

Assessing phytochemical intake in a group of Mexican women

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Abstract

Objective. Identify the content of selected phytochemicals (PHYs) in Mexican foods and evaluate the reliability of a food frequency questionnaire (FFQ) in assessing PHYs intake among Mexican women. **Material and Methods.** Values for PHYs content were obtained from four different data sets. PHYs intake was assessed in 50 women of reproductive age enrolled in a longitudinal cohort study. Values were obtained from a FFQ administered twice, one year apart in order to evaluate its reliability. Selected PHYs included flavonol (FOL), flavones (FES), flavanol (FAL), secoisolariciresinol (SE), matairesinol (MA), lariciresinol (LA), pinoresinol (PI), cinnamic acid (CA) and coumestrol (CU). **Results.** Daily PHYs intake ranged from $1.3 \mu\text{g} \pm 0.9$ for MA to 116.3 ± 43.8 mg for CA. The adjusted correlation coefficients ranged from 0.17 for FAL to 0.47 for LA. Pinto beans, oranges, hot sauce, broccoli, apples and onions were the main sources of the selected PHYs daily intake. **Discussion.** The results of this study contribute to our understanding of the consumption of PHYs in the Mexican diet, and would help evaluate their potential health impact.

Key words: phytochemical intake; Mexican populations; reliability; México

Galván-Portillo MV, Wolff MS, Torres-Sánchez LE,
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Estimación de la ingesta de fitoestrógenos
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Resumen

Objetivo. Crear una base de datos con el contenido de nueve fitoestrógenos (FIT) presentes en alimentos mexicanos y calcular su ingestión y reproducibilidad en 50 mujeres participantes en un estudio de cohorte en México. **Material y métodos.** Los FIT seleccionados incluyeron flavonol (FOL), flavones (FES), flavanol (FAL), secoisolariciresinol (SE), matairesinol (MA), lariciresinol (LA), pinoresinol (PI), ácido cinámico (CA) y coumestrol (CU). El contenido de estos compuestos se obtuvo de cuatro diferentes fuentes de datos. La ingestión diaria se estimó a través de un cuestionario de frecuencia de consumo de alimentos, aplicado en dos oportunidades con una diferencia de un año a cada participante. La reproducibilidad en el reporte de cada FIT se estimó mediante coeficientes de correlación intraclass ajustados por residuales de energía. **Resultados.** La media de consumo de los FIT seleccionados varió de $1.3 \pm 0.8 \mu\text{g/d}$ de MA hasta 116.3 ± 43.8 mg/d de CA. La reproducibilidad varió desde 0.17 para FAL hasta 0.47 para LA. Las principales fuentes de FIT fueron frijoles, naranja, salsa picante, brócoli, manzana y cebolla. **Discusión.** Este es el primer estudio que calcula la ingestión de FIT en México y podría constituir una herramienta útil para la futura evaluación de su efecto en la salud.

Palabras clave: ingesta de fitoestrógenos; población mexicana; reproducibilidad; Mexico

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Phytochemicals (PHYs) are plant compounds with estrogen-like activity. Epidemiological evidence suggest that high ingestion of these compounds is associated with a decrease on the risk of breast,¹⁻⁴ prostate,^{2,5,6} and gastric cancer,^{7,8} as well as cardiovascular diseases,^{4,9-11} osteoporosis,^{2,12-14} and menopausal symptoms.¹⁵⁻¹⁶ Fruits and vegetables are an important source of PHYs; however their consumption varies throughout the world.^{5,12,15} In Latin American countries, the energy intake from fruits and vegetables is approximately three times higher than in North America, North-Central Europe and Asian countries.¹⁷ This variation in phytochemical intake may explain differences in PHYs related disease patterns. The lack of comprehensive phytochemical composition food tables precludes the study of their health impact, especially in developing countries. This study aims to identify the content of selected PHYs in Mexican foods and evaluate the reliability of a food frequency questionnaire in assessing PHYs intake among women living in Mexico.

