

Evaluation of the composition of the regional diet in Sonora, México: Incidence of colon cancer

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SUMMARY. Diet is responsible for about one third of the cancers. Dietary fiber, energy intake, fat and consumption of fruits and vegetables play an important role in different cancers. The regional Mexican diet is characterized as being high in dietary fiber, high in fat and energy but very low in fruits and vegetables. The diet is high in insoluble fiber and phytate. The objective of this study was to evaluate the composition of the regional diet and relate this composition to the incidence of colon cancer in the northern region of México. Two traditional diets, one higher in fruits and vegetables, but both high in fat and dietary fiber were evaluated. A mathematical expression showed the typical regional diet to be low in antioxidant nutrients, even though an earlier study showed it to have a tendency to protect against colon cancer. During the years of 1991-1995, Sonora, México reported about 20 cases/ 100,000 inhabitants of colon cancer. This incidence is low compared to other regions and high dietary fiber is thought to be responsible. If antioxidant nutrient intake was elevated, possibly a greater protection could be achieved.
Key words: Fiber, phytates, antioxidants, colon cancer

RESUMEN. Composición de la dieta regional de Sonora, México: Incidencia de cáncer de colon. La dieta es responsable de aproximadamente un tercio de los cánceres. La ingesta de fibra dietética, energía, grasa y el consumo de frutas y verduras tienen un papel importante en el desarrollo de diferentes cánceres. La dieta mexicana tradicional se caracteriza por ser alta en fibra dietética, alta en grasa y energía pero muy baja en frutas y verduras. Es alta en fibra y fitatos insolubles. El objetivo de este estudio fue evaluar la composición de dietas regionales y relacionar esta composición a la incidencia de cáncer del colon en la región noreste de México. Se evaluaron dos dietas regionales, una con mayor contenido de frutas y verduras, pero ambas altas en grasa y fibra dietética. Una ecuación matemática mostró que la dieta típica presentó pocas nutrientes antioxidantes, aunque se encontró en estudio anterior una baja incidencia de cáncer del colon en ratas tratadas con un agente carcinógeno cuando fueron alimentadas con la dieta típica. Durante los años de 1991-1995, Sonora, México, reportó aproximadamente 20 casos/ 100.000 habitantes de cáncer del colon. Esta incidencia es baja comparado a otras regiones y probablemente se debe al alto consumo de fibra dietética, aunque esta protección no es completa. Adicionalmente, el alto consumo de fitatos con su efecto antioxidante tiene un papel importante. Se recomienda aumentar el consumo de nutrientes antioxidantes en la dieta típica.

Palabras clave: Fibra, fitatos, antioxidantes, cáncer de colon.

INTRODUCTION

Sonora, México is the most northern state of México, bordering the state of Arizona, USA. Due to its proximity to the United States the culture in Sonora is readily influenced by its neighbor. The diet in Sonora, México is rapidly changing and is influenced to a certain extent by the changes occurring in the socioeconomic development of the area. The advent of North America Free Trade Agreement (NAFTA) has brought even greater changes with the appearance of fast food chains and introduction into the marketplace a wide selection of imported processed foods. Comparing Sonora to other states of México, less poverty exists, average incomes are higher, and there are less nutritional problems. Most studies conducted in Sonora, in recent years, indicate the diet is adequate in protein although the diet is high in vegetable protein.

Many studies have shown that dietary levels of antioxidants

greatly affect plasma levels and the body's ability to protect against oxidative damages (1) and resultant diseases such as heart disease or cancer (2-4). One of the body's first defenses against cell damage from free radicals is the body's natural antioxidants. For colon cancer many factors play important roles in the diet. Studies have shown dietary fiber (5) and energy density to be very important (6) as well as certain antioxidants (4). Also of importance in this study is the potential antioxidative reaction of phytates (7,8). The typical Mexican diet is high in dietary fiber, high in saturated fats and low in antioxidants, due to the low consumption of fresh fruits and vegetables. In a review of the epidemiological evidence of the intake of fruit and vegetables and cancer prevention, Block, et. al. (9), showed a statistically significant protective effect of fruit and vegetable consumption for most cancer sites. The objective of this study was to evaluate the composition of the regional Mexican diet and relate this composition to the

incidence of colon cancer in the northern region of México.

