BACTERIOLOGICAL QUALITY OF RAW REFRIGERATED GROUND BEEF

C. L. Duitschaever, D. R. Arnott, and D. H. Bullock
Department of Food Science, University of Guelph
Guelph, Ontario, Canada

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Abstract

A total of 213 samples of various types of raw refrigerated ground beef from 51 different retail stores in Ontario were analyzed for their microbial content. Mesophilic and psychrotrophic counts on 64% of the samples were in excess of 10 million per gram. All samples yielded staphylococci with 98% containing >1000 organisms per gram. Coagulase-positive staphylococci were isolated from 17% of the samples. Enterococcus counts ranged from <10 to 10,000 per gram. About 95% of the samples had coliform counts in excess of 100 per gram and counts in individual samples varied from <10 to 100,000 per gram. Salmonellae were not isolated.

The process of manufacturing ground beef involves grinding of cellular tissue. Bacteria normally present on the surface of meat are distributed by this process throughout the entire product and an ideal condition for their multiplication may be created. Ground beef is not heated or otherwise processed to ensure the absence of pathogenic and spoilage organisms. Thus the microbiological quality depends on the meat used for grinding, sanitary conditions, practices during preparation, and time and temperature of storage. Rogers *(9)* pointed out that numbers of bacteria in market samples of ground beef are clearly indicative of the history of the product.

Several studies of bacteriological quality of fresh refrigerated ground beef have been published *(3, 5, 7, 11, 13, 14)*. These studies have reflected the quality situation in different American and European markets and are part of the evidence offered for use in establishing quality standards for ground beef. We are not aware of comparable data for any Canadian market. The need for information on which to base quality standards prompted the study reported here.

Methods

The Ontario cities of Guelph, Kitchener-Waterloo, and Toronto were the three market areas sampled. Each Saturday during the months of May, June, July, and August, 1972, ground beef samples of about 1 lb. were purchased directly from display cabinets in retail stores. Samples from Guelph and Kitchener-Waterloo reached the laboratory within 2 hr and were refrigerated at 2 C until they were analyzed two days later. Preliminary studies had shown that storage at 2 C or lower for 2 days did not result in an increase of bacterial counts. Toronto samples were refrigerated at 2-4 C at time of purchase because several hours were required for delivery to the laboratory. A total of 213 samples of various types of ground beef were obtained from 51 different retail stores.

Microbiological Examination

Thirty grams of sample were weighed into a sterile Waring blendor and mixed for 3 min at high speed with 270 ml peptone water (0.1% w/v, pH 6.8) at 4 C. Further dilutions were made in 0.1% peptone solutions. The following microbiological analyses were carried out: aerobic plate count and psychrotrophic plate count on standard plate count agar and incubated at 32 C for 48 hr and at 7 C for 10 days, respectively; coliform count on violet red bile agar at 37 C for 24 hr; enterococcus count on Reinbold's blue tetrazolium-citrate azide medium *(8)* at 37 C for 48 hr; staphylococcus count on Baird-Parker's tellurite polymyxin egg yolk agar at 37 C for 48 hr; and salmonellae using a secondary selective enrichment *(6)*. Biochemical confirmation tests for salmonellae were done using the multitest micromethod *(1)* followed if necessary by serotyping of positive cultures. Suspected cultures of *Staphylococcus aureus* were examined by gram stain and for coagulase by the slide method *(2)* with the use of lyophylized bacto-coagulase plasma (without EDTA, Difco).

Results and Discussion

A summary of the bacterial content of different types of ground beef is presented in Table 1. Averages of aerobic mesophilic counts of the different types of ground beef ranged from 10 million to 97 million organisms per gram. Packaged hamburger and hamburger sold in bulk showed the highest bacterial content. Psychrotrophic and mesophilic flora were comparable for all types of meat with the exception of hamburger sold in bulk where psychrotrophic counts were almost twice as high as mesophilic counts. Average coliform counts ranged from 1400 to 19,000 per gram but some individual samples were as high as 100,000 per gram. Packaged hamburger had the highest average count. The enterococcus counts ranged from <10 to 10,000 per gram. Staphylococci were isolated from all samples and 17% of them contained coagulase-positive staphylococci ranging from 5 to 100% of the total staphylococcus count. Percentage distributions of samples falling within selected population ranges for psychrotrophs, coliforms, and staphylococci are given in Table 2. *Sal-*

