

## Bacteriological Evaluation of Retail Ground Beef, Frozen Beef Patties, and Cooked Hamburger

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### ABSTRACT

A total of 108 samples of fresh refrigerated ground beef, 99 samples of frozen hamburger patties, and 107 fried hamburgers, purchased from retail stores and fast-food outlets in Ontario, were analyzed for their bacteriological quality. About 44% of non-frozen ground beef samples had aerobic plate counts exceeding 50 million/g; 50 of 108 samples (46.3%) contained *Staphylococcus aureus* and 46 of these 50 samples (88%) exceeded 1000 organisms/g; 43 of 108 samples were positive for *Escherichia coli* with 38 samples (88.4%) exceeding 500 organisms/g. About 19% of frozen hamburger patties had aerobic plate counts in excess of 10 million/g; 93 of 99 samples (93.9%) contained *S. aureus* with 83 of these samples (89.3%) exceeding 1000 organisms/g; 28 of 99 samples were positive for *E. coli* with 7 of these samples (25%) exceeding 500 organisms/g. About 96.3% of fried hamburger samples had aerobic plate counts of less than 10,000/g.

The bacteriological quality of raw ground beef has been of interest to many people and has resulted in publication of bacteriological data in several reports (1,3-8, 11-16). These reports indicate that ground beef may contain large numbers of bacteria at points of sale. Examination of ground beef in this laboratory (3) showed the bacterial quality of many samples of ground meat to be poor and supported the belief that bacterial standards for ground beef are necessary to ensure quality and safety. Recent reports (2,4,17) discuss experiences with respect to desirability and practicability of establishing bacterial standards for meats. Because of the results of our 1973 study, a follow-up study was carried out in 1975 to gather additional data on bacterial quality of fresh and frozen ground beef and fried hamburgers as sold in fast-food outlets.

### MATERIALS AND METHODS

#### Collection of samples

Two hundred and seven retail packages of ground beef, each weighing about 500 g, were collected from retail display cabinets in six major food chain stores over a period of 18 weeks during the summer months of 1975. They included 69 packages of hamburger, 14 soyaburger (composed of 30% soya flour and 70% meat), 18 ground chuck, 7 ground steak, all fresh, and 99 samples of frozen ground beef patties. The internal temperature of each package of unfrozen meat was recorded and all samples were transported in iced containers to the laboratory. Also, 107 fried hamburgers on the bun, but without added condiments, were purchased from five different major fast-food outlets.

Aseptic procedures were observed in removing the hamburgers from the buns and placing them in sterile plastic bags for immediate refrigerated transport to the laboratory. All samples were held at 0-2 C and analyzed within 24 h.

#### Analytical procedure

Each package of fresh ground beef was divided into six equal sections and 5-g portions removed from each section or a total of 30 g of raw beef; other samples consisted of 60 g of frozen beef patty which had been thawed 6 to 8 h at 5-7 C and whole fried hamburger patties. All samples were homogenized in Waring blenders with 0.1% peptone water to give a 0.1 dilution. The following tests were conducted on the homogenate: (a) Total aerobic plate count (APC); using standard methods agar, plates were incubated for 72 h at 21 C. (b) Coliforms and *Escherichia coli*; presumptive coliforms were enumerated on violet red bile agar for 18 to 24 h at 35 C. Colonies (square root of count) were picked by random design into brilliant green bile lactose broth. Growth from positive tubes was streaked on eosin methylene blue plates and an isolated typical colony picked and streaked on a plate count agar slant. The isolates were subjected to indole, methyl red, Voges-Proskauer, citrate (IMVIC) tests and inoculated into EC broth for incubation at 45.5 C and confirmation for *E. coli*. (c) Enterococci; they were enumerated on KF-Streptococcus agar that was incubated for 48 h at 37 C. (d) Staphylococci; suspected staphylococci were enumerated by pour-plating on Baird-Parker's egg yolk tellurite agar and incubating for 48 h at 37 C. Colonies (square root of count) from the countable plate, representing each type, were picked and streaked on plate count agar. The isolates were tested for coagulase production by the tube method using rabbit plasma containing EDTA. (e) Salmonellae. The procedure included using lactose broth pre-enrichment (24 h at 37 C), enrichment in selenite-cystine and tetrathionate-novobiocin broths (24 h at 37 C) followed by streaking on brilliant-green-sulfa, Salmonella-Shigella, and xylose-lactose-desoxycholate agars (24 h at 37 C). Because no suspicious colonies appeared, no further tests for confirmation were conducted. (f) *Clostridium perfringens*; enumeration and confirmation of *C. perfringens* was carried out using the method of Shahidi and Ferguson (10).