MATERIAL AND METHODS

Diets

Diet information was obtained from a 24 h dietary recall for 550 adults, 25 years or older and diet preparation was according to methods reported by Wyatt et al., (10). Nutritional analysis of the diets was obtained using database, Nutritionist IV, (11). The two diets studied, are both high in fat and fiber but differ in the antioxidant content due to a decrease in fruit and vegetable consumption for the lower income population. The regional diets were designated HFHFLA (HIGH FAT, HIGH FIBER, LOW ANTIOXIDANT) for the typical diet and HFHFHA (HIGH FAT, HIGH FIBER, HIGH ANTIOXIDANT) for the diet that is consumed by the population with a higher income.

Fiber determination

Soluble, insoluble and total dietary fiber were determined by the AOAC Sec. 45.4.07, (12) utilizing dietary fiber kits (TD FAB-1 Sigma Chemical Co., St. Louis, MO and Tecator filtering and incubation equipment (Fibertec system E 1023, Tecator, Sweden).

Total phytates

Total phytates were determined by the AOAC method, Section 986.11 (13). The method was modified slightly in the digestion procedure. If digestion was incomplete after treatment with acids as specified in the technique, the samples were placed in a muffle furnace for 8 h at 535 C. The method was validated with a reference material, Red Wheat Bran (American Association of Cereal Chemists, 3340 Pilot Knob Road, St. Paul, MN 55121) using the values for phytates reported by Harland and Oberleas (14) and Harland et al. (15).

Antioxidant quotient

The Antioxidant Quotient (AQ), mg, was expressed as a mathematical value using the following equation:

$AQ = a + 0.8b + 0.17c + 0.5d + e + 0.5f + 0.1g + h$; where

a = ascorbic acid

b = dehydroascorbic acid

c = β carotene

d = other carotenoids

e = a tocopherol

f = β tocopherol

g = δ tocopherol

h = selenium

The biological activity of each nutrient was taken into consideration in the formula (16). Because of lack of data for all of the isomers of the different nutrients, for our situation the formula was reduced to the following:

$$AQ = a + c + e + h$$

Statistical analysis

Data were evaluated by one way ANOVA for treatment means ($p < 0.05$) using a computer software package, NCSS 97 (17).

RESULTS AND DISCUSSION

The main energy and protein providers in the traditional Mexican diet are beans, corn tortillas and flour tortillas. Basically, 20 different foods represent the most commonly consumed items in Sonora and the order of frequency is the only thing that will vary by regions (18). Table 1 presents the 20 basic food items and their per capita consumption in the traditional diet. In practically all regions, beans occupy first place, or the most frequently consumed item, followed by coffee, soda, corn and flour tortillas, and milk. The order is dictated, more than anything, by availability and price, that is to say in some of the small towns, corn tortillas are not readily consumed because no commercial source exists, and the families depend upon flour tortillas prepared in the home. The flour for corn tortillas is subsidized by the Mexican government and therefore, commercially, corn tortillas are less expensive than flour tortillas.

TABLE 1
Basic food items and percapita consumption for the regional diet (18).

Basic food item	g/d
Beans, refried	211
Milk	223
Soda	192
Coffee	156
Corn tortilla	121
Meat	67
Flour tortilla	88
Eggs	52
Potatoes	42
Tomatoes	32
White bread	27
Pasta soup	26
Mexican white cheese	13
Rice	20
Beer	35
Oranges	42
Bananas	15
Fish	10
Sugar	13
Lettuce	10

Description of the diet

Table 2 presents the food items and g consumed per day for

the two regional Mexican diets and Table 3 presents the daily intake of antioxidant nutrients, dietary fiber and the calculated AQ of the HFHFHA and HFHFLA diets as well as some references values for previous published studies for white American adults. Diet HFHFLA is representative for the majority of the population, which is considered to be low income. The distribution of energy in the traditional diet is 50% from carbohydrates, 14% from protein and 36% from fat. The traditional Mexican diet mimics the diet of industrial developed countries with its high fat content, however, it differs greatly in its dietary fiber content. The diet is characterized as being high in fat, high in dietary fiber, and low in antioxidant nutrients. The total dietary fiber intake is 44 g/d (Table 3) and the three basic food items of beans, corn and flour tortillas constitute 68% of the total dietary fiber intake with a daily per capita consumption of 217, 128, and 180 g respectively.

TABLE 2
Regional Mexican diets, high in fiber and fat, and low or high in antioxidants.

