**0.3**	**0.6**	**1.7**	**0.1**	**0.1**	**0.7**	**1.2**	**3.0**	**0.1**	**2.3**	**3.3**	**4.5**
Mean (per serving)	**0.7**	**1.0**	**1.9**	**0.2**	**0.2**	**2.2**	**2.0**	**11.5**	**0.2**	**3.8**	**15.9**	**19.9**
SD (per serving)	**0.7**	**1.5**	**4.2**	**0.2**	**0.2**	**1.9**	**2.9**	**7.5**	**0.2**	**5.8**	**8.2**	**11.2**
Beverages, alcoholic												
Beer[119]												
100 g	0.3	1.3	0.0	0.0	0.0	0.6	0.3	0.2	nd	1.6	1.1	2.7
12 oz (358)	1.0	4.7	0.1	0.1	0.1	2.1	0.9	0.9	0.0	5.9	4.0	9.8
Wine, red[120]												
100 g	12.1	1.5	2.5	0.3	0.0	7.4	0.4	29.4	0.1	16.5	37.3	53.9
6 oz (176)	21.3	2.7	4.5	0.6	0.1	13.0	0.8	51.8	0.1	29.1	65.6	94.8
Wine, white[121]												
100 g	2.2	0.7	1.6	0.1	0.4	1.6	0.1	5.9	0.1	4.7	8.0	12.7
6 oz (176)	3.9	1.3	2.9	0.2	0.7	2.8	0.1	10.4	0.1	8.2	14.0	22.4
Mean (per 100 g)	**4.9**	**1.2**	**1.4**	**0.2**	**0.2**	**3.2**	**0.3**	**11.9**	**0.0**	**7.6**	**15.5**	**23.1**
SD (per 100 g)	**5.2**	**0.3**	**1.0**	**0.1**	**0.2**	**3.0**	**0.2**	**12.6**	**0.0**	**6.4**	**15.7**	**22.1**
Mean (per serving)	**8.8**	**2.9**	**2.5**	**0.3**	**0.3**	**6.0**	**0.6**	**21.0**	**0.1**	**14.4**	**27.9**	**42.3**
SD (per serving)	**9.0**	**1.4**	**1.8**	**0.2**	**0.3**	**5.0**	**0.3**	**22.1**	**0.0**	**10.4**	**27.0**	**37.5**

a: Abbreviations are as follows: FOR, formononetin; DAI, daidzein; GEN, genistein; GLY, glycitein; MAT, matairesinol; LAR, lariciresinol; PINO, pinoresinol; SECO, secoisolariciresinol; COU, coumestrol; ISO, isoflavones; LIG, lignans; PE, phytoestrogens; SD, standard deviation; nd, non-detectable.

b: Non-detectable equals reported food weight contains ≤0.00 µg; 0.0 equals detectable, reported food weight contains >0.00 but <0.05 µg; differences between reported and calculated totals and between reported per serving values and those calculated by multiplying the µg per 100 g by serving weight (g) are due to rounding of numbers to one decimal point.