### RESULTS AND DISCUSSION

#### Fresh ground beef

A summary of the APC, *S. aureus* and *E. coli* levels in the different types of fresh ground beef is presented in Table 1. Aerobic plate counts ranged from 1 million to more than 50 million/g. About 43% of the round steak samples had counts of less than 5 million/g, while only about 10% of the other samples were in this range. This difference was probably related to the bacteriological quality of the meat before grinding and/or to the length

TABLE 1. Summary of the bacteriological analysis of 108 samples of non-frozen ground

| Type of ground beef in ranges | No. of samples (total) | Aerobic plate count/g |                        | <i>S. aureus</i> /g     |              | <i>E. coli</i> /g      |                          |           |                        |
|-------------------------------|------------------------|-----------------------|------------------------|-------------------------|--------------|------------------------|--------------------------|-----------|------------------------|
|                               |                        | Ranges                | % of samples in ranges | No. of samples positive | Ranges       | % of samples in ranges | No. of samples in ranges | Ranges    | % of samples in ranges |
| Hamburger                     | 69                     | 1,000,000-5,000,000   | 5.8                    | 32                      | 101-1,000    | 12.5                   | 26                       | 101-500   | 19.2                   |
|                               |                        | 5,000,001-50,000,000  | 50.7                   |                         | 1,001-10,000 | 75.0                   |                          | 501-1,000 | 0                      |
|                               |                        | >50,000,000           | 43.5                   |                         | >10,000      | 12.5                   |                          | >1,000    | 80.8                   |
| Chuck                         | 18                     | 1,000,000-5,000,000   | 16.7                   | 9                       | 101-1,000    | 0                      | 6                        | 101-500   | 0                      |
|                               |                        | 5,000,000-50,000,000  | 38.9                   |                         | 1,001-10,000 | 33.4                   |                          | 501-1,000 | 16.7                   |
|                               |                        | >50,000,000           | 44.4                   |                         | >10,000      | 66.6                   |                          | >1,000    | 83.3                   |
| Round steak                   | 7                      | 1,000,000-5,000,000   | 42.8                   | 3                       | 101-1,000    | 33.3                   | 3                        | 101-500   | 0                      |
|                               |                        | 5,000,000-10,000,000  | 42.8                   |                         | 1,001-10,000 | 66.7                   |                          | 501-1,000 | 12.5                   |
|                               |                        | >50,000,000           | 14.3                   |                         | >10,000      | 0                      |                          | >1,000    | 87.5                   |
| Soya extended                 | 14                     | 1,000,000-5,000,000   | 0                      | 6                       | 101-1,000    | 16.7                   | 8                        | 101-500   | 0                      |
|                               |                        | 5,000,001-50,000,000  | 35.7                   |                         | 1,001-10,000 | 66.6                   |                          | 501-1,000 | 12.5                   |
|                               |                        | >50,000,000           | 64.3                   |                         | >10,000      | 16.7                   |                          | >1,000    | 87.5                   |
| Total                         | 108                    |                       |                        | 50<br>(46.3%)           |              |                        | 43<br>(39.8%)            |           |                        |

of time and conditions under which the ground meat was held before purchase. Data in Table 2 show that the aerobic plate counts were rather evenly distributed