Food item	HFHFLA g/d	HFHFHA g/d
Beans, refried	217	70
Tortillas, corn	128	82
Tortillas, flour	180	52
Potatoes, fried	98	47
Soda	380	270
Milk	228	376
Coffee	435	397
Eggs, fried	70	69
Rice, steamed	112	111
Cheese, white	40	
Tomatoes	68	45
Chile, serrano	10	15
Onions	25	27
Sugar	24	23
Vegetable oil	10	19
Meat, fried	60	104
Bread, white		74
Lettuce		42
Carrots		19
Celery		5
Oranges		100
Beef, dried		43
Beer		710
Avocados		92

HFHFLA-high in fat, high in fiber, low in antioxidants.

HFHFHA-high in fat, high in fiber, high in antioxidants.

As income improves, fiber consumption decreases and antioxidants increase (Table 3), 30 g/d and an AQ of 95 compared to 1.7 for the HFHFLA diet. Diet HFHFHA is

typical for individuals with higher income (Table 2). The distribution of energy in this diet is 45% from carbohydrates, 14% of the calories from protein, 35% from fat, and 6% from alcohol. It shows an increase in the consumption of fresh fruits and vegetables and more animal products, which are more expensive food items.

Fiber has received a great deal of attention in relation to diet and certain diseases, particularly cancer (19). Large differences exist between human populations in the frequency of colonic cancer. Epidemiological evidence indicates that these differences are strongly influenced by country of residence, and a negative correlation has been found between the fiber content of the diet and frequency of colonic cancer. Other dietary factors such as, type and amount of fat, calories and antioxidants like ascorbic acid, vitamin E, and carotenoids are very important when one considers dietary factors and cancer.

Using the values reported for what antioxidant nutrients that were available from the references studies for American adults, AQ's were calculated to compare these values with the values reported in this study. Calculated AQ's ranged from 39.54 (20) to 89.1 (21). Dietary fiber intakes of 6.6 and 13.2 g/d were reported in two of the studies (22,23). Comparing the data of this study to these values, the traditional regional Mexican diet, HFHFLA, represents a high intake of dietary fiber, 44 g/d with a corresponding low AQ of 1.71. The diet representative of the higher income group, HFHFHA, has a lower dietary fiber intake, 30 g/d, but still well above the typical intake for Americans and an AQ that is high but similar to the value calculated for the NHANES II study (21).

It is recognized that a large number of potentially anticarcinogenic chemical components are present in foods such as folate, indoles, isothiocyanates, allyl derivatives, plant sterols, isoflavones, protease inhibitors, and coumarins (24) and these compounds could participate in the protective effect. These compounds were not included in the formula but as more quantitative information becomes available, the expression can be fine tuned to be more inclusive.

Other studies have reported on antioxidant capacity or activity of individual foods or diets, measured by different means. Robinson et al., in 1997 (25), reported on the antioxidant activity of black tea using the enhanced chemiluminescence technique. This activity was attributed to the flavonoids and other polyphenols found in tea. Also by the chemiluminescent assay, red wine was evaluated as to its effect on serum antioxidant capacity (26). The Mediterranean diet, which is high in fresh fruit and vegetables, was described as having a high antioxidant potential and modulates oxidative stress through complex mechanisms (27).

Type of fiber, whether it is soluble or insoluble seems to be related with colon cancers. The traditional regional diet is very high in insoluble fiber, 88 % (Figure 1). Insoluble dietary fiber passes through the digestive tract largely unmetabolized and is thought to help in the elimination of carcinogens. Per Sjodin

et. al., (29) showed insoluble fibers reduced the uptake of a food carcinogen and decreased the transit time through the gastrointestinal tract. The increased fecal bulk provided by fiber will dilute colonic contents.

TABLE 3
Daily intake of antioxidant nutrients and dietary fiber of the HFHFHA and HFHFLA diets with reference values

Diet	Ascorbic Acid ¹ (mg/d)	α -tocopherol ² (mg/d)	β -carotene ³ (mg/d)	Selenium ⁴ (mg/d)	Dietary Fiber (g/d)	AQ
HFHFHA	93	1.8	0.77	0.26	30.4	95.19
HFHFLA	24.6	1.5	0.21	0.17	44.6	26.33
CARDIA (20)	22.1	17	2.6			39.54
Newell et al (22)	41.1				6.6	41.1
San Antonio (23)	63.7					63.7
NHANES II (21)	89.1				13.2	89.1

1 unpublished data

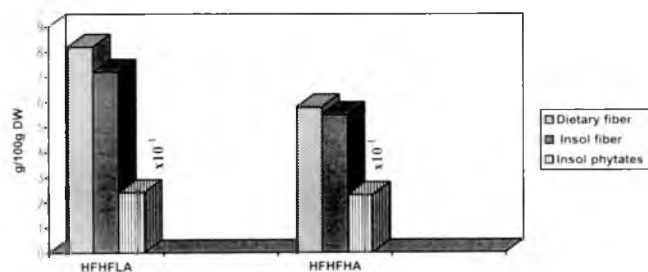
2 Wyatt et al., (28)

