Microbiological Quality of Macaroni and Noodle Products Obtained at Retail Markets

A. SWARTZENTRUBER, W. L. PAYNE, B. A. WENTZ, R. J. BARNARD, AND R. B. READ, JR.*
Division of Microbiology, Food and Drug Administration, Washington, D.C. 20204

Received 31 March 1982/Accepted 26 May 1982

The microbiological quality of macaroni and noodle products was determined by a statistically based national survey at the retail level. Geometric means of aerobic plate counts for macaroni and noodle products were 520 and 1,400 per g, respectively. Means for yeast and mold counts were 72 per g for macaroni and 100 per g for noodles. Means for counts of coliforms and Staphylococcus aureus were <3 per g for both products. Escherichia coli was not found in macaroni but was present in 0.5% of the noodle samples and ranged from 3 to 93 per g.

The manufacture of pasta products involves a controlled drying step at warm temperatures which, if not properly controlled, enables the extensive growth of microorganisms. This improperly controlled drying, with the possible proliferation of organisms such as Salmonella spp. and Staphylococcus aureus, could result in a potential hazard to public health. Most of the microbiological studies of pasta products manufactured in the United States, therefore, have focused on pathogen growth during production rather than on the general microbiological quality (3, 4, 6, 9).

Similarly, European investigators have been primarily concerned with the survival and growth of pathogens during the production of pasta products (7); however, some data have been reported on the general microbiological quality of these products. An extensive study of the microbiology of pasta products in Canada was recently reported (8). Of the 629 samples analyzed, 94% had an aerobic plate count (APC) of <50,000 per g; 98% had S. aureus counts of <25 per g; 98.1, 99.7, and 99.9% of the samples had counts of <1 per g of coliforms, fecal coliforms, or Escherichia coli, respectively. Yeast and mold counts of <100 per g were found in 98% of the samples.

Because of the limited amount of data on the microbiological quality of macaroni and noodle products obtained at the retail level, a survey was made encompassing the entire United States. This paper reports the results of that survey.

MATERIALS AND METHODS

Product Identification. The products sampled conformed to the 1981 Code of Federal Regulations 21, part 139, requirements for standardized macaroni and noodle products, which basically include macaroni, spaghetti, vermicelli, noodles, shells, elbows, and related products made by forming unleavened dough into a variety of shapes and drying to less than 13% moisture. Macaroni products may or may not contain egg whites. Vegetable macaroni may contain tomatoes or spinach or both. Noodles contain added eggs or egg yolks.

Sampling. To obtain a regionally representative data base for the United States, the country was divided into four sections. Standard metropolitan statistical areas were stratified by population to ensure representation of large and small population areas, with 64 of these areas randomly selected as collection sites. Five retail stores (three chain and two independent) were selected in each standard metropolitan statistical area, and five retail units of macaroni and five of noodles were collected at each store. If five or more different brands of either product were available, five were collected at random. If fewer than five brands of a product were available, one of each brand was collected plus enough duplicates to total five units. If duplicate brands were collected, different lot numbers were obtained whenever possible. The sampling plan was designed to provide 1,600 units of each product. In actuality, 1,607 units of macaroni and 1,477 units of noodles were collected and analyzed. The number of units of each product met the statistical requirements for valid results.

Sample Analyses. All samples were shipped to the Division of Microbiology, Food and Drug Administration, in Washington, D.C. Analyses included the determination of APCs at 35°C, coliform, E. coli, and S. aureus most-probable-number counts, and yeast and mold counts. The methods used were those described by the Association of Official Analytical Chemists (1) and the Bacteriological Analytical Manual (2).

RESULTS AND DISCUSSION

The frequency distribution, relative cumulative frequency, range, and geometric means for APCs, yeast and mold counts, coliform counts,
and _S. aureus_ counts for macaroni and noodles are shown in Tables 1 to 3. _E. coli_ was not found in the macaroni samples; however, seven samples of noodles (0.5%) were positive for _E. coli_, and the most-probable-number values ranged from 3 to 93 per g.

A comparison of the APCs for macaroni and noodles indicated a lower percentage of units of noodles than macaroni with counts of <10,000 per g; however, the distribution of counts of >10,000 per g was similar for the two products. Yeast and mold count results paralleled those of APCs in that a lower percentage of noodles than macaroni had counts of <1,000 per g; however, this difference disappeared with counts of >1,000 per g. Coliform and _S. aureus_ count results also followed this general pattern.

In a study of pasta products in Canada, Rayman et al. (8) suggested a single set of microbiological criteria for pasta products regardless of whether they contain eggs. Microbiological criteria are generally concerned with the segment of a product with the greater microbiological contamination; our data also support a single set of criteria since there was little difference in the relatively high count fraction of macaroni and noodles.