TABLE 2. Distribution of aerobic plate count (APC), *S. aureus*, and *E. coli* in non-frozen ground beef<sup>a</sup>

|                  | Arbitrary grouping of No. per g | No. of samples  | % of samples |
|------------------|---------------------------------|-----------------|--------------|
| APC              | 1,000,000-5,000,000             | 10              | 9.3          |
|                  | 5,000,001-50,000,000            | 50              | 46.3         |
|                  | >50,000,000                     | 48              | 44.4         |
|                  |                                 | 108             |              |
| <i>S. aureus</i> | 100-1,000                       | 6               | 12           |
|                  | 1,001-10,000                    | 33              | 66           |
|                  | >10,000                         | 11              | 22           |
|                  |                                 | 50 <sup>a</sup> |              |
| <i>E. coli</i>   | 100-500                         | 5               | 11.6         |
|                  | 501-1,000                       | 2               | 4.7          |
|                  | >1,000                          | 36              | 83.7         |
|                  |                                 | 43 <sup>a</sup> |              |

<sup>a</sup>Of a total of 108 samples examined, 50 and 43 were positive for *S. aureus* and *E. coli* respectively.

between 5 million and 50 million/g (46.3%) and greater than 50 million/g (44.4%). Not all samples contained *E. coli*, but those samples that were positive (39.8%) exceeded the level of 100/g. Most samples (83.7%) had counts of more than 1000/g. *S. aureus* was isolated from 43.6% of the samples with most of those samples (66%) having counts in the range of 1000 to 10,000/g.

It should be noted that 90.7% of the samples exceeded the standard for APC set by the State of Oregon (5 million/g), while 100% exceeded the guidelines (1 million/g) employed by the States of New York, Rhode Island, and Wyoming (16). Of more concern is the fact that 44.4% of the samples exceeded the recently proposed Canadian standard of 50 million/g. Also, 88.4% of the samples positive for *E. coli* and 88% of the samples positive for *S. aureus* would not be in compliance with the new Canadian standard for these organisms (9).

Temperature of the ground beef at time of purchase

ranged from 8 to 13 C. Such elevated holding temperature in the store display cases was probably one of the factors contributing to high counts.

*Frozen ground beef*

Ninety-nine samples of frozen ground beef patties were examined and the APC, *S. aureus* and *E. coli* counts are presented in Table 3. In general, the microbiological quality was better than that of the fresh ground beef. This was not surprising as counts in frozen meat are known to stabilize or even decrease during storage, while counts in fresh ground beef may increase depending on temperature abuse during retail handling. Data in Table 4 and Fig. 1 indicate considerable variation in bacterial counts among meats of the nine different suppliers. Even though the meat was frozen when purchased, data in Fig. 1 show that only the product of

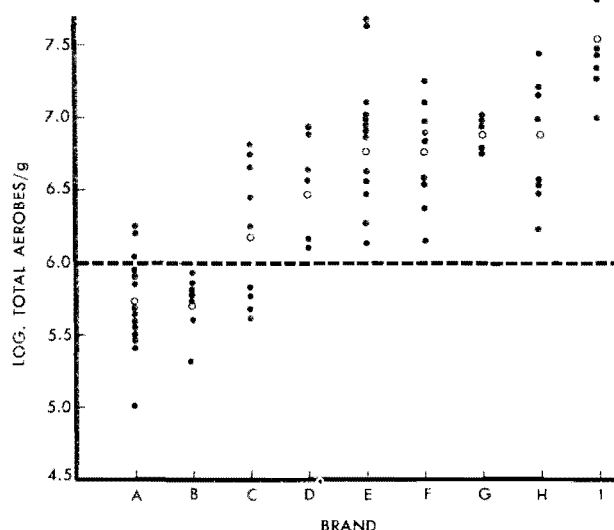


FIGURE 1. Total Aerobic Plate Count of frozen beef patties from nine different suppliers. O geometric mean; .... arbitrary standard of 1 million/g.