Material and Methods

Intake of selected PHYs was estimated in a sample of 50 women, aged between 17 and 37 years, participating in a longitudinal cohort study in the state of Morelos, Mexico from 2001-2002 that was approved by the IRB of the Mexico National Institute of Public Health.

Eligible participants were non-pregnant and non-lactating women, who reported no change in their diet over the past 12 months and signed an informed consent document. A more detailed description of the study design is published elsewhere.*

Women were asked about their dietary habits, on two different occasions using a standardized food frequency questionnaire (FFQ).^{18,19} Trained personnel completed the in-person interviews one year apart and during the same season of the year. The frequency of the consumption of foods that are sources of PHYs (54/100 items included in the FFQ) was calculated considering a pre-determined portion size and 10 frequency categories ranging from never to six times per day.

To determine PHYs intake, we developed a database of nine selected PHYs present in the 54 foods included in the FFQ. Selected PHYs included three

flavonoids (FLAV): flavonol (FOL), flavones (FES), flavanol (FAL); four Lignans (LI): secoisolariciresinol (SE), matairesinol (MA), lariciresinol (LA), pinoresinol (PI); cinnamic acid (CA) and coumestrol (COU). Mean values of FOL, FES and FAL were imputed from the 2003 USDA flavonoid data set,²⁰ while the 1998 Notice plus data base²¹ was used as a source of CA and COU. Mean values for SE, MA, LA and PI were also obtained from published databases.^{22,23} The taxonomic name, genus and species of vegetables were verified in the imputation process.²⁴ PHYs contents in mg/100g and µg/100g referred to wet edible portions. If values of PHYs for an individual food item were available from several references, we calculated a mean value from the pool of values. Non-vegetable sources of PHYs included milk chocolate, jam, wine and beer. Recipes of local dishes were also used to determine whether they included ingredients that were sources of PHYs.²⁵ The Food Intake Analysis software, along with a program written with Fox Pro v.9.0, was used to estimate the individual intake of nutrients and PHYs of interest. A detailed description of nutrient calculation is published elsewhere.²⁶

Descriptive statistics were calculated to assess the characteristics of the study population. Energy adjusted (by means of energy residuals) intra-class correlation coefficients (ρ_1) were calculated to evaluate the reliability of the FFQ results. The main food sources of selected PHYs intake were identified by partial R^2 through estimated multiple linear regression models. All analyses were performed using the statistical software package STATA 7.0.

Results

General characteristics of the study population are displayed in Table I. The study sample included mostly young (mean age 23.8 years), nulliparous (85.4%) women, with normal body mass index scores (23.7 kg/m²). Approximately half of the women had at least 12 years of education and reported having a paid job. Table II shows the imputed values (mg/100g or µg/100g in fresh edible weight) for the PHYs in the foods included in our FFQ.

Table III shows the energy-adjusted means of selected PHYs estimated in the two interviews, along with their energy adjusted intraclass correlation coefficients. The daily nutrient intake was estimated to be 2336.7 ± 476.3 kcal for energy, 76.7 ± 6.3 g for protein, 273.6 ± 26.8 g for carbohydrates and 109.5 ± 12.3 g for total fat (data not included in the table). The daily FLAV intake varied from 7.5 ± 3.8 mg for FES to 29.3 ±

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Table I
CHARACTERISTICS OF THE STUDY POPULATION

| Characteristics | (n= 50) |
|----------------------------|----------------|
| Age (years) | |
| Mean \pm SD | 23.8 \pm 4.1 |
| Median | 24 |
| Percentile 25 - 75 | 21 - 26 |
| Parity (%) | |
| Nulliparous | 85.4 |
| Parous | 14.6 |
| Body Mass Index | |
| Mean \pm SD | 23.1 \pm 3.5 |
| Median | 23.7 |
| Percentile 25 - 75 | 20.7 - 25.1 |
| Level of education (years) | |
| Mean \pm SD | 11.1 \pm 3.4 |
| Median | 12 |
| Occupation (%) | |
| Paid work | 50 |
| Housewife | 48 |
| Student | 2 |

10.1 mg for FOL. LI daily intake varied from 1.3 ± 0.9 μ g for MA to 205.3 ± 111.6 μ g for LA. CA daily intake resulted $116.3 \text{ mg} \pm 43.8$ while COU intake was 1.7 ± 1.1 mg. The adjusted correlation coefficients ranged from 0.17 for FAL to 0.47 for LA.

