

SURVEY OF THE BACTERIOLOGY OF CANADIAN GROUND BEEF RELATIVE TO A PROPOSAL FOR STANDARDS

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A survey of Canadian Ground Beef was carried out by the Health Protection Branch (H.P.B.) in 1974-75. Samples of non-frozen products were obtained from 218 retail stores in 18 urban areas and frozen products from 118 restaurants or retail stores. In all, 1,680 specimens were examined for aerobic colony count (ACC), fecal coliforms, *Staphylococcus aureus* and *Salmonella* sp. The results of the survey indicated that the bacteriological quality of non-frozen ground beef has not improved with respect to ACC during the past 4 decades.

For non-frozen products, 12% of specimens had ACC's (35°C) of $>10^7$ and 53% had ACC's (21°C) of $>10^7$; 9.3% had fecal coliforms $>5 \times 10^2$ and 9.3% had *S. aureus* counts of $>10^2$. Frozen products generally contained lower ACC's.

In addition to the results of the HPB studies, a summary of data from several manufacturers of ground beef will be presented.

To provide a uniform policy that will apply to ground beef sold throughout Canada, we propose that standards be enacted under the Food and Drugs Act. To accommodate the variable distribution of bacteria between packages of a given lot, the recommendations of the International Commission on Microbiological Specifications for Foods regarding 3-class plans for acceptance criteria will be used.

ENQUETE BACTERIOLOGIQUE SE RAPPORTANT A LA VIANDE HACHEE DE BOEUF AU CANADA RELATIVE A UNE PROPOSITION DE NORMES

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Une enquête sur la viande de boeuf hachée a été conduite par la Direction Générale de Protection de la Santé au Canada durant les années 1974-1975. Des échantillons de produits non congelés ont été obtenus de 218 magasins de détail de 18 régions urbaines, et de produits congelés de 118 restaurants ou magasins de détail. Au total 1,680 spécimens ont été examinés pour dénombrement d'hétérotrophe aérobies (DHA), coliformes fécaux, *Staphylococcus aureus* et *Salmonella* sp. Les résultats de cette enquête ont démontré que la qualité bactériologique de la viande de boeuf hachée non congelée en rapport au DHA ne s'est pas améliorée depuis les quarante dernières années.

Pour les produits non congelés, 12% des spécimens incubés à 35°C et 53% de spécimens incubés à 21°C avaient DHA $>10^7$; 9.3% ont eu des coliformes fécaux $>5 \times 10^2$ et 9.3% ont eu *S. aureus* de $>10^2$. Les produits congelés contenaient généralement moins de DHA.

Des données provenant de plusieurs manufacturiers de viande de boeuf hachée seront également présentées.

Pour assurer une politique uniforme impliquée à la vente de viande de boeuf hachée au Canada, nous proposons que les normes soient promulguées sous loi des Aliments et Drogues. Pour accommoder la répartition variable de bactéries parmi les emballages d'un lot déterminé, les "3-class plans" seront utilisés d'après les recommandations de la Commission internationale pour les spécifications microbiologiques des aliments.

MIKROBIOLOGISCHE UNTERSUCHUNG VON GEHACKTEM RINDFLEISCH IN KANADA ALS GRUNDLAGE FÜR REALISTISCHE NORMEN

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Eine mikrobiologische Untersuchung von gehacktem Rindfleisch wurde 1974 und 1975 von der Health Protection Branch (H.P.B.) in Kanada durchgeführt. Proben von ungefrorenem Fleisch wurden in 218 Läden von 18 Städten genommen; Proben von gefrorenem Fleisch kamen von 118 Restaurants und Läden. Insgesamt wurden 1,680 Proben auf Gesamtkeimzahl, faekale Coliformen, *S. aureus* und Salmonellen analysiert. Die Ergebnisse zeigten, dass sich an der mikrobiologischen Qualität von ungefrorenem Hackfleisch in bezug auf Gesamtkeimzahl in den letzten vier Jahrzehnten wenig geändert hat.