TABLE 3. Summary of the bacteriological analysis of 99 samples of frozen ground beef patties from 9 different manufacturers

| Manu-<br>facturer | No. of<br>samples | Aerobic plate count/g |                 | <i>S. aureus</i> /g         |              | <i>E. coli</i> /g |                             |        |         |
|-------------------|-------------------|-----------------------|-----------------|-----------------------------|--------------|-------------------|-----------------------------|--------|---------|
|                   |                   | Ranges                | % of<br>samples | % of<br>samples<br>positive | Ranges       | % of<br>samples   | % of<br>samples<br>positive | Ranges | samples |
| A                 | 19                | 100,000-1,000,000     | 84.2            | 19                          | 100-1,000    | 21.0              | 8                           | <10    | 12.5    |
|                   |                   | 1,000,001-5,000,000   | 15.8            |                             | 1,001-10,000 | 31.6              |                             | 11-50  | 50.0    |
|                   |                   | >5,000,000            | —               |                             | >10,000      | 47.4              |                             | >50    | 37.5    |
| B                 | 10                | 100,000-1,000,000     | 100             | 10                          | 100-1,000    | —                 | 0                           |        |         |
|                   |                   | 1,000,001-5,000,000   | —               |                             | 1,001-10,000 | 100               |                             |        |         |
|                   |                   | >5,000,000            | —               |                             | >10,000      | —                 |                             |        |         |
| C                 | 10                | 100,000-1,000,000     | 40              | 8                           | 100-1,000    | 12.5              | 2                           | <10    | —       |
|                   |                   | 1,000,001-5,000,000   | 60              |                             | 1,000-10,000 | 75.0              |                             | 11-50  | 50      |
|                   |                   | >5,000,000            | —               |                             | >10,000      | 12.5              |                             | >50    | 50      |
| D                 | 8                 | 100,000-1,000,000     | —               | 8                           | 100-1,000    | 37.5              | 0                           |        |         |
|                   |                   | 1,000,001-5,000,000   | 100             |                             | 1,000-10,000 | 50.0              |                             |        |         |
|                   |                   | >5,000,000            | —               |                             | >10,000      | 12.5              |                             |        |         |
| E                 | 18                | 100,000-1,000,000     | —               | 17                          | 100-1,000    | 5.9               | 7                           | <10    | —       |
|                   |                   | 1,000,001-5,000,000   | 44.4            |                             | 1,000-10,000 | 58.8              |                             | 11-50  | 14.3    |
|                   |                   | >5,000,000            | 55.6            |                             | >10,000      | 35.3              |                             | >50    | 85.7    |
| F                 | 10                | 100,000-1,000,000     | —               | 9                           | 100-1,000    | 11.1              | 0                           |        |         |
|                   |                   | 1,000,001-5,000,000   | 40              |                             | 1,000-10,000 | 88.9              |                             |        |         |
|                   |                   | >5,000,000            | 60              |                             | >10,000      | —                 |                             |        |         |
| G                 | 5                 | 100,000-1,000,000     | —               | 5                           | 100-1,000    | —                 | 2                           | <10    | —       |
|                   |                   | 1,000,001-5,000,000   | —               |                             | 1,000-10,000 | —                 |                             | 11-50  | 50      |
|                   |                   | >5,000,000            | 100             |                             | >10,000      | 100               |                             | >50    | 50      |
| H                 | 10                | 100,000-1,000,000     | —               | 9                           | 100-1,000    | —                 | 9                           | <10    | —       |
|                   |                   | 1,000,001-5,000,000   | 40              |                             | 1,000-10,000 | 77.8              |                             | 11-50  | —       |
|                   |                   | >5,000,000            | 60              |                             | >10,000      | 22.2              |                             | >50    | 100     |
| I                 | 9                 | 100,000-1,000,000     | —               | 8                           | 100-1,000    | —                 | 0                           |        |         |
|                   |                   | 1,000,001-5,000,000   | —               |                             | 1,000-10,000 | 12.5              |                             |        |         |
|                   |                   | >5,000,000            | 100             |                             | >10,000      | 87.5              |                             |        |         |
| Total             | 99                |                       |                 | 93<br>(93.9%)               |              |                   | 28<br>(28.3%)               |        |         |

suppliers A and B could meet a APC standard of one million/g. This indicates that the other meats were perhaps excessively contaminated or were held too long at elevated temperature before freezing. The results for suppliers A and B indicate that it is possible to process and market frozen beef patties of acceptable quality.