Foods that contributed 10% or more to the selected PHYs daily intake are shown in Table IV. Pinto beans were the main sources of CA, SE and COU intake, and apples accounted for 28.7% of the FLA intake variance. Hot sauce was the main contributor of FES and onion contributed to FOL intake. Broccoli was the primary source of LA and PI, and oranges explained 53.2% of the MA intake variation.

Discussion

These results provide information about the intake of selected PHYs in a group of Mexican women. Our database contains information about frequently consumed foods in the Mexican diet, which are sources of PHYs.

There are several important limitations to our study. First, our analyses were limited to nine selected PHYs, therefore we were not able to calculate total PHYs consumption. Second, we were unable to obtain data about the PHYs content of some local and frequently consumed foods included in the FFQ, including edible cactus, squash blossoms, mamey, zapote and prickly pears (local fruits). Finally, information about food preparation was not included in our questionnaire; therefore we were not able to adjust for its affect on PHYs content. Certain food preparation methods may alter the content of PHYs, although the magnitude of these effects is still unknown.^{1,27}

Pinto beans provided the highest percentage of three PHYs intake (SE, COU and CA). According to very recent information several PHYs are present in different kinds of Mexican beans^{28,29} however, only one type of bean was evaluated in our FFQ, further studies should include other types of beans.

The variability in the estimated intake of PHYs among countries may be explained by the fact that the many of the databases do not contain complete information on PHYs content. For example, not all database values refer to the same compounds –they may comprise as many as 4000 structurally different phytochemicals with structures varying from simple molecules (e.g. phenolic acid) to highly polymerized substances (e.g. tannins).³⁰

Worldwide comparisons of PHYs should be approached with caution, as methodologies used to calculate these estimates are not standardized.

In spite of these limitations, the results of this study provide an important first step towards improving our knowledge about the consumption of PHYs in the Mexican diet that might be useful to further evaluate their health impact.

