
SHORT PAPER

Faecal contamination and enterotoxigenic *Escherichia coli* in street-vended chili sauces in Mexico and its public health relevance

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SUMMARY

The street-vended food industry provides employment and cheap ready-to-eat meals to a large proportion of the population in developing countries like Mexico, yet little is known about its role in the transmission of food borne diseases (FBD). Because of its wide consumption, street-vended chili sauces in Mexico are potential vehicles of FBD. An observational study was performed in Mexico City collecting 43 street-vended chili sauces. These sauces were prepared under poor hygienic conditions of handling and selling. Consumers add 4–8 ml of chili sauce per taco, ingest 2–5 tacos per meal and on average, 50 consumers frequent a stall per day. Seventeen (40%) samples were faecally contaminated and 2(5%) sauces harboured sufficient enterotoxigenic *Escherichia coli* to cause disease. We estimate that the consumption of only one of these chili sauces could result in ETEC disease in at least 21 000 consumers per year, making them important potential vehicles of FBD.

Economic ‘adjustments’ have dramatically increased the ‘informal economy’ in Mexico. During 1993–8 this sector employed 28.5% of the labour force, generating 12.7% of the national gross product, with 30.8% of its commercial activity in street-vended food [1]. Conservative estimates suggest that the latter provides employment to at least 120 000 street-food vendors in Mexico City alone [2]. In addition, this industry provides, especially in large cities, cheap ready-to-eat meals close to the work place of a large proportion of the population, mostly the poor or middle class. Although practically absent in industrialized countries, street-vended food must be considered when assessing the impact of food borne disease (FBD) in developing countries. Food safety and FBD are increasingly important public health issues worldwide. In the USA, FBD causes approxi-

mately 76 million illnesses, 325 000 hospitalizations and 5000 deaths [3]. Certain food items make excellent vehicles of disease as the infectious dose needed to cause illness is greatly reduced when the organisms are ingested together with food but not with water. Such is the case with *Vibrio cholerae* [4] where, in order to produce high attack rates of cholera, normal volunteers need to ingest as many as 10^{11} cholera vibrios in water. In contrast, when the stomach acid is neutralized or vibrios are ingested with certain food items, the infectious dose is reduced to as low as 10^2 – 10^3 organisms.

Chili sauce consumption in Mexico has ancient precolumbian roots [5] and it is a traditional dressing of most typical street-vended meals. The sauces are made of several ingredients including chili, onion, red and green tomatoes, and coriander. The ingredients can be raw or cooked. Chili has been used since precolumbian times for popular healing preparations,

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Table 1. Frequency and toxigenicity of *Escherichia coli* in chili sauces samples (n = 43) sold on the street

Faecally contaminated samples 17 (40%)				ETEC contaminated samples 2 (5%)		
Chili sauce type	Positive samples	CFU/g range	CFU/g mean	Chili sauce type	CFU/g	Positive LT/ST strains
Green sauce	12	2–1300 × 10 ²	177 × 10 ²	Green sauce	7.6 × 10 ³	5/5
Red sauce	5	4–300 × 10 ²	74 × 10 ²	Green sauce	1.3 × 10 ⁴	5/5

for stomachache and treatment of cough [5]. Even today, it is widely believed that chili consumption is beneficial for nasal decongestion, as an antiseptic or even against some diarrhoeal diseases. Furthermore, it has been documented that some chili species (*Capsicum* spp.) [6] or their alkaloid capsaicin [7] display antimicrobial activity against some Gram-positive bacteria, namely *Bacillus cereus*, *B. subtilis*, *Clostridium tetani*, and *C. sporogenes*, and on *Escherichia coli* and *Ralstonia (Pseudomonas) solanacearum*.

Enterotoxigenic *E. coli* (ETEC) is the leading cause of weanling diarrhoea in developing countries and of travellers' diarrhoea around the world [8]. It is estimated that ETEC in children under age 5 years cause 400 million cases and 700 thousand deaths per year world wide [9], the main vehicles of transmission being water and food [8]. Several studies have shown the importance of ETEC in infant [10,11] and travellers' diarrhoea in Mexico [12,13], but nevertheless little is known of its prevalence in food.

