Critical Control Points of Street-Vended Foods in the Dominican Republic

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(Received for publication May 15, 1987)

ABSTRACT

Hazard analyses were conducted at four street-vending stands in the Dominican Republic. Temperatures of foods were measured during cooking, display (holding), and reheating (when done). Samples were taken at each step of the operation and at 5 to 6-h intervals during display. Foods usually attained temperatures that exceeded 90°C at the geometric center during cooking and reheating. At three of the stands, foods (e.g., fish, pork pieces) were fried and held until sold. Leftovers cooking and reheating. At three of the stands, foods (e.g., fish, temperatures that exceeded 90°C at the geometric center during cooking and reheating. At three of the stands, foods (e.g., fish, pork pieces) were fried and held until sold.

Samples were taken at each step of the operation and at 5 to 6-h intervals during display. Foods usually attained temperatures that exceeded 90°C at the geometric center during cooking and reheating. At three of the stands, foods (e.g., fish, temperatures that exceeded 90°C at the geometric center during cooking and reheating. At three of the stands, foods (e.g., fish, pork pieces) were fried and held until sold.

During the interval of holding, aerobic mesophilic counts progressively increased with time from about 10^5 after cooking to between 10^9 to 10^10/g. The higher counts were usually associated with holding overnight. Escherichia coli (in water, milk and cheese samples), Bacillus cereus (in water, milk and cheese samples), and Clostridium perfringens (in meat, chicken and bean samples) were isolated, but usually in numbers less than 10^5/g. At the other stand, foods (e.g. beans, rice, meat and chicken) were cooked just before serving as complete meals. There were no leftovers. This operation was less hazardous, although there were many sanitary deficiencies. Recommendations for prevention and control of microbial hazards (mainly reducing holding time, periodic reheating and requesting reheating just before purchasing) are given. The need and suggestions for implementing educational activities to alert and inform those concerned about hazards and preventive measures are presented.

Street vendors of foods are a common part of the lifestyle in countries in which there are high unemployment, low salaries, limited work opportunities, limited social programs and urbanization. Persons who sell foods on streets benefit from a positive cash flow, are often free from taxes, can sell what they want, are able to set their own work hours (but which are often long), are frequently free from regulation because the few existing regulations on the subject are usually not enforced, and can get into business with a minimal outlay of capital. Street vendors provide an essential service to factory, construction and office workers, shoppers, persons in transit, persons with low income and others by selling complete meals, refreshments and snacks at a relatively low price without delay for preparation. The long distance between home and work place forces many workers to eat away from home. Facilities that meet modern standards of sanitation and provide food at low prices, however, are not always located near work places, markets, schools, parks, recreation events or bus stops.

Because of these situations and of the crowds of people at these locations, street vendors often congregate. Purchasers of street-vended foods are often preoccupied with food prices and convenience rather than with food safety, quality and hygiene.

There are many concerns about the sanitation of street vending operations. For example, stands and carts used by vendors are often of crude construction. Running water is seldom available at the stands. Hand, dish and utensil washing is usually done in one or more buckets or pans of water (sometimes without soap) and disinfection is rarely done. Waste water is usually discarded in streets and garbage is sometimes discarded nearby providing attraction, food and harborage for insects and rodents. Foods are ineffectively protected from flies. Most importantly, safe food storage temperatures are difficult to maintain. Furthermore, toilet and lavatory facilities are not readily available, which forces vendors to eliminate their body wastes in nearby secluded areas, and they often do not properly wash hands afterwards. Foods are either prepared in these itinerant places or in the homes of the vendors, which may also lack sanitary facilities. The situations described are typical of street vending in many places throughout the world as well as the Dominican Republic.

Health risks are associated with initial contamination of raw foods with pathogenic bacteria and subsequent contami-
nation by vendors during preparation from cross contamination, survival of pathogens during preparation, and microbial proliferation during display.

In countries where street vending of foods is common, there is usually a lack of information about the incidence of foodborne diseases, and investigations of outbreaks of these diseases is seldom done. (This is so in the Dominican Republic). Yet, diarrheal diseases are commonly experienced by persons of all ages. The relative importance of street- vended foods in contributing to diarrheal disease, in general, and outbreaks of foodborne diseases, in particular, is undefined. (Also, the situation in the Dominican Republic). Epidemiologic associations between street- vend foods and illnesses, however, have been made (10,17). Furthermore, certain foods (e.g., poultry, pork, beef, fish and rice) that are sold by street vendors are frequently identified as vehicles during investigation of outbreaks of foodborne disease in countries that have surveillance activities. Pathogens, indicator organisms or groups, and high numbers of aerobic mesophilic microorganisms have been isolated from street- vended foods (8,9,14,16,17). The high counts suggest microbial propagation.