Gesamtkeimzahlen von $>10^7/g$ wurden in 12% der ungefrorenen Proben bei 35°C Inkubation und in 53% dieser Proben bei 21°C Inkubation gefunden. Jeweils 9,3% enthielten $>5 \times 10^2$ faekale Coliformen und $>10^2$ *S. aureus*. Proben des gefrorenen Produktes hatten niedrigere Keimzahlen.

Eine Zusammenfassung mikrobiologischer Analysen der Fleischindustrie wird ebenfalls gegeben.

Um eine einheitliche Kontrolle von gehacktem Rindfleisch in Kanada zu gewährleisten, haben wir mikrobiologische Normen im Rahmen des "Food and Drugs Act" vorgeschlagen. Schwankungen im Bakteriengehalt unter Proben ein und der selben Produktion werden durch den "3-class plan" der ICMSF berücksichtigt.

БАКТЕРИОЛОГИЧЕСКОЕ ИССЛЕДОВАНИЕ КАНАДСКОЙ ИЗМЕЛЬЧЕННОЙ ГОВЯДИНЫ ПО ОТНОШЕНИЮ К ПРЕДЛАГАЕМЫМ СТАНДАРТАМ

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Исследование канадской измельченной говядины было проведено Отделом Здравоохранения (H.P.B.) в 1974-1975 гг. Были взяты пробы незамороженных продуктов из 218 магазинов в 18 городских районах и пробы замороженных продуктов из 18 ресторанов или магазинов. Таким образом исследовано в общей сложности 1,680 проб на количество аэробных колоний (АСС), наличие фекальных коли-форм, *Staphylococcus aureus*, *Salmonella* sp. Результаты исследований указывали на то, что бактериологическое качество незамороженной измельченной говядины не улучшилось, что касается АСС за последние четыре десятка лет.

Что касается незамороженных продуктов то в 12% проб имелось АСС (35°C) в $>10^7$ и в 53% имелось АСС (21°C) в $>10^7$; в 9,3% были обнаружены фекальные коли-формы $>5 \times 10^2$ и в 9,3% имелся *S. aureus* в $>10^2$. Замороженные продукты содержали как правило меньше АСС.

Кроме результатов H.P.B. будет представлено резюме сообщений предприятий, изготавливающих измельченную говядину.

Для проведения одной общей линии в отношении измельченной говядины, продаваемой во всей Канаде предлагается внесение стандартов в Постановление о пищевых и лекарственных продуктах / Food and Drugs Act /. Для унифицирования неравномерного распределения бактерий в пакетах данной партии будут применяться рекомендации Международной Комиссии по микробиологическим спецификациям по пищевым продуктам относительно 3-х классной схемы для критерий приемки продуктов.

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INTRODUCTION

There is much concern by the general public in North America about the microbial quality of ground meat. This concern results from lack of understanding by the non-specialist of the significance of high bacterial counts, the presence of indicators of fecal contamination such as *E. coli* and the presence of potential or real pathogens such as enteropathogenic *E. coli*, *S. aureus* and *Salmonella* species. As a result there has been a proliferation of guidelines and standards by municipal, provincial and state agencies; a few of these appear to be illogical and even unachievable under current slaughtering, processing and vending practices. Nevertheless, there is a need for intervention by regulatory agencies: a comparison of bacteriological counts of ground meat in 1933 (Geer), 1952 (Kirsch et al.), 1957 (Rogers and McCleskey) with results of recent surveys of ground meat purchased, from retail sources (Duitschaeffer et al., 1973; Law et al., 1971, Smit, 1973; Shoup and Oblinger, 1976; Goepfert, 1976; Pivnick et al., 1976) indicates little improvement in 4 decades. In fact, in some instances, quality appears to have deteriorated. Moreover, ground meat may be a more significant source of food-borne disease (Fleming et al., 1973; MMWR, 1975a; MMWR, 1975b) than it is usually considered to be.

In Canada the Health Protection Branch (HPB) conducted a nation-wide survey to determine the bacteriological quality of ground beef sold in retail stores and used by restaurants specializing in hamburgers. Standards are proposed based on the results of the survey.