We set out to determine whether chili sauces are potential vehicles of FBD and carried out an observational study to assess the prevalence of *E. coli* and ETEC in street-vended chili sauces. The area selected for the survey was 'La Villa', north of Mexico City, which has a high concentration of street-food vendors and consumers, with an average of 6000000 visitors estimated per year because of its importance as a national and international place of pilgrims. During summer–autumn 1999, 43 samples of street-vended chili sauces (30 green-chili, 13 red-chili) were collected. A record was made of the general hygienic conditions of the selling place and the street-vendor, the average amount of chili sauce added per taco and the number of tacos consumed per person, as well as the average number of consumers per stall/day. The acidity was determined for all samples (range of pH 4–5), and 100 µl of each sample and their respective dilutions were plated on MacConkey agar and incubated at 37 °C overnight. The number of *E. coli*-like colonies was counted and five colonies were selected and tested for indole production. Indole

positive isolates were analysed by a colony hybridization method [14] using DNA probes to detect the genes for heat-labile (LT) and heat-stable (ST) enterotoxins. Probes were prepared by labelling the LT and ST PCR products with digoxigenin-11-UTP (Boehringer Mannheim GmbH, Mannheim, Germany) and the primers were as previously described [15]. The label was detected with anti-digoxigenin-AP antibodies (Boehringer Mannheim).

Table 1 shows that each of the five selected colonies of the ETEC positive green chili sauces was positive for LT and ST toxins, and thus was potentially pathogenic. Considering that consumers added 4–8 ml of chili sauce per taco, ingested 2–5 tacos per meal, that the stalls were visited on average by 50 consumers per day, and that one of the chili sauces contained 1.3 × 10⁴ ETEC/g, we estimated that consumption of a contaminated sauce could result in ETEC disease in at least 21000 consumers per year. This poses a significant health risk to consumers. Consumption of street-vended food and the risk of developing travellers' diarrhoea has been linked in Mexico [16–18], where, as in other countries, sampling of food and water from areas of endemic infection has demonstrated high rates of ETEC contamination [19–21] although the ETEC concentration in food was not reported. Experiments with well-fed volunteers show that to establish infection relatively high doses (10⁸ cfu of ETEC) in water are required to achieve high attack rates [22]. However, it is widely held that when ingested with food the infectious dose may be reduced by at least 1000-fold.

Street-vended chili sauces in Mexico City are prepared, handled and sold under poor hygienic conditions. They are made at home the same day or a day before sale and remain exposed to the street environment for about 8 h without refrigeration providing conditions highly favourable for microbial growth. This survey shows that street-sold sauces are important potential vehicles of FBD as a result of (a) their wide daily consumption, (b) prevailing popular beliefs of their benefit, (c) inappropriate sanitary

conditions and (d) the type and amount of microbial contamination detected. There is a lack of information on the prevalence of ETEC in foods worldwide due mainly to the fact that ETEC is not routinely screened for owing to the lack of a rapid and inexpensive detection method. To the best of our knowledge there is only one report of ETEC isolation from food in Mexico [19]. This latter study included food from homes, supermarkets, restaurants and street-vendors in Guadalajara, Mexico and from restaurants in Houston USA. ETEC was isolated only from two samples (shrimp and potato salad) purchased in a supermarket in Mexico.

Consumption of street-vended food in Mexico [16–18] and other developing countries [23–25] has also been linked to travellers' diarrhoea or 'Montezuma's revenge' in Mexico. Thus, attempts to improve the safety of this food should improve public health. Indeed, in order to reduce the risk posed by street-sold food, rather than penalizing their sale which impinges only upon the street-vendors economy, other measures are urgently required in big cities and tourist areas. For example, accessibility of street-food vendors to potable water with appropriate waste disposal and toilet facilities. Food safety educational campaigns for both handlers and consumers [26] and identification of the main pathogens and sources of food contamination would also be beneficial.

