

Enteric Pathogens in Mexican Sauces of Popular Restaurants in Guadalajara, Mexico, and Houston, Texas

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Background: The transmission of traveler's diarrhea is primarily foodborne.

Objective: To examine the level of microbial contamination of tabletop sauces found in Mexican-style restaurants.

Design: Cross-sectional study of Mexican sauces.

Setting: Mexican restaurants in Guadalajara, Mexico, and Houston, Texas, during the summer of 1998.

Measurements: 71 sauces from Guadalajara and 25 sauces from Houston were examined. The number of sauces contaminated with *Escherichia coli*, the median number of *E. coli* colonies per gram of sauce, and enteropathogens were identified.

Results: 47 of 71 sauces from Guadalajara were contaminated with *E. coli* versus 10 of 25 sauces from Houston ($P = 0.03$); the median number of *E. coli* colonies per gram of sauce was 1000 in the Guadalajara sauces versus 0.0 in the Houston sauces ($P = 0.007$). Among sauces from Guadalajara tested for diarrheogenic *E. coli*, 4 of 43 sauces contained enterotoxigenic *E. coli* and 14 of 32 contained enteroaggregative *E. coli*.

Conclusions: Contamination with *E. coli* was common in samples of Mexican tabletop sauces from Guadalajara restaurants. These sauces commonly contained enteric pathogens.

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Traveler's diarrhea is the main health problem in international tourism in terms of frequency and economic impact (1). We previously found that among cases of traveler's diarrhea with known causes, approximately 80% were caused by bacterial enteropathogens (2, 3). Contaminated food was the major vehicle of transmission of these infections (4-6).

We studied Mexican sauces in Guadalajara, Jalisco, Mexico, to determine levels of *Escherichia coli* contamination and the presence of enteropathogens. We also studied a comparison group of similar sauces from Mexican-food restaurants in Houston, Texas.

METHODS

We studied the level of contamination of tabletop sauces because they are a typical food found in most restaurants in Mexico and are commonly consumed by international tourists. We collected samples of Mexican sauces—popularly known in the United States as “green sauces,” guacamole, “pico de gallo,” and “red sauces”—from restaurants in the summer of 1998. We tested 71 sauces from 36 independently owned Mexican-style restaurants in Guadalajara that are known to be popular among U.S. travelers. We also studied a comparison sample of 25 similar sauces from 12 popular Mexican-style nonchain restaurants in Houston, Texas. For the Houston sample, we arbitrarily decided to include ap-

proximately one third of the number of samples and restaurants studied in Guadalajara.

A well-mixed tablespoon-size (approximately 15 mL) sample of each type of sauce was collected from each restaurant in sterile containers. The samples were efficiently transported to our laboratories in Guadalajara or in Houston and were processed by trained personnel who followed the same standard procedures. The temperature of the sauces was not recorded. If the sample was collected in the evening, it was refrigerated at 4 °C overnight and processed the next morning.

The samples were diluted in sterile distilled water at a ratio of 1 to 10 and were placed in sterile Whirl-Pak bags (American Scientific Products, Houston, Texas) for homogenization in a Stomacher 400 blender (Dynatech Laboratories, Alexandria, Virginia). The pH of the food samples was determined by using a laboratory pH meter (Dynatech Laboratories).

Enteric pathogens were identified from the sauces according to published methods (7). Five *E. coli*-like colonies were retrieved from MacConkey agar plates of each food sample, stored in peptone media, and transported to our laboratory in Houston, where they were tested for the presence of enterotoxigenic *E. coli* by DNA hybridization and for enteroaggregative *E. coli* by HEp-2 adherence assay.

The level of *E. coli* contamination was determined by placing serial twofold dilutions of food suspensions in

4-methylumbelliferyl- β -D-glucuronide medium plates. This method has proven to be as efficacious as and faster than conventional microbiological techniques (8, 9). *Escherichia coli* was chosen as an indicator of fecal contamination because it is more specific than measurements of total fecal coliforms (8, 9).

Significant differences between groups were assessed by using the Fisher exact test to compare prevalence and the Wilcoxon rank-sum test to compare medians of sauce contamination in the two locations. We defined statistical significance as a *P* value less than 0.05.