MATERIALS AND METHODS

The HPB survey was conducted from December 1974 to March 1975. Non-frozen ground beef was purchased from 218 stores in 18 urban areas and their suburbs. The samples were transported in refrigerated boxes and analyzed usually within 3 hr of purchase. The frozen products (preformed portions ready for cooking) were obtained from 59 restaurants in the same 18 areas. Each sample consisted of 5 packages (subsamples) of non-frozen product or two portions from each of 5 packages of frozen product. Each subsample was examined for aerobic colony count (ACC) at 35C and 21C, fecal coliforms (data presented as *E. coli* in tables), *S. aureus* and presence of *Salmonella* in 25 gm. In all 1090 subsamples of non-frozen and 590 subsamples of frozen product were examined by Acceptable Methods of the HPB.

Industrially produced ground beef made from non-frozen and frozen boneless beef was examined by 3 manufacturers in their normal quality control procedures. Data supplied by two manufacturers (A and B) is from a single plant of each; data from the third manufacturer (C) is collated from results obtained from several of its plants that are widely scattered geographically. Most of the data were obtained in 1975, and consist of ACC's at 25C or 35C. A and B presented data for both ingoing boneless meat and ground meat frozen in patties; C presented data only for ground beef, but not ingoing boneless beef. Where feasible, published data have been tabulated for comparison.

RESULTS AND DISCUSSION

Bacteriological results depend on the method used. Moreover, bacterial content may vary widely between subsamples from a single lot. Table 1 illustrates both concepts with samples (each of 5 subsamples) taken from two stores. For Sample A, the ACC obtained by incubating petri dishes at 35C is 10 times less than the ACC obtained by incubating identical petri dishes at 21C. Subsamples of Sample B varied at least 7 fold from the lowest ACC to the highest. The effect of temperature used for obtaining the ACC on the percentage of subsamples meeting arbitrarily chosen limits is shown in Table 2. When the ACC was incubated at 35C, 48% of subsamples met an arbitrary limit of 1×10^6 , but when the ACC was conducted at 21C, only 11% met the same limit. We have chosen the ACC at 35C for further work and for our proposed standards because our regulatory laboratories use that temperature of incubation for almost all of their analytical determinations. We realize fully, however, the implications of this choice and emphasize that both producer and consumer should be aware that higher counts are obtained when the incubation for the ACC is conducted at lower temperatures. Smit (1973) and Goepfert (1976) have shown similar differences in ACC's conducted at different temperatures.

E. coli is an indication of care and sanitation in slaughtering and processing. In Table 3 we have compiled data from 5 recent surveys. All data were obtained from analysis of single packages except that reported by Surkiewicz et al. (1973): his data are based on the geometric mean of 10 subsamples. The percentage of samples (or subsamples) meeting a limit of 100 *E. coli* per gm varied from 71 to 92. Samples examined by Company C and by Surkiewicz were taken from federally inspected factories, the other 3 sources of samples were retail vendors. No distinction was made by us in Table 3 between non-frozen and frozen product although we recognize that freezing may reduce the viable population of *E. coli*.

S. aureus does not appear to be an important pathogen in ground beef and, like other pathogens or potential pathogens, does not grow at temperatures used for storing this product. All 3 surveys indicated that at least 97% of samples (or subsamples) contained fewer than 1000 S. aureus per gm and a high percentage contained fewer than 100 per gm (Table 4).

Salmonella were infrequently found in ground beef during several recent surveys in North America. The following percentages have been reported: 20 of 1680 subsamples (1.2%) by Pivnick et al.; 4 of 1425 (0.2%) by Surkiewicz et al.; 1 of 40 by Shoup and Oblinger (2.5%); 0 of 213 (<0.5%) by Duitschaever et al.