Quantitatively, our results are similar to those found by Rayman et al. Table 4 compares the results of APCs and yeast and mold counts for the two studies. Coliform and _S. aureus_ count results in the two surveys were also similar in that most samples had <3 per g. _E. coli_ organisms were found in 1% of the samples with egg in the Canadian survey. None were found in the Canadian macaroni samples.

The International Commission for Microbiological Specifications for Foods has recommended the following microbiological specifications for pasta with egg (5): for APCs, values are _n_ = 5, _c_ = 2, _m_ = 10⁵ per g, and _M_ = 10⁶ per g; for _S. aureus_ counts, _n_ = 5, _c_ = 1, _m_ = 10 g, and _M_ = 10⁵ per g. The symbol _n_ is the number of units in a sample, _m_ is the value which separates good microbiological quality from marginally acceptable quality, _M_ is the value that separates marginal quality from defective quality, and _c_ is the maximum number of allowable marginal units in the sample of _n_ units. When these criteria were applied to the results of our study, one unit of noodles tested exceeded the _M_ value for APC, and none exceeded that value for the _S. aureus_ count. Almost 7% of the units of noodles exceeded the _m_ value for APC, and 2% exceeded that for the _S. aureus_ count. Undoubt-

### TABLE 1. APCs and yeast and mold counts of macaroni obtained at the retail level

<table>
<thead>
<tr>
<th>Type of count</th>
<th>Range/g</th>
<th>No. of positive samples</th>
<th>RCF&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>APC&lt;sup&gt;b&lt;/sup&gt;</td>
<td>&lt;100</td>
<td>231</td>
<td>14.4</td>
</tr>
<tr>
<td></td>
<td>100–500</td>
<td>623</td>
<td>53.1</td>
</tr>
<tr>
<td></td>
<td>510–1,000</td>
<td>339</td>
<td>74.2</td>
</tr>
<tr>
<td></td>
<td>1,100–5,000</td>
<td>281</td>
<td>91.7</td>
</tr>
<tr>
<td></td>
<td>5,100–10,000</td>
<td>50</td>
<td>94.8</td>
</tr>
<tr>
<td></td>
<td>11,000–50,000</td>
<td>38</td>
<td>97.2</td>
</tr>
<tr>
<td></td>
<td>51,000–100,000</td>
<td>14</td>
<td>98.1</td>
</tr>
<tr>
<td></td>
<td>110,000–500,000</td>
<td>23</td>
<td>99.5</td>
</tr>
<tr>
<td></td>
<td>510,000–1,000,000</td>
<td>2</td>
<td>99.6</td>
</tr>
<tr>
<td></td>
<td>1,100,000–5,000,000</td>
<td>3</td>
<td>99.8</td>
</tr>
<tr>
<td></td>
<td>5,100,000–10,000,000</td>
<td>3</td>
<td>100.0</td>
</tr>
</tbody>
</table>

<sup>a</sup> RCF, Relative cumulative frequency.

<sup>b</sup> Range of the count per gram, <100 to 9,400,000; number of samples, 1,607; geometric mean, 520.

<sup>c</sup> Range of the count per gram, 40 to 72,000; number of samples, 1,607; geometric mean, 72.

### TABLE 2. APCs and yeast and mold counts of noodles obtained at the retail level

<table>
<thead>
<tr>
<th>Type of count</th>
<th>Range/g</th>
<th>No. of positive samples</th>
<th>RCF&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>APC&lt;sup&gt;b&lt;/sup&gt;</td>
<td>&lt;100</td>
<td>34</td>
<td>2.3</td>
</tr>
<tr>
<td></td>
<td>110–500</td>
<td>241</td>
<td>18.6</td>
</tr>
<tr>
<td></td>
<td>510–1,000</td>
<td>377</td>
<td>44.1</td>
</tr>
<tr>
<td></td>
<td>1,100–5,000</td>
<td>654</td>
<td>88.4</td>
</tr>
<tr>
<td></td>
<td>5,100–10,000</td>
<td>74</td>
<td>93.4</td>
</tr>
<tr>
<td></td>
<td>11,000–50,000</td>
<td>64</td>
<td>97.8</td>
</tr>
<tr>
<td></td>
<td>51,000–100,000</td>
<td>13</td>
<td>98.6</td>
</tr>
<tr>
<td></td>
<td>110,000–500,000</td>
<td>17</td>
<td>99.8</td>
</tr>
<tr>
<td></td>
<td>510,000–1,000,000</td>
<td>2</td>
<td>99.9</td>
</tr>
<tr>
<td></td>
<td>1,100,000–5,000,000</td>
<td>1</td>
<td>100.0</td>
</tr>
</tbody>
</table>

<sup>a</sup> RCF, Relative cumulative frequency.