c: **Additional food notes:** [1]a,b; [2]white, Hanamaruki; [3]from local Japanese restaurant, c; [4]b,d; [5]a,b,p1,p2; [6]original fortified, So Good, e; [7]b,f; [8]NHF Soydelicious; [9]VH; [10]low-fat vanilla, So Nice, e; [11]organic, Noble Bean, g,p3; [12]a,b,p3; [13]extra firm, President's Choice, e,p1,p2; [14]Yves, e,p4; [15]in tomato sauce, Heinz, h; [16]with garlic, Lee Kum Kee; [17]Unico,h,p2; [18]Unico, h,p2; [19]Unico, h,p2; [20]garlic, President's Choice, e,f; [21]red, Unico, h,p2; [22]green, a,b,p1; [23]Green Giant, g,p1,p2; [24]b,d; [25]a,b,p1; [26]aduki, organic, Eden, h,p2; [27]French Canadian, Habitant, h,p5; [28]navy,a,b,p1,p2; [29]unsalted, b,i; [30]salted, b; [31]b,d,p4; [32]brown, b; [33]b,i; [34]smooth, light, Kraft; [35]salted, cocktail, Planters, f,j; [36]b; [37]b; [38]mixed light and dark, b; [39]b,f; [40]b; [41]Sprouts Alive, d; [42]USA, d,p1,p2; [43]green, b,d; [44]Bradford's Best, Canada, d,i,p1,p2; [45]Bradford's Best, Canada, i; [46]Little Bear, USA, d,p1,p2; [47]Flyn Produce, USA, d,p1,p2; [48]straight cut, McCain, g,p6; [49]b,d; [50]b,d,p1,p2; [51]Romaine hearts, Tanimura&Antle, USA, d; [52]extra virgin, Bertolli; [53]green, jumbo, Unico, p2; [54]yellow cooking, Horodynsky Farms, Ontario, d,p4; [55]b,d,p4; [56]Sushihane, Koufuku Nori, a; [57]condensed, Campbell's, h,p5,p7; [58]Queen Victoria, USA, d,p3; [59]Queen Victoria, USA, d; [60]b,d,j,p1,p2; [61]red, hot house, b,d; [62]PEI, Canada, d,j,p1,p2; [63]butternut, Martin Farms, USA, d, p6; [64]b,d,j,p1,p2; [65]McIntosh variety, Ontario, d, i; [66]Dole, d; [67]Ontario, d; [68]Tecnovital, Argentina and Sunnyridge Farm, USA, d; [69]Central America, d; [70]Ocean Spray, d, p1,p2; [71]Turkish, b; [72]b; [73]whole pitted, b; [74]whole pitted, b; [75]California seedless, SunMaid, b; [76]Star ruby red variety, Ocean Spray, USA, d; [77]green seedless, Castlerock Vineyards, USA, d; [78]Navel variety, Sunkist, USA, d; [79]Chile, d,j; [80]Driscoll's, California, d; [81]Driscoll's California, d; [82]seedless, Little Bear, USA, d; [83]Dempsters, k; [84]12 grain, Dempsters, k; [85]wheat and oats with honey, Dempsters, k; [86]Jagdschnitten hunter style, Dimpflmeier, k; [87]Dempsters, k; [88]enriched, Wonder, k; [89]original 100%, Dempsters, k; [90]Raisin Bran, Kellogg's; [91]Cheerios, General Mills; [92]oatmeal, quick cooking, Quaker, p1; [93]President's Choice, p3; [94]plain old fashioned, 75cm diameter, Tim Hortons, c; [95]almond, Nature Valley, f; [96]white, original, converted long grain, Uncle Ben's, p3; [97]soft candy, Twizzlers; [98]all beef mini-sizzlers, Schneiders, g,p2,p3; [99]Swiss chocolate flavour, moist deluxe, Duncan Hines, p8; [100]chocolate chip, Decadent, President's Choice; [101]17% meat protein, Ziggy Black Forest, e; [102]regular wieners, Schneiders, e,p1,p2; [103]vegetable with 7 cheeses, President's Choice, g,p6; [104]original, Aunt Jemima, p8; [105]pepperoni, rising crust, McCain, g,p6; [106]chocolate chip, Vector, Kellogg's; [107]pure pumpkin, E.D. Smith, h,p8; [108]condensed, Campbell's, h,p5,p7; [109]flaked white, in water, Clover Leaf; [110]grounds, Maxwell House, p9, p10; [111]grounds, Maxwell House, p9,p10; [112]Ocean Spray; [113]homestyle with pulp, 100% juice, Tropicana, e; [114]tomato based, original vegetable blend, Campbell's; [115]2% fat, Neilson, e; [116]powder, diet, strawberry supreme, Slimfast, p8; [117]teabags, orange pekoe, Tetley, p9; [118]teabags, Tetley, p9; [119]4% alc/vol, Coors Light, Canada; [120]Merlot, Jackson-Triggs, Ontario; [121]Chardonnay, Sawmill Creek, Ontario.

Food description codes: [a] dried; [b] no brand; [c] fresh; [d] raw; [e] refrigerated; [f] roasted; [g] frozen; [h] canned; [i] with skin or peel; [j]without skin or peel; [k]pre-sliced.