To develop a better understanding of the microbiologic problems associated with street- vended foods, hazard analyses were used to identify hazards and to assess risks associated with street- vended foods in Santo Domingo, Dominican Republic. Critical control points were determined and preventive measures suggested.

**MATERIALS AND METHODS**

**Hazard analyses**

Hazard analyses were made of three street- vending stands along a busy street in Santo Domingo, and a fourth vendor on a neighborhood street was visited twice but only food temperatures were measured. The hazard analyses consisted of observing food preparation and storage practices to identify sources and modes of actual or potential contamination. The hazard analysis critical control points concepts is reviewed in reference (19). Temperatures in internal regions of foods were measured throughout cooking, during holding after cooking, and during reheating (when this was done). Samples were taken of foods at sequential stages of preparation and subsequently tested for aerobic mesophilic colony counts and pathogens of concern.

Food temperatures were measured by inserting a thermocouple (type T) with a needle- type sensor of appropriate length with the point near the geometric center and with the shaft mostly covered by the food. Air temperatures were taken with type- T thermocouples with welded ends. Thermocouples were washed, immersed in 95% alcohol and flamed three times before inserting into foods. The thermocouple leads were plugged into either a battery- powered data logger (MLX Minilogger, A. D. Data Systems, Inc., Rochester, N. Y.) or a hand- held battery- powered potentiometer (Atkins Digital Thermocouple, 497, Atkins Technical, Gainesville, FL.; reference to trade marks does not constitute recommendation by the sponsoring institutions nor by the authors). Time was recorded automatically on the data logger and observed from a wrist watch when the hand- held potentiometer was used.

Observations made at the vending sites were evaluated by diagramming sequential flow of foods during preparation and holding. Potential sources of contamination from raw foods, equipment, utensils, and persons preparing the foods as well as likelihood of microbial survival or destruction and likelihood of microbial multiplication were noted on the diagram. Critical control points that need to be monitored were indicated at appropriate steps of the operations.

Samples of foods that were collected were not the same as those having thermocouples attached, but they underwent the same process. They were taken either after cooking or reheating or during holding, as appropriate, to evaluate either a potential hazard or control measure. These were collected aseptically with either metal spoons or forks which had been cleaned and then inserted into 95% alcohol and flamed. The inserting into alcohol and flaming was repeated three times. Samples were put into sterile Whirl- Pak plastic bags. Food- contact surfaces were sampled by rubbing a sterile swab over them to attempt recovery of Salmonella. If the surface was dry, the swab was first moistened in sterile 0.1% peptone water (Difco). The cotton- tipped end of the swab was broken into a tube of tetrathionate (Difco) brilliant green broth.

Samples were put immediately in an insulated container with ice, and they were taken to the laboratory on the day of collection. Examination started either on that day or samples were kept refrigerated overnight and tested the next morning.

**Laboratory procedures**

Ten g of solid or semi- solid analytical samples were homogenized with 90 ml of 0.1% peptone water in plastic bags by using a Stomacher 400. Liquid or semi- liquid analytical samples were mixed by inversion before 10 ml were taken. Decimal dilution(s) were made according to ICMSF (13). Aerobic mesophilic colony count (AMCC) was made by the pour plate method (ICMSF) (13) method 1.

Beans and rice, only, were tested for Bacillus cereus. If it was enumerated on phenol- red egg- yolk polymyxin agar (prepared from ingredients) by spreading 0.25 ml of the homogenate on each of four petri plates and 0.1 ml per dilution on duplicate plates. The plate lids were cracked open in an incubator for 15 min at 50°C to prevent spreading before incubation at 35°C for 24 h (13). Motility- nitrate and Voges- Proskauer tests were used for confirmation.

Meat, poultry and beans were tested for Clostridium perfringens. It was enumerated by inoculating 1 ml of the homogenates and their dilutions into tryptose sulfite cycloserine agar without egg yolk (prepared from ingredients) in duplicate plastic pouches prepared according to Bladel and Greenberg (3). Incubation was done at 35°C for 48 h. Gelatin- lactose and motility- nitrate tests were used for further confirmation (13).

Water, milk and cheese were tested for Escherichia coli. Biovar 1 was enumerated on tryptone bile agar (prepared from ingredients), by using acetate filter membrane (pore sized 0.45 μm; 85 mm- diameter, Millipore) according to the procedure of Anderson and Baird- Parker (1).

For isolation of Salmonella, analytical samples of 25 g were preenriched in 225 ml of lactose broth (Difco or Merck). Either selenite broth (Difco) or selenite cisteine (Merck) and tetrathionate brilliant green broth (Difco) were used as selective enrich-
Figure 1. Contamination, survival and growth of microorganisms associated with the preparation and display of fried chicken and fried fish and critical control points of operations and monitoring of Street Vendor 1 in Santo Domingo, Dominican Republic.