#### Fried hamburger

Total aerobic plate counts ranged from less than 100 to 1,700,000/g. Most samples (75.7%) had counts of less than 1000 organisms/g (Table 5). Enterococci, coliforms, staphylococci, salmonellae, and *C. perfringens* were not isolated. The contributions of buns to the total counts was considered negligible; an assortment of 50 buns

TABLE 4. Distribution of aerobic plate count (APC), *S. aureus*, and *E. coli* in frozen hamburger patties

|                  | Arbitrary grouping<br>of No. per g | No. of<br>samples | % of<br>samples |
|------------------|------------------------------------|-------------------|-----------------|
| APC              | 100,000-1,000,000                  | 30                | 30.3            |
|                  | 1,000,001-5,000,000                | 29                | 29.3            |
|                  | 5,000,000-10,000,000               | 21                | 21.2            |
|                  | >10,000,000                        | 19                | 19.2            |
|                  |                                    | 99                |                 |
| <i>S. aureus</i> | 100-1,000                          | 10                | 10.7            |
|                  | 1,001-10,000                       | 52                | 55.9            |
|                  | >10,000                            | 31                | 33.4            |
|                  |                                    | 93 <sup>a</sup>   |                 |
| <i>E. coli</i>   | <100                               | 15                | 53.6            |
|                  | 100-500                            | 6                 | 21.4            |
|                  | >500                               | 7                 | 25.0            |
|                  |                                    | 28 <sup>a</sup>   |                 |

<sup>a</sup>Of a total of 99 samples, 93 and 28 were positive for *S. aureus* and *E. coli* respectively.

examined had counts of less than 100/g. Bacterial growth in hamburger subsequent to frying is possible since hamburgers may be held at ambient temperature by the consumer before consumption. Although no organisms known to cause foodborne illness were isolated, the high surviving population in seven samples makes questionable the quality of the meat and the time-temperature relationship of the cooking procedure.

Results of this study show some improvement in the bacterial quality of raw ground beef as compared to results of the 1973 study (3). Incidence of high count ground beef is still excessive and the fact that over 44% of the samples exceeded the recently proposed Canadian standard (APC 50 million/g) indicates the magnitude of the task facing those responsible for the bacterial quality

TABLE 5. Range of aerobic plate count [APC, 21 C, 72 h] in fried hamburger

| Arbitrary grouping<br>of No. per g | No. of<br>samples | Percent |
|------------------------------------|-------------------|---------|
| <100                               | 50                | 46.7    |
| 101-1,000                          | 31                | 29.0    |
| 1,001-5,000                        | 19                | 17.8    |
| 5,000-10,000                       | 3                 | 2.8     |
| >10,000                            | 4                 | 3.7     |
|                                    | 107               |         |

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of the meat. About 19% of the frozen ground beef samples would have been unacceptable based on APC (Canadian standard 10 million/g) but the majority (89.3%) would be unacceptable based on excessive numbers of *S. aureus* (Canadian standard 1000/g). Most fried hamburger samples were of acceptable bacterial quality. Unacceptable counts after frying can reflect both high initial counts or insufficient heat treatment and are of concern if the handling of the hamburger after cooking is inadequate.

Aerobic plate counts in the present study were obtained at 21 C, an incubation temperature at which more bacteria are expected to be recovered as compared to 35 C (9,16). The proposed Canadian standard (APC) for ground beef is based on incubation at 35 C. These standards are rather lenient compared to some standards in the United States, but may reflect the bacterial quality of ground meat in Canada. To achieve a ground meat of improved bacterial quality, Canadian regulatory officials should consider a progressive tightening of standards. APC maxima proposed for ground beef as a standard or guideline in two states of the U.S.A. are 10 million/g (16). Most other states have proposed standards or guidelines ranging from 0.5 to 5 million/g.

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