TABLE 1. BACTERIAL COUNTS PER GRAM FROM DIFFERENT TYPES OF GROUND BEEF

Type	No. of samples	Aerobic plate count mean, range (millions)	Psychrotrophs mean, range (millions)	Coliforms mean, range (hundreds)	Enterococci mean, range	Staphylococci		
						mean, range (thousands)	No. coagulase positive samples	Coagulase positive (range) %[a]
Hamburger, pkgd.	87	77 2-740	76 0.5-800	191 3-1000	506 <10-6000	116 7-490	16	7-75
Hamburger, bulk	13	97 0.7-270	170 0.7-310	14 3-400	862 10-9000	115 30-440	4	20-100
Chuck, pkgd.	41	33 0.5-270	41 0.9-120	81 0.2-480	380 <10-9000	58 3-240	9	5-100
Chuck, bulk	15	44 4-130	60 2.8-220	68 1-170	2530 10-8000	33 3-300	0	
Round, pkgd.	18	15 0.12-50	24 0.12-90	23 0.3-1000	191 <10-1400	40 3-120	3	12-22
Round, bulk	9	10 0.6-20	9 0.1-30	20 2-100	2620 40-10,000	30 5-70	2	11-33
Steakettes	30	25 0.11-500	25 0.1-500	15 0.1-400	917 <10-3000	14 1-160	3	25-33

[a]Refers to percentage of coagulase-positive staphylococci in the coagulase positive samples.

TABLE 2. POPULATION RANGES PER GRAM OF GROUND BEEF OF PSYCHROTROPHS, COLIFORMS, AND STAPHYLOCOCCI IN THE VARIOUS TYPES OF GROUND BEEF AND PERCENTAGE DISTRIBUTION OF SAMPLES FALLING WITHIN SELECTED POPULATION RANGES

Type of meat	No. of samples	Psychrotrophs (millions)				Coliforms			Staphylococci		
		<1	1-4.9	5-10	>10	<10	10-100	>100	<100	100-1000	>1000
Hamburger, pkgd.	87	1	1	10	75	0	1	76	0	0	87
Hamburger, bulk	13	2	0	3	8	0	0	13	0	0	13
Chuck, pkgd.	41	1	7	9	24	0	0	41	0	0	41
Chuck, bulk	15	0	1	3	11	0	1	14	0	0	15
Round, pkgd.	18	1	3	5	9	0	2	16	0	0	18
Round, bulk	9	1	3	2	3	0	0	9	0	0	9
Steakettes	30	9	6	8	7	0	7	23	0	3	27
TOTAL	213	15	21	40	137	0	11	202	0	3	210
Percentage		7.2	9.9	18.7	64.2		5.2	94.8	0	1.4	98.60

monella organisms were not isolated from any of the samples. The predominant microorganisms were psychrotrophs. This is not surprising in refrigerated products but the extent of the psychrotrophic flora here is disturbing. This cannot be readily explained because information regarding quality of meat used in the ground product and duration of storage before sale was not available. Also, accuracy of showcase thermometers present in retail outlets is questionable. Microbial content was greatest in the hamburger type of ground meat. This may reflect the condition of meat that was used for its preparation.

Some authors have suggested standards for raw hamburger meat ranging from 0.25 to 10 million total viable aerobes per gram *(4, 13, 14)*. If 10 million per gram was the standard, then 64% of the samples in our study were unacceptable. Thieulin et al. *(11)* reported counts of mesophilic and psychrotrophic bacteria of <10 million per gram in 98% of the samples examined. Although aerobic psychrotrophic bacteria are generally non-pathogenic to man, they are important to the hygienist because they are the most common cause of refrigerated food spoilage. High bacterial counts may indicate unsanitary conditions and practices in packing houses, or during transportation, or during handling of meat in retail stores.

The presence of staphylococci in all samples at levels far above suggested standards of none in 0.01 or 0.1 g *(4)* is disturbing. Even a more liberal standard of not more than 1000 per gram of raw meat was exceeded by more than 98% of the samples. The fact that 37% of the samples contained coagulase-positive staphylococci which could be associated with food intoxication emphasizes the potential dan-

ger of mishandling ground meat.

Tobey *(12)* suggested a coliform standard of not more than 200 per gram while Rogers *(9)* considered the mere presence of coliforms in ground meat as evidence of poor sanitation during production or handling of the product. About 95% of the samples examined in this study had coliform counts in excess of 100 per gram. The apparent absence of salmonellae may be explained by the relatively low pH 5.6-5.8 of fresh ground beef and the intensive competition of the dominating spoilage flora.

With the present emphasis on food inspection and sanitation and use of mechanical refrigeration in food retail outlets one might have expected better microbiological quality of ground beef products.

Generally, the quality was similar to that reported in previous investigations dating as far back as 1914. This may indicate a need for a thorough examination of the practices used in the handling of meat from the abattoir to the consumer.