STREET-VENDED FOODS

**LIME**
**TEMPERATURE**
**TIME LIMIT**
**TO 6 H.**
**BETWEEN**
**REHEATING**
**CHICKEN PIECES**
 **FISH**

**WATER**
**VINEGAR**
**LEMON JUICE**
**COMMERCIAL SEASONING**
**SALT**
**WHEAT FLOUR**
**lard**

**BREAD**
**DEEP-FAT FRY**

**INSPECT**

**SEASON**

**PUNCHC H**

**CCP: TEMPERATURE**
**DEEP-FAT FRY X**

**CCP: TIME LIMIT TO 6 H., BETWEEN REHEATING**
**HOLD AT AMBIENT TEMPERATURE +**

**CCP: TEMPERATURE**
**REFRIGERATION REQUEST X**
**SERVE**

**LEGEND**

△ INITIAL CONTAMINATION LIKELY
△ CONTAMINATION FROM EQUIPMENT/UTENSIL SURFACES LIKELY
▽ CONTAMINATION BY PERSONS HANDLING FOODS LIKELY
CCP: CRITICAL CONTROL POINT
X INACTIVATION OF VEGETATIVE FORMS OF BACTERIA LIKELY
+ PROPAGATION OF BACTERIA LIKELY
S SPORES
- OPERATIONAL STEP NOT ALWAYS CARRIED OUT

Descriptions of the street vending operations

Several street vending operations were visited before the analysis to select operations that were typical. Others were visited afterwards by teams to confirm that similar procedures were carried out and that similar hazards prevailed.

Street Vendor 1 was located on a busy street along side other vendors in a factory district near an area where transport vans parked for loading. The vendor’s stand consisted of a rectangular metal frame, approximately 1 m x 1 m x 2 1/2 m high having three shelves in the upper portions and a cabinet in the bottom. Cooked foods were put on white paper on the lower two shelves. Sheets of plastic were draped from several stands to a fence on the other side of a side walk to provide some protection from rain and sun.

The stand was operated by the owner and an assistant between 06:00 and 22:00 hours. Most business was done around noon, but sales were made sporadically throughout the day.

Foods served were fried chicken, fried pork ribs with rind (chicharrón), fried fish (Bocito), fried ham and pieces of fried pig’s head. Fried pork ribs with rind and pig’s head were boiled before frying in lard.

Cooking was done over charcoal in a metal tire-rim (supported by three legs that were welded to the rim) in the street in front of the stand. The cooked foods were displayed on the shelf.
until sold: when sales were made, foods were either reheated or not, as requested by the customer. Requests for reheating, however, were unusual during the time that the survey was made. According to the operator, food leftover at the end of the day was taken to his home and put into a refrigerator. It, however, was either not very cold, the foods were kept in bulk during storage, or the story was untrue because the foods were at ambient temperature when the vendor began operations the following morning. At that time, leftover foods were reheated by deep-fat frying. The operation was observed and temperature measurements were taken from 06:00 until 20:30 one day and from 06:00 until 10:00 the next day. Figures 1 and 2 illustrate the steps of the operation and indicate critical control points.

Street Vendor 2 sold fried pork ribs with rind, pork belly, ham, beef, sausage, cheese, plantains, corn bollito (corn dough with anise), wheat torreja (containing salted fish, green pepper and vegetables), and boiled yuca.

Two men operated the stand from about 06:00 until 21:00 or 22:00 hours. The stand was located in a factory district on the same street as Vendor 1 (two blocks away) near a busy intersection and transfer point for taxis, vans and trucks that carried people to various locations throughout the city and suburbs. The stand was crudely made of wood and consisted of a cabinet and overhead framing. A plastic sheet was draped from the framing to a 2 1/2-m high wall in back of the stand to provide some protection from the sun and rain. Another sheet of plastic was put over the food when it was raining.

Cooking was done, by charcoal, in pots supported either on a metal rack a half meter above the ground or on a square metal-frame behind the vendor’s stand. Foods were prepared in a manner similar to that used by Vendor 1, but they were initially cooked and sometimes reheated in the early afternoon instead of early morning. Cooked foods were displayed on top of the cabinet in a white metal pan. Sporadic sales occurred throughout the day. More foods were leftover than sold, and these were piled into a plastic bucket and put in the cabinet overnight. Reheating

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**Figure 2.** Contamination, survival and growth of microorganisms associated with preparation and display of pork ribs (with attached rind) and pieces of pig’s head and critical control points and monitoring of operations of Street Vendor 1 in Santo Domingo, Dominican Republic.