Food preparation codes: [p1]boiled in water; [p2]drained; [p3]cooked in water; [p4]cooked by microwave; [p5]reheated in pan; [p6]baked in oven; [p7]prepared with water; [p8]prepared as instructed on package; [p9]steeped in boiling water; [p10]filtered.

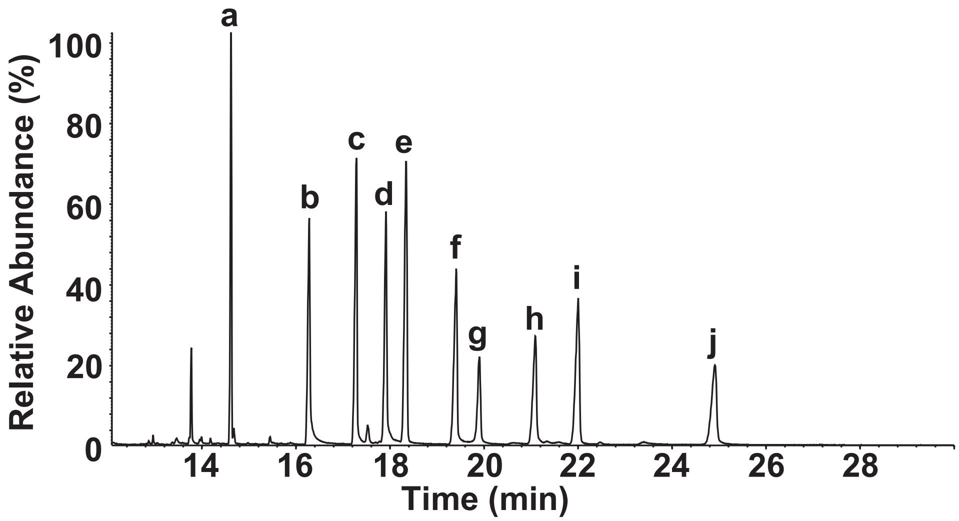

Figure 1. Typical gas chromatograph–mass spectrometer chromatogram with all phytoestrogens. a, 5α-androstane-3β, 17β-diol; b, formononetin; c, daidzein; d, genistein; e, secoisolariciresinol; f, coumestrol; g, glycitein; h, matairesinol; i, lariciresinol; j, pinoresinol.

lsilylated sample was dissolved in 150 μL of hexane. Then 1 μL aliquot was injected to GC-MS.

An Agilent 6890 series GC system (Agilent Technologies, Wilmington, DE) interfaced with an Agilent 5973 network mass selective detector and with an HP-5ms (5%-phenyl)-methylpolysiloxane capillary column (25 m × 0.12 mm i.d. × 0.25 μm film thickness; Agilent Technologies) was used for all analysis. Data acquisition and processing were carried out using enhanced Chemstation software (G1701CA version C.00.00; Agilent Technologies). Operating conditions were as follows: injection port temperature 250°C; splitless mode; carrier gas He at a constant flow rate of 1 mL/min; oven program temperature 100°C held initially for 1 min, increased at 15°C/min to 280°C and held for 17 min at 280°C (total run time 30 min); GC-MS interface temperature 280°C; MS source temperature 230°C; MS quad temperature 150°C; ionization by electron ionization (70 eV). Analysis was performed in the scan ion monitoring mode and two or three characteristic ions were chosen for each analyte or standard. The selected ions for each analyte were as follows: *m/z* 421.3, 346.3, and 436.3 for 5α-androstane-3β, 17β-diol; *m/z* 340.1 and 325.1 for formononetin; *m/z* 398.1 and 383.1 for daidzein; *m/z* 414.1 and 399.1 for genistein; *m/z* 560.3 and 209.1 for secoisolariciresinol; *m/z* 412.1 and 397.1 for coumestrol; *m/z* 428.1 and 398.1 for glycitein; *m/z* 502.2 and 209.1 for matairesinol; *m/z* 576.3 and 486.2 for lariciresinol; *m/z* 502.2 and 487.2 for pinoresinol. A typical GC-MS chromatogram with all phytoestrogens is shown in Figure 1.