A distinction must be made between ACC's in non-frozen ground beef from retail stores and ACC's obtained for product at the manufacturing level or frozen at the factory and distributed to retailers and restaurants. The ACC of non-frozen product may increase 10 fold within one to two days at 5C (Al-Delaimy and Stiles 1975) and in our study (Pivnick et al., 1976) over one-half of samples exceeded 5C at time of purchase. Also, non-frozen ground beef sold at retail may contain substantial amounts of trimming from carcasses aged for variable periods of time by the retailer. Thus, one would expect that non-frozen ground beef vended from retail stores would have higher ACC's than non-frozen ground beef sampled at a factory, or frozen ground beef that is produced in a factory. Following are results for ACC's of industrially produced ground beef: some were obtained at 35C, others at 25C.

In Table 5 we compared ACC's (35C) of frozen ground beef from 4 separate studies. Company B is a single plant; Company C collated results from several of its plants; studies by Pivnick et al. and Surkiewicz et al. were nation-wide surveys in Canada and the U.S.A., respectively. Over 99% of the products had ACC's (35C) of $<1 \times 10^7$. Table 6 shows ACC's (35C) of boneless beef and ground beef made from it by Company B: 98% of ingoing material and 98% of product had counts of $<2 \times 10^6$.

ACC's at 25C from industrial sources are presented in Table 7. Company A used ingoing material (boneless beef) of better bacteriological quality than Company B and was able to produce ground beef of better bacteriological quality than Company B. These data are important in the context of comparing ingoing material with finished product but, because the ACC's were obtained at 25C, they have little value in relationship to regulatory activity in North America: almost all regulatory agencies that have publicized numerical data for ACC's of ground meat have stated their limits for ACC's obtained by incubation at 35C.

Table 8 shows recommendations for bacteriological limits for ground meat as stated by various agencies. Most are guidelines; only one is a standard and, therefore, enforceable by law. They range from the unrealistic low ACC (35C) of 1×10^5 to the realistic recommendations of 1×10^6 to 1×10^7 for frozen ground meat expressed by the ICMSF (International Commission on Microbiological Specifications for Foods).

The ICMSF recommends a 3-class sampling plan (ICMSF, 1974) with a sample consisting of 5 subsamples (packages, units, etc.) from a lot of ground beef. Definitions of parameters for the 3-class plan are shown in Table 9.

In December, 1974, the Government of Canada proposed bacteriological standards for ground beef and invited comments from interested parties. The proposed standards are based on the 3-class sampling plan and are shown in Table 10. After evaluation of the comments, the standards may be promulgated as proposed, or they may be modified. On the basis of the proposed standards, 37% of non-frozen and 33% of frozen product examined in the Canadian survey (Pivnick et al., 1976) would have failed.

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Table 1. Comparison of aerobic colony counts obtained at 35C & 21C: non-frozen ground beef^a

Subsample ^b	Aerobic colony count ($\times 10^{-6}$)			
	Sample A		Sample B	
	35C	21C	35C	21C
1	16	130	1.2	3.9
2	8	94	0.7	1.2
3	11	130	0.5	1.0
4	16	90	0.5	1.6
5	6	97	3.6	8.5
Mean	11	108	1.3	3.2

^aPivnick et al., 1976.^bA sample consisted of 5 subsamples taken from a single store at one time.Table 2. Comparison of effect of temperature used in obtaining the aerobic colony count on per cent samples falling within arbitrary limits: non-frozen ground beef^a

Arbitrary limits of ACC ($\times 10^{-6}$)	Per cent of samples	
	35C	21C
<0.5	35	6
<1.0	48	11
<10.0	88	47
<100.0	99	92

^a1090 subsamples; Pivnick et al., 1976Table 3. *E. coli* in ground beef

Arbitrary limits of <i>E. coli</i> per gm	Per cent of samples				
	Producer		Retailer		
	C ^a	SUR	GPF	PIV	S&O
<100	72	92 ^b	74	76	71
<500	97		90	91	92
Number of samples	79	74	955	1090	49

^aCompany C; Surkiewicz et al., 1975; Goepfert, 1976; Pivnick et al., 1976; Shoup and Oblinger, 1976.^bBased on geometric mean of 10 subsamples per sample; other sources of data based on analyses of single packages.