<table>
<thead>
<tr>
<th>CCP: Temperature</th>
<th>CCP: Time Limit to 6 H Between Reheating</th>
<th>CCP: (\times) Inactivation of Vegetative Forms of Bacteria Likely</th>
<th>CCP: (\times) Propagation of Bacteria Likely</th>
<th>CCP: Critical Control Point</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pork Ribs with Fat and Skin or Pig’s Head</td>
<td>Scrape</td>
<td>Cut</td>
<td>Puncture</td>
<td>DEEP-FAT FRY</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(\Delta) Initial Contamination Likely</td>
</tr>
<tr>
<td></td>
<td></td>
<td>HOLD AT AMBIENT TEMPERATURE +</td>
<td>REFRY (\times) (On Request)</td>
<td></td>
</tr>
<tr>
<td>WATER</td>
<td>LEMON JUICE</td>
<td>COMMERCIAL SEASONING</td>
<td>SALT</td>
<td>LARD</td>
</tr>
</tbody>
</table>
Figure 3. Temperatures of foods prepared by Street Vendor 1, Santo Domingo, Dominican Republic.

Figure 4. Documented (from Table 1) and extrapolated time-temperature exposures of foods prepared and displayed by Street Vendor 1, Santo Domingo, Dominican Republic.
Cooked beans in her home the day before leaving them at ambient temperature overnight. This process obviously permitted considerable multiplication of microorganisms, because the AMCC of the beans before cooking on the day of final preparation was 1.8 x 10^7/g (Table 1). During cooking at the vending site, the beans were boiled for approximately 1 h (Fig. 9), yet the AMCC was still quite high (9.2 x 10^7/g) just before serving. Spore formers were probably present, but B. cereus and C. perfringens were not recovered.

Rice was heated to near-boiling (Fig. 9). Shortly after cooking, the AMCC was 1.0 x 10^7/g, most of the organisms were B. cereus (Table 1).

Chicken attained a temperature of 82°C (180°F) during cooking (Fig. 9); the AMCC after cooking was 5.0 x 10^7/g. A surprisingly high AMCC (9.0 x 10^7/g) was found in the recently cooked meat.

Salmonella (polyvalent II) was isolated from a swab sample taken from the wooden table used to cut meat. Enterobacteriaceae (but no Salmonella) was isolated from the cooked beans. Salmonella was neither isolated from wash water from raw chicken nor from swabs rubbed over raw chicken skin, raw meat, or the table on which chicken was prepared.

The water activity was 0.95 for a sample of fried ham, 0.88 for fried sausage, 0.93 for bollito, 0.92 for torreja, 0.82 for fried fish and 0.83-0.94 for fried chicken.

During display of foods by Vendor 4 at 17:00 hour, food temperatures ranged from 27-41°C (80-150°F); the temperature of the air in the cabinet was 27°C (80°F). Foods would have remained within this temperature range until either they were sold or until the shop closed, and longer for foods left overnight.

A few samples of foods were collected from other vendors. Two raw milk samples had AMCC of 1.0 x 10^7/g and 9.9 x 10^7/g; S. aureus counts of 2.5 x 10^7/g and 4.4 x 10^7/g, respectively; E. coli biovar I was <10/g in both. A mixture of concentrated milk and orange juice (PH3.5) had an AMCC of 2.7 x 10^7/g. Pastel de hoja (minced meat in mashed plantains wrapped in banana leaves) had an AMCC of 1.0 x 10^7/g and a B. cereus count of 1.5 x 10^7/g when collected at 18:00 hours (59°C/138°F).

**RESULTS**

Food preparation activities by Street Vendor 1 are summarized in Fig. 1 and 2. Time/temperature exposures during cooking, displaying and reheating of many foods that were prepared are illustrated in Fig. 3; laboratory results are listed in Table 1. Fish and chicken reached a temperature of 99°C (210°F) (Fig 3). After 1.5 h of display on the stands, their temperatures fell to 49°C (120°F) or below and continued downward toward the ambient temperature. The temperature remained between 49°C (120°F) and 21°C (70°F) for 22 h until foods were reheated the next morning, unless they were sold before then. During reheating, temperature above 74°C (165°F) and usually near or above 94°C (200°F) were attained. While on display for approximately 8 h after cooking (at 14:00 hours), AMCC of the foods ranged from 1.0 x 10^7/g to 3.4 x 10^7/g. After an additional 5.5 h (at 19:30), the AMCC ranged from 1.3 x 10^7/g to 9.1 x 10^7/g. After another 11 hours (at 06:30 hours next day), the AMCC ranged from 5.8 x 10^7/g to 4.2 x 10^7/g (Table 1). AMCCs of fish and chicken, leftover from the previous night, dropped from 8.5 x 10^7/g and 4.4 x 10^7/g to 5.3 x 10^7/g and 1.1 x 10^7/g, respectively, after reheating (Table 1). Figure 4 illustrates microbial counts in relation to operations and time of day.