Discretionary funds from the University of Texas–Houston Medical School were used to support the collection and analysis of the data.

RESULTS

All samples were collected from sauce containers noted to be sitting on the tables at room temperature when we arrived at the restaurants in Guadalajara. In Houston, all of the sauces were brought to the tables on our arrival, and we noted that they were cold to the touch.

Of the 96 samples of Mexican sauce that we studied, all tested negative for non-*E. coli* enteropathogens. Forty-seven (66%) of the 71 samples from Guadalajara grew *E. coli*, with a median count of 1000 *E. coli* colony-forming units (CFUs) per gram of sauce (range, 0 to 80 000 CFU/g). Of the 25 sauce samples from Houston, 10 (40%) grew *E. coli*, with a median of 0.0 CFU/g. We found a significant difference between sauces from the two cities when we compared the percentage of samples contaminated with *E. coli* (*P* = 0.03) and the median amount of *E. coli* colonies per sample (*P* = 0.008) (Table). The number of samples with *E. coli* contamination, as well as the median and total CFUs per gram of *E. coli*, were consistently higher in the samples from Guadalajara compared with Houston.

Guacamole was the most frequently contaminated sauce tested in both cities; all three samples in Guadalajara and three of four samples in Houston tested positive for *E. coli*. The level of contamination of the guacamole sauces was higher in the Guadalajara samples than in the Houston samples (median, 4000 CFU/g vs. 10 CFU/g; *P* = 0.029). Moreover, among the sauces from Guadalajara restaurants, we found that the type of sauce containing the highest level of contamination was pico

Context

Traveler's diarrhea is a foodborne illness. Identification of potentially contaminated food types can help physicians counsel patients.

Contribution

These investigators tested Mexican-style condiment sauces from 36 restaurants in Guadalajara, Mexico, and from 12 restaurants in Houston, Texas.

Escherichia coli was present in 47 of 71 sauces from Guadalajara and 10 of 25 sauces from Houston. Enterotoxigenic *E. coli* was present in 4 of 43 tested sauces from Guadalajara; enteroaggregative *E. coli* was present in 14 of 32 tested sauces from Guadalajara.

None of the Houston sauces contained enteropathogenic *E. coli*.

Implications

Restaurant condiment sauces are a potential source of *E. coli* enteropathogens in Guadalajara.

—The Editors

de gallo (median among all pico de gallo samples, 10 000 CFU/g), followed by guacamole (median, 4000 CFU/g) and green sauce (median, 1000 CFU/g). The samples of red sauce contained the lowest levels of contamination (median, 100 CFU/g). For each type of sauce studied, the Houston samples had lower median counts of *E. coli*, ranging from 0.0 CFU/g to 10 CFU/g.

Of the 47 *E. coli*-contaminated sauces from Guadalajara, 43 were available to be tested for enterotoxigenic *E. coli* and 32 were available for enteroaggregative testing. Enterotoxigenic *E. coli* was identified in 4 (9%) of the sauces, and enteroaggregative *E. coli* was found in 14 sauce samples (44%). All contaminated samples from Houston were tested for diarrheogenic *E. coli* strains, and neither enterotoxigenic *E. coli* (*P* = 0.128) nor enteroaggregative *E. coli* (*P* = 0.002) was identified. The average pH of all sauces from Guadalajara was 4.6 (range, 3.6 to 6.3), compared with 4.9 (range, 3.2 to 6.5) for the Houston sauces (*P* > 0.05).

DISCUSSION

Traveler's diarrhea is mainly a foodborne illness (4–6). We studied samples of sauces from popular restaurants in a tourist-oriented city—Guadalajara, Mexico—where rates of traveler's diarrhea are known to be high (2, 3). Our

Table. Presence of *Escherichia coli* in Tabletop Sauces from Public Mexican-Style Restaurants in Guadalajara, Mexico, and Houston, Texas