<sup>b</sup> Range of the count per gram, <100 to 1,800,000; number of samples, 1,477; geometric mean, 1,400.

<sup>c</sup> Range of the count per gram, 20 to 58,000; number of samples, 1,477; geometric mean, 100.
edly, because of the tolerance in the criteria for marginal units for APC (c = 2) and for the S. aureus count (c = 1), many of these marginally high count units would not prevent a lot from meeting the overall criteria recommended by the International Commission for Microbiological Specifications for Foods.

Rayman et al. recommended a single three-class plan of microbiological criteria for all pasta products (8). Using the same symbols as those used by the International Commission for Microbiological Specifications for Foods, they proposed the following specifications, based on $n = 5$; for APCs, $m = 5 \times 10^4$ per g, $M = 10^6$ per g, and $c = 2$; for S. aureus counts, $m = 2.5 \times 10^5$ per g, $M = 1 \times 10^6$ per g, and $c = 2$; for E. coli, $m = 1$ per g, $M = 5 \times 10^5$ per g, and $c = 2$; and for yeast and mold counts, $m = 2 \times 10^3$ per g, $M = 5 \times 10^4$ per g, and $c = 2$. With a few exceptions, these proposed criteria are easily met by the products sampled in the United States.

### TABLE 3. Coliform and S. aureus counts in macaroni and noodles obtained at the retail level

<table>
<thead>
<tr>
<th>Type of count</th>
<th>Macaroni</th>
<th>Noodles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Range (MPN)a</td>
<td>No. of positive samples</td>
</tr>
<tr>
<td>Coliforms 100</td>
<td>&lt;3</td>
<td>1,566</td>
</tr>
<tr>
<td></td>
<td>3–19</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>20–42</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>43–64</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>72–150</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>160–460</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>530–1,100</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1,200–9,500</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>11,000–95,000</td>
<td>1</td>
</tr>
<tr>
<td>S. aureus 100</td>
<td>&lt;3</td>
<td>1,578</td>
</tr>
<tr>
<td></td>
<td>3–19</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>20–42</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>43–64</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>72–150</td>
<td>3</td>
</tr>
<tr>
<td></td>
<td>160–460</td>
<td>3</td>
</tr>
</tbody>
</table>

a MPN, Most probable number.
b RCF, Relative cumulative frequency.
c Range per gram for macaroni, <3 to 2,400; number of samples, 1,607; geometric mean, <3. Range per gram for noodles, <3 to 46,000; number of samples, 1,477; geometric mean, <3.
d Range per gram for macaroni, <3 to 93; number of samples, 1,607; geometric mean, <3. Range per gram for noodles, <3 to 240; number of samples, 1,477; geometric mean, <3.

### TABLE 4. Comparison of results from surveys of APCs and yeast and mold counts of pasta products in Canadaa and the United States

<table>
<thead>
<tr>
<th>Count/g</th>
<th>Macaroni (without egg)</th>
<th>Noodles (with egg)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Canada</td>
<td>United States</td>
</tr>
<tr>
<td>APC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;50</td>
<td>15.1</td>
<td>6.0</td>
</tr>
<tr>
<td>&lt;500</td>
<td>55.4</td>
<td>51.1</td>
</tr>
<tr>
<td>&lt;5,000</td>
<td>82.5</td>
<td>91.7</td>
</tr>
<tr>
<td>&lt;50,000</td>
<td>95.5</td>
<td>97.2</td>
</tr>
<tr>
<td>Yeast and mold</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;200</td>
<td>88.6</td>
<td>85.3</td>
</tr>
<tr>
<td>&lt;2,000</td>
<td>98.5</td>
<td>98.6</td>
</tr>
<tr>
<td>&lt;20,000</td>
<td>99.5</td>
<td>99.7</td>
</tr>
<tr>
<td>&lt;200,000</td>
<td>99.9</td>
<td>100.0</td>
</tr>
</tbody>
</table>

a Data for Canadian products are from Rayman et al. (8).
b The total number of samples tested in each category were: macaroni (Canada)—1,500; macaroni (United States)—1,607; noodles (Canada)—387; noodles (United States)—1,477.
ACKNOWLEDGMENTS

We gratefully acknowledge the assistance of the Food and Drug Administration District Office personnel who collected the samples studied in this survey.

LITERATURE CITED