Preparation procedures were similar to those of Street Vendor 1 (see Fig. 1 and 2). Temperatures of certain foods were measured during display on Stand 2 from 08:00 hours until 20:00 hours (Fig. 5). After either cooking or reheating, the foods were displayed until either sold or until the stand closed. AMCC of samples of foods collected at 08:00, 14:45 and 20:15 hours the first day and at 08:30 the next day are shown in Table 1. (The lower AMCC at 14:45 hours is attributed to cooking and reheating done between 13:00 and 14:30 hours). After overnight storage in a covered plastic bucket in the cabinet of the stand, AMCCs exceeded 3.4 x 10^7/g in all samples.

Food preparation activities by Street Vendor 3 are illustrated in Fig. 6-8. Laboratory results are listed in Table 1; time/temperature data are shown in Fig. 9. Vendor 3 prepared beans in her home the day before leaving them at ambient temperature overnight. This process obviously permitted considerable multiplication of microorganisms, because the AMCC of the beans before cooking on the day of final preparation was 1.8 x 10^7/g (Table 1). During cooking at the vending site, the beans were boiled for approximately 1 h (Fig. 9), yet the AMCC was still quite high (9.2 x 10^7/g) just before serving. Spore formers were probably present, but B. cereus and C. perfringens were not recovered.

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**DISCUSSION**

Cooking is a critical control point relative to vegetative forms of pathogenic bacteria (e.g., Salmonella) that may be on raw meat, raw poultry and raw fish, or that may reach foods during preparation. Foods cooked by Street Vendors 1 and 3 attained temperatures that should be sufficiently high to kill large numbers of vegetative cells, but not all spores, of pathogenic bacteria. Yet, some foods had rather high aerobic mesophilic colony counts afterwards. The high count found in cooked beans at Vendor-3’s operation could be explained either by survival of spores which could have come initially from the beans, garlic, coriander or pepper or by reduction of, but not elimination of, a very large number of vegetative cells that propagated during soaking overnight. In regard to
TABLE 1. Aerobic mesophilic colony count (AMCC) and foodborne pathogens isolated from food prepared by street vendors after cooking, while on display and after reheating.