Type of Mexican Sauce	Proportion of Tested Samples with <i>Escherichia coli</i> Detected	P Value	Mean Level of Contamination (Range)	Median Level of Contamination	P Value*
	<i>n/n</i> (%)		CFU/g†		
Green					
Guadalajara	12/17 (71)	0.091	8077 (0–80 000)	1000	<0.007
Houston	1/4 (25)		2.5 (0–10)	0.0	
Red					
Guadalajara	25/42 (60)	0.070	3624 (0–40 000)	100	0.043
Houston	4/13 (31)		3.1 (0–10)	0.0	
Guacamole					
Guadalajara	3/3 (100)	>0.2	8333 (100–20 000)	4000	0.029
Houston	3/4 (75)		7.5 (0–10)	10	
Pico de gallo					
Guadalajara	7/9 (78)	>0.2	11 333 (0–40 000)	10 000	0.023
Houston	2/4 (50)		2.8 (0–10)	0.5	
All sauces					
Guadalajara	47/71 (66)	0.022‡	5866 (0–80 000)	1000	<0.008
Houston	10/25 (40)		3.6 (0–10)	0.0	

* *P* value for comparison of median levels between the Guadalajara and Houston sauces. For all comparisons reflected in this column, the difference was statistically significant.

† Colony-forming unit per gram of contaminated sauce sample.

‡ Statistically significant difference between values for Guadalajara versus Houston.

study has several unique features: 1) We tested a specific and popular kind of food (Mexican sauces) from a group of nonchain restaurants that were open to the public, and 2) we compared the level of contamination of Mexican sauces from a city (Guadalajara) in a developing country with that of similar sauces from a city (Houston) in a developed country. We used this commonly consumed food item as a marker of fecal contamination.

In our study, the Mexican sauces from Guadalajara more frequently contained fecal contaminants, and the median level of contamination (as measured by *E. coli* colonies per gram of sauce) was more than 1000 times greater than that of the sauces from Houston. We have previously shown frequent enteropathogen contamination of food samples in Guadalajara (6).

We found enterotoxigenic and enteroaggregative *E. coli*, currently the major causes of diarrhea in travelers visiting Guadalajara (2, 3), in the sauces studied. Thus, these foods may play a role in the acquisition of illness. We previously reported a high prevalence of enterotoxigenic *E. coli* in cases of traveler's diarrhea and the isolation of enterotoxigenic *E. coli* in food samples in Guadalajara (4–6). Although the presence of enterotoxigenic *E. coli* in food served in Mexico has been reported previously, this is one of the first descriptions of enteroaggregative *E. coli* contamination of such food.

Enterotoxigenic *E. coli* is a newly recognized pathogen in the group of diarrheogenic *E. coli* (3, 10). Its pathogenic role has been confirmed in outbreaks and in volunteer studies (11), and recent studies by our group have shown that enteroaggregative *E. coli* is nearly as important as enterotoxigenic *E. coli* in causing traveler's diarrhea in Guadalajara (3). The prevalence of enteroaggregative *E. coli* in Mexican sauces may provide valuable information about the source of symptomatic and asymptomatic enteroaggregative *E. coli* infection in U.S. students visiting Guadalajara (12).

It is a popular notion that low pH protects against bacterial food contamination. However, our results suggest that pH is an ineffective deterrent to microbial contamination because *E. coli* contamination was found in sauces with acidic pH levels. This finding could be explained by the recently described capacity of some *E. coli* strains to adapt to acidic conditions (13, 14).

The higher level of *E. coli* contamination in the sauces in Guadalajara could be explained by the amount of time that sauces were kept at room temperature. We noted that the sauces in Guadalajara were prepared on the premises and were not refrigerated before or between meals, while the Houston sauces were refrigerated before they were served to customers. Moreover, we believe that the sauces were more likely to be handled by mul-

tiple workers and patrons (reuse of the same sauce) in Mexico than in Houston. Further studies of food hygiene practices are needed to clarify the dynamics of microbial contamination.

Our study is limited by a small sample size, the evaluation of sauces in only two cities, and the lack of inclusion of persons consuming these foods for acquisition of illness. Although our results are not generalizable to all Mexican and U.S. cities, our findings clearly show greater prevalence of and a higher level of *E. coli* contamination in the Mexican sauces from Guadalajara, Mexico, than in those from Houston, Texas. Also of importance, the principal pathogens causing traveler's diarrhea in this part of Mexico were commonly found in the tested sauces. We feel that travelers to Mexico should be cautious about consuming sauces served on the table, particularly if previous refrigeration cannot be assured.

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