Results

The phytoestrogen content of foods and food groups are provided on an as is (wet) per 100 g and a per serving basis (Table 1). Based on group averages on an as is basis per 100 g, the food groups in decreasing order of total phytoestrogens are nuts and oilseeds, soy products, cereals and breads, legumes, meat products and other processed foods, vegetables, fruits, alcoholic, and nonalcoholic beverages. If two items (protein bar and black licorice) were removed from the meat products and other processed foods group, this group would have the lowest amount of phytoestrogens. A very similar ranking of groups was observed when values were expressed on a per serving basis although fruits, nonalcoholic beverages, and vegetables moved to the lowest ranks. Likewise, excluding the beverages, a similar ranking as the as is basis was observed when the data were expressed on a moisture-free (dry) basis (data not shown), except that soy foods were higher than nuts and oilseeds, and vegetables were higher than meat products and other processed foods because of their higher moisture relative to phytoestrogen contents. Fruits did not increase in ranking because some were already partially dried as is and therefore already had low moisture content. On an as is basis, foods with the highest amounts of total phytoestrogens are soy beans, flaxseed, sesame seed, and products that contain them.

As expected, on an as is basis per 100 g, soy products (particularly soy beans and soy nuts) contained the highest concentration of total isoflavones, primarily as daidzein and genistein, followed by legumes, meat products and other processed foods (because of their soy contents), cereals and breads, nuts and oilseeds, vegetables, alcoholic beverages, fruits, and nonalcoholic beverages. Tofu, tempeh, textured vegetable protein, miso paste, and soy yogurt also have high amounts of isoflavones, with tofu having the highest. Unlike the other soy products, soy nuts have high amounts of formononetin, and soy beans have higher daidzein relative to genistein.

All non-soy products also contain isoflavones and those containing relatively high amounts of total isoflavones per 100 g in descending order are black bean sauce, doughnuts, protein bar, black licorice, alfalfa sprouts, flaxseed, and flax bread. The high isoflavone contents of flax bread, doughnuts, protein bar, and black bean sauce are likely due to the soy that may have been added during processing. Of the non-soy beverages, red wine has the highest amounts of isoflavones. Very little isoflavones are present in meat products and other processed foods, other than the protein bar and black licorice already mentioned.

All analysed foods contain lignans and, except for soy or soy containing products, most have higher concentrations of lignans than isoflavones. On an as is (wet) basis per 100 g, decreasing amounts of total lignans are found in nuts and oilseeds, cereals and breads, legumes, fruits, vegetables, soy products, meat products and other processed foods, alcoholic, and nonalcoholic beverages. In decreasing order within each group, the richest sources of total lignans among nuts and oilseeds are flaxseed, sesame seed, sunflower seed, pistachios, and chestnuts; among cereal products, other than those containing flaxseed, are rye bread and sesame bread; among legumes are hummus, mung bean sprouts, mung beans, and white (navy) beans; among fruits are dried apricots, dried dates, dried prunes, peaches, and strawberries; among vegetables are garlic, olive oil, winter squash, collards, and broccoli; among soy products are soy beans, soy nuts, and textured vegetable protein; among meat products and other processed foods are black licorice, protein bar, and pizza. Among the alcoholic beverages, red wine is the richest source, having higher total lignan (and isoflavone) values than white wine or beer. Except for milk and instant milk shake, the nonalcoholic beverages have similar amounts of total lignans although the teas tend to have slightly higher amounts than the coffees, and green tea slightly higher amounts than black tea. With few exceptions, matairesinol is the least concentrated lignan in foods. Compared with the other lignans, secoisolariciresinol was found in the highest concentration in 63 foods, lariciresinol in 44 foods, and pinoresinol in 14 foods. Coumestan, measured as coumestrol, is generally present in very low concentrations with the food groups containing decreasing amounts as follows: legumes, nuts and oilseeds, soy products, fruits, meat products and other processed foods, vegetables, cereals and breads, nonalcoholic beverages, and alcoholic beverages. Within food groups, those with the highest concentrations are (in decreasing order) in legumes, mung bean sprouts; in nuts and oilseeds, flaxseed; in soy products, soy nuts; in fruits, dried apricots; in meat products and other processed foods, black licorice; in vegetables, alfalfa sprouts; in cereals, multigrain bread; in nonalcoholic beverages, green tea; and in alcoholic beverages, white wine. Although other sprouts are rich in coumestrol, soy bean sprouts have nondetectable levels.