Table 5. Aerobic colony counts at 35C in samples of frozen ground beef in Canada and the USA

Arbitrary limits of ACC ($\times 10^{-6}$)	Per cent of samples			
	B ^a	C	PIV	SUR
<0.5	26	81	57	56
<1.0	69	96	80	73
<2.5	98			89
<10.0	100	100	99	100
Number of samples	172	1638	590	420

^aCompany B; Company C; Pivnick et al., 1976; Surkiewicz et al., 1975Table 4. *S. aureus* in ground beef

Arbitrary limits of <i>S. aureus</i> per gm	Per cent of samples		
	C ^a	PIV	SUR
<100		91	85 ^b
<500	95		
<1000	97	99	97
Number of samples	908	1090	74 ^b

^aCompany C; Pivnick et al., 1976; Surkiewicz et al., 1975.^bEach sample consisted of 10 subsamples (patties); 85% of the samples had a geometric mean of <100 *S. aureus* per gm.

Table 6. Aerobic colony counts at 35C in samples of boneless and ground beef: Company B

Arbitrary limits of ACC at 35C ($\times 10^{-6}$)	Boneless ^a	Ground ^b
	Per cent	Per cent
<0.01	6	0
<0.1	49	0
<0.5	92	26
<1.0	96	69
<2.0	98	98
<10.0	100	100
Number of samples	516	172

^aFrozen and non-frozen^bFrozen

Table 7. Aerobic colony counts at 25C in samples of boneless and ground beef

Arbitrary limits of ACC at 25C ($\times 10^{-6}$)	Company A		Company B	
	Boneless ^a	Ground ^b	Boneless ^a	Ground ^b
	Per cent	Per cent	Per cent	Per cent
<0.01	19		9	0
<0.1	54	16	36	1
<0.5	76	57	66	7
<1.0	84	79	74	25
<2.0	90	94	84	56
<10.0	99	100	100	100
Number of samples	2266	1004	554	186

^aFrozen and non-frozen^bFrozen

Table 8. Bacteriological limits for ground meat

Organization	Type of limit	ACC (35C)	Coliforms	<u>E. coli</u>	<u>S. aureus</u>	<u>Salmonella</u>
ICMSF ^d	Recommendation	1x10 ⁶ -1x10 ⁷				1(0) ^c
Idaho	Guideline	5x10 ⁶		50		
Massachusetts	Guideline	1x10 ⁵	50		0	0 ^a
Virginia	Guideline	1x10 ⁷		500	200	0 ^a
West Virginia	Guideline	1x10 ⁵	400			
North Dakota	Guideline	5x10 ⁶		50	50	
New York State	Guideline	5x10 ⁶		50	<1000	0 ^b
City of Edmonton	Guideline	5x10 ⁵				
Oregon	Standard	5x10 ⁶		50		

^aSize of sample not stated

^bNone in one gm

^cNone in 5 subsamples, each of 25 gm, but as an interim recommendation, 1 of 5 subsamples may contain Salmonella

^dICMSF recommendation is for frozen meat only.

Table 9. Definitions of parameters for 3-class plan for ground beef^a

LOT:	All packages of a single product that have been produced, handled and stored within a limited period of time under uniform conditions;
SAMPLE:	Predetermined number of subsamples from lot;
n:	Number of subsamples (packages or patties) to be examined;
m:	Maximum number of bacteria per gm in any subsample that is of no concern;
c:	Maximum number of subsamples that can have concentrations between m and M without rejection of the lot;
M:	Number of bacteria per gm which, if exceeded by any subsample causes violation of standard (i.e. rejection of the lot).

^aICMSF, 1974

Table 10. 3-class plan for proposed Canadian standards for ground beef

Test	Non-frozen				Frozen			
	n	c	m	M	n	c	m	M
ACC (35°C)	5	3	10 ⁷	5x10 ⁷	5	2	10 ⁶	10 ⁷
<u>E. coli</u>	5	3	10 ²	5x10 ²	5	2	10 ²	5x10 ²
<u>S. aureus</u>	5	2	10 ²	10 ³	5	2	10 ²	10 ³
<u>Salmonella</u>	5	0 ^a			5	0		

^aAbsent in 25 gm in each of 5 subsamples