<table>
<thead>
<tr>
<th>Vendor product</th>
<th>Description of</th>
<th>AMCC/g</th>
<th>Temperature (C/F)</th>
<th>Sampling time Day Hours</th>
<th>Clostridium perfringens lg</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Street-vended foods</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>1 Bocito (Fried fish)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left overnight</td>
<td>1</td>
<td>06:20</td>
<td>25/77</td>
<td>8.5x10^6</td>
<td>-</td>
</tr>
<tr>
<td>After reheating</td>
<td>1</td>
<td>06:45</td>
<td>99/210</td>
<td>5.3x10^3</td>
<td>-</td>
</tr>
<tr>
<td>After 7 h holding</td>
<td>1</td>
<td>14:00</td>
<td>29/84</td>
<td>8.6x10^3</td>
<td>-</td>
</tr>
<tr>
<td>After additional 5 h holding</td>
<td>1</td>
<td>19:45</td>
<td>26/79</td>
<td>1.9x10^3</td>
<td>-</td>
</tr>
<tr>
<td>After overnight holding</td>
<td>2</td>
<td>06:30</td>
<td>19/66</td>
<td>9.8x10^6</td>
<td>-</td>
</tr>
<tr>
<td>After reheating and 3 h holding</td>
<td>2</td>
<td>10:00</td>
<td>29/84</td>
<td>4.0x10^3</td>
<td>-</td>
</tr>
<tr>
<td><strong>Fried chicken</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left overnight</td>
<td>1</td>
<td>06:20</td>
<td>25/77</td>
<td>4.4x10^7</td>
<td>2.2x10^2</td>
</tr>
<tr>
<td>After reheating</td>
<td>1</td>
<td>06:30</td>
<td>97/206</td>
<td>1.1x10^5</td>
<td>&lt;10</td>
</tr>
<tr>
<td>After 7 h holding</td>
<td>1</td>
<td>14:00</td>
<td>28/82</td>
<td>1.0x10^5</td>
<td>&lt;10</td>
</tr>
<tr>
<td>After additional 5 h holding</td>
<td>1</td>
<td>19:35</td>
<td>26/79</td>
<td>1.3x10^4</td>
<td>-</td>
</tr>
<tr>
<td>After overnight holding</td>
<td>2</td>
<td>06:30</td>
<td>20/68</td>
<td>3.7x10^3</td>
<td>-</td>
</tr>
<tr>
<td><strong>Fried pigs head pieces</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left overnight</td>
<td>1</td>
<td>06:20</td>
<td>25/77</td>
<td>6.3x10^8</td>
<td>3.5x10^2</td>
</tr>
<tr>
<td>After reheating and 7 h holding</td>
<td>1</td>
<td>14:00</td>
<td>27/80</td>
<td>4.4x10^4</td>
<td>2.9x10^2</td>
</tr>
<tr>
<td>After additional 5 h holding</td>
<td>1</td>
<td>19:35</td>
<td>28/82</td>
<td>9.1x10^6</td>
<td>-</td>
</tr>
<tr>
<td>After holding overnight</td>
<td>2</td>
<td>06:30</td>
<td>20/68</td>
<td>4.2x10^6</td>
<td>-</td>
</tr>
<tr>
<td>After reheating and 3 h holding</td>
<td>2</td>
<td>10:00</td>
<td>30/86</td>
<td>6.7x10^4</td>
<td>-</td>
</tr>
<tr>
<td><strong>Fried ham</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left overnight</td>
<td>1</td>
<td>06:20</td>
<td>25/77</td>
<td>6.9x10^6</td>
<td>3.5x10^2</td>
</tr>
<tr>
<td><strong>Chicharron (fried pork ribs with rind attached)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After cooking and 5 h holding</td>
<td>1</td>
<td>14:00</td>
<td>30/86</td>
<td>3.4x10^6</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Left overnight</td>
<td>2</td>
<td>06:20</td>
<td>20/68</td>
<td>5.8x10^4</td>
<td>-</td>
</tr>
<tr>
<td><strong>Drinking water</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>14:00</td>
<td>-</td>
<td>1.5x10^9</td>
<td>-</td>
</tr>
<tr>
<td><strong>2 Fried corn bollito (history unknown)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>After additional 12 h holding</td>
<td>1</td>
<td>20:18</td>
<td>23/73</td>
<td>9.0x10^5</td>
<td>&lt;10</td>
</tr>
<tr>
<td>After left overnight</td>
<td>2</td>
<td>08:30</td>
<td>25/77</td>
<td>4.6x10^6</td>
<td>-</td>
</tr>
<tr>
<td><strong>Fried wheat torreja (history unknown)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>1</td>
<td>08:15</td>
<td>28/82</td>
<td>7.5x10^6</td>
<td>-</td>
</tr>
<tr>
<td><strong>Fried sausage (history unknown)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After additional 6 h holding</td>
<td>1</td>
<td>14:45</td>
<td>25/77</td>
<td>4.2x10^6</td>
<td>5x10^2</td>
</tr>
<tr>
<td>After additional 5 h holding (cooked 1400-1500)</td>
<td>1</td>
<td>20:15</td>
<td>23/73</td>
<td>1.2x10^6</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Left overnight</td>
<td>2</td>
<td>08:24</td>
<td>25/77</td>
<td>3.5x10^6</td>
<td>-</td>
</tr>
<tr>
<td><strong>Fried beef (history unknown)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After cooking</td>
<td>1</td>
<td>14:50</td>
<td>25/77</td>
<td>4.6x10^6</td>
<td>&lt;10</td>
</tr>
<tr>
<td>After 5.5 h holding</td>
<td>1</td>
<td>20:13</td>
<td>23/73</td>
<td>7.9x10^6</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Left overnight</td>
<td>2</td>
<td>08:27</td>
<td>25/77</td>
<td>3.6x10^6</td>
<td>-</td>
</tr>
<tr>
<td><strong>Fried ham</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Left overnight, not reheated</td>
<td>1</td>
<td>08:05</td>
<td>28/82</td>
<td>1.4x10^8</td>
<td>3.5x10^2</td>
</tr>
<tr>
<td>After cooking or reheating</td>
<td>1</td>
<td>14:45</td>
<td>-</td>
<td>1.5x10^6</td>
<td>&lt;10</td>
</tr>
<tr>
<td>After 5 h holding</td>
<td>1</td>
<td>20:10</td>
<td>23/73</td>
<td>1.3x10^6</td>
<td>-</td>
</tr>
<tr>
<td>Left overnight</td>
<td>2</td>
<td>08:23</td>
<td>25/77</td>
<td>1.1x10^6</td>
<td>-</td>
</tr>
<tr>
<td><strong>Fried cheese (history unknown)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>After heating</td>
<td>1</td>
<td>14:50</td>
<td>25/77</td>
<td>4.5x10^6</td>
<td>&lt;10</td>
</tr>
<tr>
<td>After 5 h holding</td>
<td>1</td>
<td>20:14</td>
<td>23/74</td>
<td>1.7x10^6</td>
<td>-</td>
</tr>
<tr>
<td><strong>Chuleta (Fried pork belly) (history unknown)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At least 5 h holding</td>
<td>1</td>
<td>20:15</td>
<td>23/73</td>
<td>4.5x10^6</td>
<td>-</td>
</tr>
<tr>
<td>Left overnight</td>
<td>2</td>
<td>08:37</td>
<td>25/77</td>
<td>2.8x10^6</td>
<td>-</td>
</tr>
<tr>
<td><strong>Chicharron (fried pork ribs with rind attached)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(history unknown)</td>
<td>1</td>
<td>20:20</td>
<td>23/73</td>
<td>7.3x10^6</td>
<td>-</td>
</tr>
<tr>
<td>Left overnight</td>
<td>2</td>
<td>08:23</td>
<td>25/77</td>
<td>5.7x10^6</td>
<td>-</td>
</tr>
<tr>
<td><strong>3 Beans</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Precooked at house: left overnight</td>
<td>1</td>
<td>08:53</td>
<td>25/77</td>
<td>1.8x10^6</td>
<td>&lt;10</td>
</tr>
<tr>
<td>Cooked and at end of serving</td>
<td>1</td>
<td>12:57</td>
<td>27/80</td>
<td>9.2x10^5</td>
<td>-</td>
</tr>
<tr>
<td><strong>Rice</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooked</td>
<td>1</td>
<td>11:15</td>
<td>72/162</td>
<td>1.0x10^1</td>
<td>-</td>
</tr>
</tbody>
</table>