The richest sources of specific phytoestrogens, in descending order within each group, are formononetin in black licorice and in alfalfa sprouts; daidzein and genistein in soy beans, soy nuts, tofu, tempeh, and textured vegetable protein; glycitein in soy nuts, soy beans, miso paste, tofu, and tempeh; matairesinol in flaxseed and sesame seed; lariciresinol in flaxseed, sesame seed, sunflower seed, hummus, and pistachios; pinoresinol in sesame seed, hummus, flaxseed, garlic, and dried apricots; secoisolariciresinol in flaxseed, flax bread, multigrain bread, black licorice, and dried apricots; and coumestrol in mung bean sprouts, flaxseed, and soy nuts.

Discussion

This study provides the first database to include nine major phytoestrogens analyzed simultaneously in the same foods. The data are presented on an as is (wet) per 100 g basis to allow comparison of foods as consumed. Presentation of the data on a per serving basis, which was not done in other published databases, will facilitate the estimation of phytoestrogen intake in epidemiological and clinical studies. The specific foods that were analyzed were those identified as important phytoestrogen sources in the literature as well as those most commonly reported in our population-based survey among a sample of Ontario women. Thus the database will be particularly relevant and useful to clinical and epidemiological studies in North American populations.

This database, although comprehensive, is still incomplete because it does not include the isoflavone biochanin A and the mammalian lignan precursors syringaresinol and arctigenin, with the former, due to the inability to detect its peak using our GC-MS analytical method, and the latter two, due to lack of authentic standards that can be used for their analysis. Although known to be a mammalian lignan precursor, 7-hydroxymatairesinol was also not analyzed because it is present primarily in knot heartwood, which is not consumed by humans (60). However, the effect of these omissions may be minimal. Given that the conversion of these plant lignans to mammalian lignans by intestinal microflora was only 4–15% compared with 55–100% for the other lignans (11), their contribution to total mammalian lignan production in vivo may not be very high. In addition, biochanin A is present at very low levels, even in soy products (39), therefore its contribution to overall isoflavone intake may also be low.

For most soy products, the isoflavone levels, particularly daidzein and genistein, are within the range of values reported in the literature (36–39,61,62). However, the soy protein powder has lower concentration of total isoflavones than commonly reported perhaps because alcohol washing, which can remove some of the isoflavones, may have been used in its preparation to reduce the beany taste. Differences in isoflavone content in soy products may be related to natural differences in soy variety, growing location, and processing methods. Heat treatment of soy products particularly in the presence of water prior to analysis, which may not have been done in other studies, may also have contributed to differences in values. Phytoestrogens may be leached in water during processing as indicated by their presence in the beverages obtained when ground coffee or tea leaves are boiled in water. In previous studies, several meat products and other processed foods including sausages, pancakes, canned tuna, and hot dogs were reported to contain high amounts of isoflavones because of their soy additives (40,51,63). Because only very low levels of isoflavones were present in similar processed foods in this study, soy may be less extensively used in these products available in Ontario. However, soy appeared to be added to some cereal foods in Ontario, such as doughnuts and flax bread, but not to others, such as white bread, reported previously as high isoflavone sources (43,51,63).