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REFERENCES

1. 'Cuenta Satélite del Subsector Informal de los Hogares 1993–1998' Instituto Nacional de Estadística e Informática (INEGI), México, 2000.
2. Lomeli A. Los serios riesgos de la venta callejera. Asociación Mexicana de Estudios Para la Defensa del Consumidor (Boletín de Prensa), 30 de abril, 2001.
3. Mead PS, Slutsker L, Dietz V, et al. Food-related illness and death in the United States. *Emerg Infect Dis* 1999; **5**: 607–25.
4. Estrada-García T, Mintz ED. Cholera: Foodborne transmission and its prevention. *Eur J Epidemiol* 1996; **12**: 461–9.
5. de Sahagún B. Historia General de las Cosas de la Nueva España (originally written in 1582). 7th ed. Mexico: Porrúa S.A., 1989: 585–95.
6. Cichewicz RH, Thorpe PA. The antimicrobial properties of chile peppers (*Capsicum* species) and their uses in Mayan medicine. *J Ethnopharmacol* 1996; **52**: 61–70.
7. Molina-Torres J, García-Chavez A, Ramírez-Chavez E. Antimicrobial properties of alkaloids present in flavouring plants traditionally used in Mesoamerica: affinin capsaicin. *J Ethnopharmacol* 1999; **64**: 241–8.
8. Nataro JP, Kaper JB. Diarrheagenic *Escherichia coli*. *Clin Microbiol Rev* 1998; **11**: 142–201.
9. Todd E. Epidemiology of foodborne diseases: a world wide review. *World Health Stat Q* 1997; **50**: 30–50.
10. Cravioto A, Reyes RE, Ortega R, Fernández G, Hernández R, López D. Prospective study of diarrhoeal disease in a cohort of rural Mexican children: incidence and isolated pathogens during the first two years of life. *Epidemiol Infect* 1988; **101**: 123–4.
11. Huilan S, Zhen LG, Mathan MM, et al. Etiology of acute diarrhoea among children in developing countries: a multicentre study in five countries. *Bull WHO* 1991; **69**: 549–55.
12. DuPont HL, Ericson CD. Prevention and treatment of traveler's diarrhea. *N Engl J Med* 1993; **328**: 1821–7.
13. Arduino RC, DuPont HL. Traveler's diarrhoea. *Baillieres Clin Gastroenterol* 1993; **7**: 365–85.
14. Sambrook J, Fritsch EF, Maniatis T. Molecular cloning. A laboratory manual, 2nd ed. New York: Cold Spring Harbor Laboratory Press, 1989; **1**: 92–104.
15. Stacy-Phipps S, Mecca JJ, Weiss JB. Multiplex PCR assay and simple preparation method for stool specimens detect enterotoxigenic *Escherichia coli* DNA during the course of infection. *J Clin Microbiol* 1995; **33**: 1054–9.
16. Tjoa WS, DuPont HL, Sullivan P, et al. Location of food consumption and travelers' diarrhea. *Am J Epidemiol* 1977; **106**: 61–6.
17. Ericsson CD, Pickering LK, Sullivan P, DuPont HL. The role of location of food consumption in the prevention of travelers' diarrhea in Mexico. *Gastroenterology* 1980; **79**: 812–6.
18. Ericsson CD, DuPont HL, Mathewson III JJ. Epidemiologic observations on diarrhea developing in U.S. and Mexican students living in Guadalajara, Mexico. *J Travel Med* 1995; **1**: 6–10.
19. Wood LV, Ferguson LE, Hogan P, et al. Incidence of bacterial enteropathogens in foods from Mexico. *Appl Environ Microbiol* 1983; **46**: 328–32.
20. Ryder RW, Sack DA, Kapikian AZ, et al. Enterotoxigenic *Escherichia coli* and reovirus-like agent in rural Bangladesh. *Lancet* 1976; **i**: 659–63.
21. Vadivelu J, Feachem RG, Drasar BS, et al. Enterotoxigenic *Escherichia coli* in the domestic environment of a Malaysian village. *Epidemiol Infect* 1989; **103**: 497–511.
22. DuPont HL, Forman SB, Hornick RB, et al. Pathogenesis of *Escherichia coli* diarrhea. *N Engl J Med* 1971; **285**: 1–9.
23. Oyemade A, Omokhodion FO, Olawuyi JF, Sridhar MK, Olaseha IO. Environmental and personal hygiene practices: risk factors for diarrhoea among children of Nigeria market women. *J Diarrhoeal Dis Res* 1998; **16**: 241–7.
24. Ries AA, Vugia DJ, Beingolea L, et al. Cholera in

- Piura, Peru: a modern urban epidemic. *J Infect Dis* 1992; **166**: 1429–33.
25. Bryant HE, Csokonay WM, Love M, Love EJ. Self-reported illness and risk behaviours amongst Canadian travellers while abroad. *Can J Public Health* 1991; **82**: 316–9.
26. Estrada-Garcia MT. Cholera and street food. *Lancet* 1997; **350**: 1032.