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REFERENCES

1. Analytab Products Inc., 919 Third Avenue, New York, N. Y. 10022.

2. Baker, F. J. 1962. Handbook of bacteriological technique. Butterworth and Co., (Publishers) Ltd., London, 88 Kingsway, W.C.2. p. 210.

3. Elford, W. C. 1936. Bacterial limitations in ground fresh meat. Amer. J. Public Health 26:1204.

4. Elliott, R. P., and H. D. Michener. 1961. Microbiological standards and handling codes for chilled and frozen foods. A review. Appl. Microbiol. 9:452.

5. Foltz, V. D. 1941. A bacteriological study of ground meat. J. Bacteriol. 42:289.

6. Galton, M. M., G. K. Morris and W. T. Martin. 1968. Salmonellae in foods and feeds. U. S. Dept. of Health, Education and Welfare, Atlanta, Georgia 30333. pp. 19-20.

7. Kirsch, R. H., F. E. Berry, C. L. Baldwin, and E. M. Foster. 1952. The bacteriology of refrigerated ground beef. Food Res. 17:495.

8. Reinbold, G. W., M. Swern, and R. V. Hussong. 1953. A plating medium for the isolation and enumeration of enterococci. J. Dairy Sci. 36:1.

9. Rogers, E. R., and C. S. McCleskey. 1957. Bacteriological quality of ground beef in retail markets. Food Technol. 11:318.

10. Thatcher, F. S., and D. S. Clark. 1968. Microorganisms in foods: Their significance and methods of enumeration. University of Toronto Press, Toronto, Canada. pp. 115-122.

11. Thieulin, G., J. Pantaleon, and R. Rosset. 1966. Contribution à l'étude des germes aérobies psychrotrophes des viandes hachées. Ann. Inst. Pasteur, Lille 17:131.

12. Tobey, E. R. 1944. Analyses of hamburger steak. Maine Agr. Exp. Sta. Off. Inspection Bull. No. 191, 145; Chem. Abs. 42, 8363 g (1948).

13. Weinzirl, J., and E. B. Newton. 1914. Bacteriological methods for meat analyses. Am. J. Pub. Health 4:408.

14. Weinzirl, J., and E. B. Newton. 1914. Bacteriological analyses of hamburger steak with reference to sanitary standards. Amer. J. Public Health 4:413.

SOURCE OF PHOSPHORUS IN MILK PROTEINS SUGGESTED BY USDA RESEARCH

Phosphorus is incorporated into milk proteins in a specific site in the lactating mammary gland, a U. S. Department of Agriculture scientist proposed here.

Phosphorus is combined with casein, the principal protein of milk. The sequence in which this phosphoprotein is formed was suggested on the basis of studies done with lactating rat mammary gland by Mrs. Elizabeth W. Bingham, a research chemist at the Eastern Regional Research Laboratory of USDA's Agricultural Research Service in Philadelphia.

She said the casein is made at the base of the mammary gland cells from amino acids. The newly formed proteins pass into a cuplike structure called the Golgi apparatus where phosphorus (in the form of phosphate) is combined with them. Calcium is then added and the completed casein is secreted in tiny packages of nourishment called micelles.

ARS scientists envision that further knowledge of the mechanism by which casein is formed in the cow might lead to milk with unique properties through variation in the amounts and ratios of phosphorus and calcium present.

Mrs. Bingham spoke before the Federation of American Societies of Experimental Biology. She reported work which she did with Dr. Harold M. Farrell, Jr., on the origin of milk casein and the mechanism by which this phosphoprotein is formed. Such knowledge is of practical importance to dairy research in view of the well-known nutritional value of the protein-phosphorus-calcium complex. Also, earlier research by Dr. Farrell and Mrs. Bingham has established that the phosphate in the protein contributes to keeping the casein micelles of milk in solution.

Electron photomicrographs of casein micelles being formed, taken by ARS microscopist Robert J. Carroll, were shown by Mrs. Bingham to illustrate the process. The pictures did not show the phosphate specifically, so further research was required to find out whether the phosphate and casein were put together in the Golgi apparatus or in some other part of the mammary gland.

The ARS researchers worked with rat mammary gland separated into its various fractions, including the Golgi fraction. They put each fraction into a solution with milk casein whose phosphate had been removed. The object was to see if the enzymes in these mammary tissues would restore phosphate to this dephosphorylated casein. The Golgi fraction had a marked phosphorylating effect, and it was the only fraction that did. Even normal casein was somewhat further phosphorylated by this fraction. This research establishes, said Mrs. Bingham, that the Golgi apparatus is the specific site where phosphate is added to the casein molecule.