JOURNAL OF FOOD PROTECTION, VOL. 51, MAY 1988
Salmonella was not isolated from any food sample.

*Escherichia coli* <10/ml; AMCC results/ml.

*Bacillus cereus* <10/g.

*Staphylococcus aureus* <10/g.

*E. coli* 7.4x10⁷/g.

*B. cereus* 1.0x10⁸/g.

*B. cereus* 2.0x10⁸/g.

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*E. coli* 7.4x10⁷/g.

*B. cereus* 1.0x10⁸/g.

*B. cereus* 2.0x10⁸/g.

the latter possibility, growth of *B. cereus* in uncooked beans during prolonged soaking has been observed (4). Either raw meat or raw poultry or spices could have accounted for the presence of heat-resistant spores in the meat dish. The high count in the cooked meat at Vendor-3’s operation could have been due to a combination of survivors and contaminants from utensils. Large numbers of microorganisms could have been initially on the meat or introduced during cutting the raw meat on the wooden table slat or during other preparation methods.

The finding of *B. cereus* cells in rice and *moro* (which contains rice) shortly after cooking suggests that their spores survived cooking (4,11). Although vegetative cells can multiply in moist rice which is held for sufficient time within a temperature range that permits multiplication (12), high *B. cereus* counts were not recovered from the few samples obtained. This bacterium, however, has been responsible for outbreaks of foodborne illness when similar foods were held under similar conditions for several hours (6,11). Additional testing is needed to fully evaluate this situation for foods that are sold by street vendors.

Holding cooked foods at ambient temperature for 13 h or longer, as done by Vendors 1,2 and 4 is quite hazardous. It is the major critical control point of the street-vending (cook/hold) operations surveyed. Increases in AMCC were observed as the duration of holding was prolonged, indicat-
Figure 7. Contamination, survival and growth of microorganisms associated with preparation and display of beef stew and critical control points and monitoring of operations of Street Vendor 3 in Santo Domingo, Dominican Republic.

Figure 8. Contamination, survival and growth of microorganisms associated with preparation and display of beans, rice and moro and critical control points and monitoring of operations of Street Vendor 3 in Santo Domingo, Dominican Republic.
Fig. 4). During the interval of holding, spores that survived cooking could germinate, if present and if redox conditions permit. B. cereus and C. perfringens were isolated, but counts were low, perhaps due to the low aw at the surface of the fried foods. The climatic temperature was just a little below the optimal temperature for growth of B. cereus, and the relative humidity was high. The situation could have been even more hazardous if the temperature had not been cooled by rain during the days of the survey.

Data from United States, England and Wales and New South Wales (a State of Australia), show that the major factor that contributed to outbreaks of foodborne diseases is holding cooked foods at ambient (room or outside) temperature for several hours (5,7,15). It must also be a significant factor contributing to outbreaks of foodborne disease elsewhere.

There are a few basic control measures to counter this hazard: (a) eat food promptly after cooking, (b) hold cooked foods at or above 55°C (131°F), (c) cool cooked foods rapidly and hold them at 7°C (45°F) or below and (d) ensure that the foods have either aw values of 0.85 or below or pH values of 4.6 or below or some combination of pH values (e.g., 5.2 or below) and aw values (e.g., 0.92 or below) that can be demonstrated to inhibit growth of pathogenic microorganisms in the food under investigation.

Cooked foods were eaten promptly after cooking at the Vendor 3 facility, but it was contrary to cook/hold operations used by Vendors 1, 2 and 4. Hot holding would, of course, be desirable from the standpoint of having foods at enjoyable eating temperatures for some, but this requires a constant and controllable heat source that street vendors often do not have. Many citizens of the Dominican Republic apparently accept and enjoy fried foods at ambient temperature.

Cooling requires either refrigeration, ice or some sort of solar energy device. It may necessitate reheating of some products which would nullify one of the attributes - fast service - of street vending.