3 Nutritionist IV (11)

4 Wyatt et al., (10)

FIGURE 1

Dietary fiber, insoluble fiber and insoluble phytates in regional Mexican diets



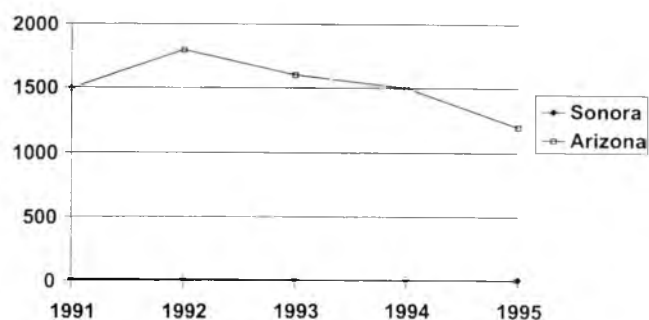
Diets high in phytates have been thought to play a protective role in cancer by the phytates acting as an antioxidant. Phytic acid forms iron chelates, inhibiting *in vitro* iron catalyzed hydroxyl radical formation. (Fenton reaction) and lipid peroxidation (7,8). Unlike flavonoids and most other antioxidants, phytic acid does not act as an antioxidant by scavenging radicals, but it exerts its activity through inhibition of the iron-mediated generation of hydroxyl radicals. On the assumption that phytic acid suppress oxidant damage to intestinal epithelium cells in this or in another way, its possible anticarcinogenic properties have been studied intensively. Epidemiological studies indicate that the prevalence of colon cancer declines with increasing intake of dietary fiber. It has been hypothesized therefore that high levels of dietary phytate may protect against colon cancer (7,8). The regional Mexican diets are not significantly different ($p=0.001$) in their insoluble phytate content. The HFHFLA contains 238 mg insoluble phytates/ 100 g, on a dry weight basis, compared to 225 mg/100g for the HFHFHA diet (Figure 1).

Cancer situation

Health statistics for the state of Sonora present an interesting panorama in regards to the incidence of colon and stomach cancer in comparison to its neighboring state of Arizona, and other more industrialized countries. Figure 2 presents the number of cases of colon cancer reported in the states of Sonora and Arizona for the period of 1991-1995.

FIGURE 2

Number of reported cases of colon cancer in Sonora, México and Arizona, USA



As can be seen, the cases of colon cancer are very low for the state of Sonora. On the basis of population, the number of cases of colon cancer in Arizona is over ten fold greater than in Sonora (30,31). The lack of adequate consumption of fruits and vegetables to cancer incidence has been related to most types of cancer (lung, larynx, oral cavity, esophagus, stomach, colon and rectum, bladder, pancreas, cervix, and ovary (9, 32). Ferguson et. al., in 1995 (33) reported on an interesting study that has particular application to this paper. These workers

evaluated the intake of specific food plants by Polynesians as compared to other ethnic groups in New Zealand and attempted to explain the incidence of colorectal cancer that is observed between these groups. Unfortunately they failed to obtain actual data on dietary intake which would have been a real contribution of the study. They attributed the lower incidence of colorectal cancer observed in the Polynesians to the differences in consumption of specific food plants. The Polynesians have high intakes of alcohol, fat, energy, and high body mass indexes, all of which are very similar to characteristics of Mexicans and their diet. One important difference is the high intake of dietary fiber in the Mexican diet which is attributed mainly to beans and tortillas, not fruit and vegetables that constituted the major food plants in the New Zealand study, although some legumes were included.

In an earlier study in rats (34), the traditional regional diet (HFHFLA), which represents the diet for approximately 72% of the Mexican population (10) was shown to have a tendency to protect against colon cancer. This effect was attributed to the high dietary fiber content of the diet.

CONCLUSIONS

From the data of this study it appears that the typical regional Mexican diet offers a degree of protection against the development of colon cancer, however not completely. This effect is attributed to the high dietary fiber content of the diet. Additional protection could be obtained with higher levels of antioxidant nutrients. This combined epidemiological and experimental data confers with the findings of others, that diets rich in fiber and phytic acid are associated with decreased risk of colonic cancer in human populations.

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