Table II
CONTENTS OF SELECTED PHYTOCHEMICALS VALUES IN 54 FOODS

| Food item | Flavone ^{&} | Flavanol ^{&} | Flavonol ^{&} | Lariciresinol ^{#,*} | Pinoresinol ^{#,*} | Secoisolariciresinol ^{#,*} | Matairesinol ^{#,*} | Cinamic acid ^{‡,&} | Coumestrol ^{‡,&} |
|--------------------------------|--------------------------|---------------------------|---------------------------|------------------------------|----------------------------|-------------------------------------|-----------------------------|---------------------------------|-------------------------------|
| 1 Margarine | | | | 7.00 | 0.00 | 32.00 | 0.00 | | |
| 2 Red plum | 6.19* | 1.05 [§] | | 4.00 | 74.00 | 4.00 | 0.00 | | |
| 3 Yellow peach | 2.33* | | | 80.00 | 186.00 | 27.00 | 0.00 | | |
| 4 Apple | 9.09* | 3.92 [§] | | 1.00 | 0.00 | 0.00 | 0.00 | | |
| 5 Orange | | | | 47.00 | 24.00 | 5.00 | 2.00 | 8.36 | |
| 6 Orange juice | 0.35 [‡] | | 0.30 [§] | | | | | 0.24 | |
| 7 Grapes | 20.39* | 2.37 [§] | | 52.00 | 0.00 | 4.00 | 5.00 | | |
| 8 Strawberry | 4.47* | 1.74 [§] | | 117.00 | 212.00 | 5.00 | 0.00 | 6.63 | |
| 9 Blackberry | 18.74* | 1.22 [§] | | | | | | | |
| 10 Canteloupe | | | | 28.24 | 15.53 | 3.53 | 0.00 | | |
| 11 Mango | 1.72* | | | | | | | 49.22 | |
| 12 Pear | 4.25 [§] | 0.79 [§] | | 155.00 | 34.00 | 4.00 | 0.00 | 34.20 | |
| 13 Papaya | | | | | | | | 29.37 | |
| 14 Pineapple | | | | | | | | 26.20 | |
| 15 Cauliflower | 0.08* | | 0.28* | | | | | 3.07 | |
| 16 Broccoli | | 9.79 [§] | | 972.00 | 315.00 | 38.00 | 0.00 | | |
| 17 White corn | | | | | | | | 48.80 | |
| 18 Potato | | 0.06* | | 17.00 | 0.00 | 2.00 | 0.00 | 24.18 | |
| 19 Carrot | | 0.07* | | 73.00 | 27.00 | 77.00 | 0.00 | 71.48 | |
| 20 Spinach | 1.11* | | 4.88* | | | | | 0.78 | |
| 21 Lettuce | 0.44* | | 2.70 [§] | 3.20 | 1.60 | 8.60 | 0.00 | 7.13 | |
| 22 Cooked tomato with garlic | | | 0.72 [§] | 38.35 | 13.77 | 2.17 | 0.00 | 4.69 | |
| 23 Raw tomato | | | 0.72 [§] | 42.00 | 14.00 | 2.00 | 0.00 | 4.69 | |
| 24 Pinto beans | | | | | | 25.99 | | 31.83 | 1.18 |
| 25 Avocado | | 0.56* | | | | | | | |
| 26 Beet | 0.37* | | 0.13* | 3.00 | 0.00 | 1.00 | 0.00 | | |
| 27 Onion | | 106.58 [§] | | 19.00 | 0.00 | 18.00 | 0.00 | 1.33 | |
| 28 Green peas | | | | 9.30 | | 9.30 | | | 1.50 |
| 29 Lentil soup | | | 3.94 [§] | 15.60 | 3.53 | 4.74 | 0.00 | 0.89 | |
| 30 Broad beans | | 49.37* | 4.60* | | | 26.00 | | | 1.50 |
| 31 Hot sauce | 5.13 [§] | | 70.41 [§] | 10.10 | 3.72 | 2.75 | 0.00 | 8.84 | |
| 32 Pickled jalapenos | 2.33 [§] | | 36.60 [§] | 5.09 | 0.00 | 5.98 | 0.00 | 0.29 | |
| 33 Milk chocolate | | 13.35* | | | | | | | |
| 34 Marmelade | | 0.90* | 0.76* | | | | | | |
| 35 Freshly toasted bread slice | | | | 52.25 | 52.85 | 16.35 | 1.30 | | |
| 36 French rolls | | | | 11.00 | 7.00 | 0.00 | 0.00 | | |
| 37 Rice soup | | | | 2.55 | 0.00 | 5.83 | 0.00 | 2.85 | |
| 38 Pasta soup | 2.37* | | 9.82 [§] | 3.22 | 0.78 | 2.66 | 0.00 | 0.45 | |
| 39 Ground coffee | | | 0.10* | 0.12 | 0.14 | 0.15 | 0.01 | 19984.47 | |
| 40 Instant coffee | | | | | | | | 12830.57 | |
| 41 Herbal tea | 4.86 [‡] | | | 0.00 | 0.00 | 0.00 | 0.00 | | |
| 42 Black tea | 4.20 [‡] | 3.84 [‡] | | 0.01 | 0.01 | 0.00 | 0.00 | | |
| 43 Red wine | 11.90* | 1.62* | | 8.60 | 11.90 | 41.70 | 6.90 | | |
| 44 White wine | 1.38* | 0.06* | | 7.30 | 1.70 | 12.20 | 2.70 | | |
| 45 Beer | | | 0.10* | 9.00 | 21.70 | 1.00 | | | |
| 46 Vegetable oil | | | | 0.00 | 0.00 | 0.00 | 0.00 | 4.69 | |
| 47 Pastor tacos | | | 3.68 [§] | 0.76 | 0.00 | 0.89 | 0.00 | 2.00 | |
| 48 Gorditas | | 0.07* | 6.37 [§] | 10.54 | 2.92 | 4.21 | 0.00 | 2.97 | |
| 49 Memelas | | | 6.60 [§] | 2.14 | 0.50 | 1.80 | 0.00 | 1.04 | |
| 50 Pozole | | | 1.94 [§] | 0.49 | 0.00 | 0.86 | 0.00 | 0.47 | |
| 51 Sopos | | | 0.07 [‡] | 0.12 | 0.00 | 0.53 | 0.00 | 0.42 | |
| 52 Quesadillas | 0.03 [§] | | 0.11 [§] | 0.07 | 0.00 | 17.04 | 0.00 | 21.40 | 0.76 |
| 53 Pambazos | 0.02 [‡] | | 4.18 [§] | 9.68 | 2.96 | 3.02 | 0.00 | 7.04 | |
| 54 Garlic | | | | 286.00 | 200.00 | 50.00 | 0.00 | | |