Although the aw of some fried foods was apparently low, considerable microbial multiplication occurred. The low aw values, however, may have inhibited growth of pathogens. Assurance of control of aw is difficult to achieve under the conditions that prevail during preparation and the vending of foods on streets.

Reheating, when done, would kill vegetative forms of pathogenic bacteria that may reach the products after cooking or that germinate from spores which survived cooking. Some control would be achieved if the cooked foods on display were reheated to high temperatures (e.g., 71°C/160°F) every 5 to 6 h. Heat-resistant toxins (e.g. B. cereus emetic toxin and staphylococcal enterotoxins), if present, would persist, but the interval of heating should prevent their development. Verification that reheating is done by street vendors as routine practice would be difficult to achieve.

Cooked foods were subjected to cross contamination and contamination from flies that sporadically landed on the foods and from occasional handling by vendors. Hygienic practices such as meat and poultry cutting and dish and utensil washing were poor by modern standards of sanitation. Yet, neither Salmonella nor high numbers of other pathogens sought were recovered. Limited sampling, however, may have affected these results. Conditions were conducive to contamination by pathogenic bacteria and their growth.

There is a law in the Dominican Republic that prohibits vending on streets, but it is not enforced (2). At one time when the law was strictly enforced by authorities, street vending operations were closed and unsanitary equipment was destroyed. Vending operations, however, reestablished within a short time. This was so because the general public accepts street vending. Practices, such as holding cooked foods for several hours at ambient (room) temperature, in many food service establishments and in many homes do not differ greatly from those used by the vendors. Furthermore, some vending (e.g., cook/serve sale of packaged, low-moisture foods) operations are basically safe. Enforcement of the law banning street vendors, did not work in the past and will not reach the core of the problem, which is the lack of understanding of hazards and safe practices.

The remedy is education: education of public health personnel, education of street vendors and food service personnel, and education of the public who either purchase street-vended foods or become vendors themselves. This will be a considerable task with many barriers to overcome.

Microbiological hazards and their solutions, food processing and preparation technology, critical control points, practical control measures and monitoring procedures (19) as well as the principles of food microbiology and food safety need to be incorporated into training programs for public health personnel. The challenge will be to show limitations of current practices, put emphasis on microbiological hazards and not aesthetics, dispel defensive reactions, teach the new approach and stimulate trainees to take action. To achieve this, program resources and priorities will have to be shifted away from such practices as health certificates for food workers and expiration dates on packages (for example) to solutions of time-temperature and contamination hazards. As
codes of practice or guidelines are developed, critical control points, criteria for satisfactory practices, monitoring procedures, and actions to take when critical control points are out of control, will need to be specified (19). Foodborne disease surveillance data should be sought and used to give direction to the food safety activity.

Street vendors will need to be trained either in courses or during visits to their facilities. This will be challenging because of the transient nature of some vendors, their long hours of operation, and the limited financial resources available to make some of the changes needed in their operations to ensure the safety of food. Developing training in cooperation with vending-trade associations, where they exist, will facilitate this endeavor and stimulate action. Illustrated leaflets showing acceptable practices could be posted at the stands or on carts or nearby for both the vendor and the purchaser of vended food to see and heed.

Prospective consumers of street-vended foods should be alerted to the hazards and cautioned to request that the cooked foods they select be reheated (fried) before they purchase them. Various media—television, radio, newspaper—should be considered to transmit this message. If practicable, educational endeavors should be coordinated between official monitoring agencies, public education departments and consumer groups.

Education in food safety also needs to be incorporated into health education programs in schools because the pupils either are or will become customers of street vendors in the near future and some may become vendors themselves. Appropriate health education materials must be developed for use by teachers and, no doubt, teachers will have to be trained in the principles of food safety as well as in use of the materials.

Most likely, no single approach will reach all the people who need the information, but it is essential that action be initiated to make an impact on prevention of foodborne disease.

ACKNOWLEDGMENTS

Appreciation is given to the following persons for their assistance in this project: Dr. Amiro Perez Mera, Secretary of State for Public Health and Social Assistance; Dr. Oviedo J., Director General of the Standardization Program SESPAS; Milagros Peralta de Campilla, Carolina de Rimoli, Marisol Valdez de Peña, INDOTEC; Luis E. Feliz Roa, Supervisor of Environmental Sanitation, Santo Domingo; Dr. Guillermo Torres Cortes, Country Representative and staff, Pan American Health Organization, Santo Domingo, Dominican Republic. Appreciation is also given to Dr. Fritz Kaferstein and Ms. J. Sims, Food Safety Unit, Division of Environmental Health, World Health Organization and Dr. Fernando Quevedo and Dr. Mario Fernandes, Veterinary Public Health, Pan American health Organization for their stimulation and coordination of this investigation. Furthermore, thanks are given to the street vendors for their cooperation during the survey.

REFERENCES