It is well known that flaxseed and flaxseed containing foods (e.g., flax bread and multigrain breads) are exceptionally rich sources of mammalian lignan precursors particularly secoisolariciresinol diglucoside (12–14), but this study showed that sesame seed is also rich in lignans and is the richest source of pinoresinol. We recently observed in postmenopausal women that the high urinary mammalian lignan excretion after the intake of 25 g flaxseed was not significantly different from that after the intake of 25 g sesame seed, suggesting similar amounts of lignan precursors in both oilseeds (64). However, as found in our current study, the total amount of known mammalian lignan precursors in sesame seed, although high, was still considerably lower than that in flaxseed and cannot account for the large production of mammalian lignans in vivo (64). As is, sesame seed contains the plant lignans sesamin (537,210 μg/100g), sesamolin (134,070 μg/100g), and sesaminol (102,589 μg/100g). We (65) and others (66) recently have shown that sesamin can be metabolized to mammalian lignans and can in part account for the large production of mammalian lignans from sesame seed. Despite this, sesamin and the other sesame seed lignans were not analyzed in this study because these lignans are found primarily in sesame seed. Nevertheless, in light of these recent findings (65,66), it would be important to consider the intake of these sesame lignans in foods containing sesame seed when estimating the intake of mammalian lignan precursors.

Hummus, which has not previously been analyzed for phytoestrogen content, contains primarily chickpeas but has higher levels of all lignans compared with chick peas. Because hummus commonly contains sesame seed and garlic, their high levels particularly of pinoresinol and lariciresinol may have contributed to the high amounts of these lignans in hummus.

Milder et al. determined the amounts of secoisolariciresinol, matairesinol, pinoresinol, and lariciresinol simultaneously in the same foods although did not analyze the isoflavones (14). As in their study, we observed the presence of these lignans in almost all foods, with about half of them containing lariciresinol and/or pinoresinol at levels higher than that of secoisolariciresinol. Secoisolariciresinol and matairesinol levels in our food samples were generally higher than those reported by Horn-Ross et al. who analyzed only these two lignans, and the isoflavones in foods found primarily in California (40). They reported non-detectable amounts of these lignans in many of the foods where we reported small amounts perhaps due to the lower sensitivity of their analytical method involving high performance liquid chromatography–mass spectrometry (LC-MS) and no alkaline treatment during extraction. Alkaline extraction, which was used in our study, has been reported to increase the extractability of lignans because of its ability to hydrolyze the ester-linked oligomers of secoisolariciresiniol and other lignans not only in flaxseed but also in other foods (14,67). On the other hand, our lignan values, particularly in fruits and vegetables, are generally lower than those reported by Milder et al. who used alkaline hydrolysis for extraction and LC-MS method for quantitation (14). As in the soy products, the difference could be in part related to differences in variety, growing location, time of harvest, degree of maturity or ripeness, and processing of the foods. However, our results are in general agreement with Milder et al. regarding which food is higher in a specific lignan and the ranking of specific lignan values within a given food (14). Lariciresinol and pinoresinol intakes have been estimated in only one epidemiological study (68), indicating that lignan intake may have been underestimated in many previous studies where only the amount of secoisolariciresinol and matairesinol were accounted for (26–30,39).

In this study, the total concentrations of secoisolariciresinol, matairesinol, and lariciresinol in red wine (36.8 μg/100g) and white wine (7.9 μg/100g) were, respectively, within the range of that in red wine (24.8–48.1 μg/100 mL) and close to that in white wine (8.3–15.8 μg/mL) reported by Nurmi et al. (69). However, Milder et al. reported higher levels in both red and white wine than the above (14). Lignan concentration in wine may differ depending on the growing conditions, grape variety, and the process of winemaking, including the storage time and conditions that would allow potential leaching of lignans from the wooden barrel. Of the nonalcoholic beverages, the teas tended to have higher concentration of total lignans than the coffees, in agreement with others (14,46), although our values were about 4–6 times lower. Similarly, we observed about two times less lignan content in orange juice and tomato based (V-8) juice than reported by others (14).

Olive oil contains high amounts of lignans (142.6 μg/100g) primarily as pinoresinol although lower than that reported by others (248 μg/100g) (14), whereas olives have lower concentrations (33.2 μg/100g) primarily as secoisolariciresinol, indicating that pinoresinol may be more concentrated in the oil part of olives.