* USDA flavonoid database

‡ Notis plus database

§ USDA flavonoid and notis plus databases

Milder *et al* 2005 and Mazur *et al* 1997

& mg/100g wet edible food

* mg/100g wet edible food

Table III
ENERGY ADJUSTED MEANS AND CORRELATION
COEFFICIENTS OF DAILY INTAKE
OF SELECTED PHYTOCHEMICALS

| Phytochemical | 1 st FFQ* | 2 nd FFQ† |
|-----------------------------------|----------------------|----------------------|
| Flavonol (mg/d) [#] | | |
| Mean ± sd | 31.8 ± 15.1 | 26.8 ± 11.3 |
| ρ_i^{\S} | 0.18 | |
| Flavones (mg/d) [#] | | |
| Mean ± sd | 8.7 ± 5.2 | 6.3 ± 4.0 |
| ρ_i^{\S} | 0.21 | |
| Flavanol (mg/d) [#] | | |
| Mean ± sd | 11.9 ± 6.5 | 8.1 ± 5.3 |
| ρ_i^{\S} | 0.17 | |
| Cinnamic acid (mg/d) [#] | | |
| Mean ± sd | 133.1 ± 50.2 | 99.6 ± 50.8 |
| ρ_i^{\S} | 0.37 | |
| Lariciresinol (µg/d) [#] | | |
| Mean ± sd | 236.5 ± 144.1 | 174.1 ± 98. |
| ρ_i^{\S} | 0.47 | |
| Pinoresinol (µg/d) [#] | | |
| Mean ± sd | 102.0 ± 62.5 | 73.4 ± 36.5 |
| ρ_i^{\S} | 0.39 | |
| Secoisolariciresinol (µg/d) | | |
| Mean ± sd | 122.7 ± 63.6 | 122.9 ± 93.1 |
| ρ_i^{\S} | 0.37 | |
| Matairesinol (µg/d) [#] | | |
| Mean ± sd | 1.5 ± 1.2 | 1.1 ± 1.0 |
| ρ_i^{\S} | 0.18 | |
| Coumestrol (mg/d) | | |
| Mean ± sd | 1.7 ± 1.1 | 1.7 ± 1.5 |
| ρ_i^{\S} | 0.39 | |

* Administered in Morelos, Mexico during 2001

† Administered in Morelos, Mexico during 2002

§ Energy adjusted

ttest $p < 0.05$

Table IV
FOODS THAT CONTRIBUTE ≥ 10% TO THE SELECTED
PHYTOCHEMICAL INTAKE OF STUDY POPULATION

| Food | Phytochemicals | % intake |
|-------------|----------------------|----------|
| Pinto beans | Secoisolariciresinol | 75.8 |
| | Coumestrol | 66.9 |
| | Cinnamic acid | 20.5 |
| Broccoli | Lariciresinol | 20.0 |
| | Pinoresinol | 10.3 |
| Orange | Matairesinol | 55.2 |
| Apple | Flavonol | 28.7 |
| Hot sauce | Flavones | 48.0 |
| Onion | Flavonol | 16.5 |

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