The significance of the measured food lignans depends on whether they reflect the amount of mammalian lignans that can be produced after they are acted upon by the human or animal microflora. In this study, the ranking of foods within food groups according to their decreasing concentration of total mammalian lignan precursors on an as is basis, has some similarity to the ranking of foods according to their production of mammalian lignans by human microflora in vitro (12). For example, of the oilseeds that were analyzed by both methods, flaxseed produced the highest amount of total mammalian lignans in vitro, followed by soy beans, sunflower seeds, and peanuts, similar to the results of total mammalian lignan precursor analysis in this study (12). Of the vegetables, garlic and winter squash, which contained some of the highest amounts of total mammalian lignan precursors, also produced the highest amounts of mammalian lignans in vitro. Of the fresh fruits, strawberries, which contain higher amounts of total lignan precursors than orange, cantaloupe, and bananas also produced higher mammalian lignans in vitro than these other fruits. The close similarity to the in vitro data of the relative ranking of the richest sources of lignans provides some validity to the data on mammalian lignan precursors reported here. Where the ranking of foods based on total mammalian lignans produced in foods in vitro did not exactly match that based on the precursor concentration, the difference may be related to differences in food varieties, growing locations, and processing methods. For example, dried legumes were fermented in vitro (12) whereas boiled legumes were analyzed for lignan precursor in this study.

Although some foods such as fruits, vegetables, and beverages contain low concentrations of lignans, they are consumed in large amounts and can contribute significantly to lignan intake. For example, coffee and orange juice contributed about 40% of total lignan intake in postmenopausal women in the United States (52), and beverages, vegetables, and fruits contributed 37%, 24%, and 7% respectively of total lignan intake in the Dutch population (68). In Western diets where soy beans do not contribute substantially to the diet, lignans are the phytoestrogens that are mostly consumed (28,35,52). Coumestrol is present in most foods in even lower concentration than lignans and is relatively rich in only very few foods: mung bean sprouts, flaxseed, and soy nuts. Its contribution to total phytoestrogen intake may not be significant unless individuals eat considerable amounts of these foods. Horn-Ross et al. (40) reported high concentration of coumestrol in orange juice, but almost none was observed in this study.

Phytoestrogens in foods have been suggested to have potential health benefits in reducing the risk of cancer, cardiovascular disease, osteoporosis, and menopausal symptoms (1–7). Structural similarities between estradiol and the isoflavones, lignans, and coumestans suggest that these compounds may exert their effects through binding with estrogen receptors (ER), acting estrogenically or antiestrogenically depending on endogenous estrogen levels and the type of receptor (ERα or ERβ) in specific body tissues (70,71). However, mechanisms including inhibition of tyrosine kinase (72), DNA topoisomerases II (73), and growth factors, alteration of enzymes involved in estrogen synthesis and metabolism, such as aromatase (74–76) or 17 β-hydroxysteroid dehydrogenase (75), as well as antiangiogenesis (77) and antioxidant activities (78) have also been suggested. Because individual phytoestrogens may differ in these activities, this database may also be helpful in understanding the potential effects of specific phytoestrogens found in certain foods or food combinations.

In conclusion, a comprehensive database of phytoestrogen content determined simultaneously in foods has been developed. The study demonstrated that phytoestrogen sources, particularly of the lignans, are diverse. The lignan levels are often substantial and, therefore, a variety of plant foods can contribute significantly to phytoestrogen intake in the Western diet. The database should be useful in estimating more accurately the phytoestrogen intake in epidemiological and clinical studies and in designing high phytoestrogen diets in clinical trials that are related not only to breast or prostate cancer but also to other hormone-related diseases or conditions particularly in the North American population.

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LUT is the principal investigator of this substudy, which is a component of a larger study (MC is the PI). LUT drafted the manuscript. MC, BAB, NK, and LUT identified the need for this database and obtained the funding. BAB, ZL, MC, NK helped in the writing of the manuscript. BAB and MC designed and analysed the survey to determine foods to be analysed. BAB determined the serving portions and coordinated the purchase of food. ZL developed, validated, and standardized the analytical methods and analyzed the samples. None of the authors had conflict of interest. Address correspondence to Dr. Lilian U. Thompson, Department of Nutritional Sciences, University of Toronto, 150 College St., Toronto, Ontario, Canada M5S 3E2. Phone: (416) 978–3523. FAX: (416) 978–3523. E mail: lilian.thompson@utoronto.ca.

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