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Review

Current microbiological status of 'health foods' sold in Canada

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Abstract

A follow-up survey was conducted across Canada to evaluate the current status of 'health foods' sold in Canada. A total of 1239 sample units of 'health foods' were analysed for a variety of bacteria, including aerobic colony counts (ACC), coliforms, aerobic and anaerobic sporeformers, *Escherichia coli* and *Bacillus cereus*. Results presented indicate that 16.8–18.4% of the 'health foods' exceed ACC guidelines, 16.0–17.8% exceeded coliform guidelines, 35.7% exceeded aerobic sporeformer guidelines, 81.4% exceeded anaerobic sporeformer guidelines, and 9% exceeded *B. cereus* guidelines. Some ACC were further identified and found to be opportunistic pathogens, including the genera *Bacillus*, *Enterococcus*, and *Staphylococcus*. It was concluded that more extensive surveillance of this industry by health officials is needed.

Keywords: Health foods

1. Introduction

With increased consumer concern and awareness about health, many people are choosing 'health foods' as an alternative or supplement to conventional foods. 'Health foods' are advertised as food products that do not contain any additives such as emulsifiers, colours, dyes, sweeteners, antioxidants, bactericides or mold inhibitors (Andrews et al., 1979). It is not surprising that such products have been found to frequently contain bacterial pathogens (including opportunistic pathogens) as many 'health foods' receive minimal heat treatment, are freeze-dried products (Thomason et al., 1977; Warburton and Brodsky, 1993), or are simply a mixture of dry components (McCall et al., 1966). The lack of processing step(s) to inhibit or destroy pathogenic

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bacteria enables many harmful bacteria to survive the food manufacturing process.

Bacillus cereus has been found in high numbers in bovine heart and ovary concentrates (Warburton and Brodsky, 1993), while *Salmonella minnesota*, *S. anatum*, and *S. derby* have been found as contaminants in dried beef liver powders (Thomason et al., 1977). Powdered protein mixes and herbal products have been linked to several outbreaks of salmonellosis (Health and Welfare Canada, 1986; Kunz and Ouchterlony, 1955; McCall et al., 1966; Gregg, 1972; Thomason et al., 1977). High levels of psychrotrophs and coliforms have been found previously in tofu and related products (Szabo et al., 1989). Whole food concentrates, made from soybean, fruit and vegetable extracts, were recalled in Canada due to contamination with three *Salmonella* serotypes (Warburton and Brodsky, 1993), while a case of listeriosis has been linked to the consumption of alfalfa tablets (Farber et al., 1990). *Escherichia coli, Pseudomonas aeruginosa, Salmonella newport*, other salmonellae, and other pathogenic bacteria have been associated with fresh produce, especially bean sprouts (Anonymous, 1996; Andrews et al., 1982; Beuchat, 1996; Patterson and Woodburn, 1980; Health Canada, unpublished data).

In a preliminary study to assess the current state of 'health foods' sold in Ontario, Warburton and Brodsky (1993) surveyed 'health foods' imported or produced in Canada using guidelines established for various indicator microorganisms. In this survey, a total of 166 sample units were tested for ACC, *B. cereus*, coliforms and *E. coli*. Fifty-three (31.9%) of the sample units exceeded the ACC guidelines of 10^4 cfu g^{-1}, while 19 (11.5%) sample units had *M* values exceeding 10^5 ACC g^{-1}. Fourteen (8.4%) exceeded the *B. cereus* guidelines of 10^3 cfu g^{-1}, of which only one sample unit (0.6%) exceeded the guidelines of $M = 10^5$ *B. cereus* g^{-1}. Coliforms ranged from 80 to 1.3×10^2 cfu g^{-1} while staphylococcal counts (not *S. aureus*) ranged from greater than 10^4 to 2.3×10^5 cfu g^{-1}. Coliforms were detected in 27 sample units of which 21 exceeded the $M = 10$ guideline and nine exceeded the $M = 10^2$ guideline. *E. coli* was detected in one herbal product and exceeded the $M = 10$ guideline.

It was concluded that further sampling and monitoring by health agencies was needed due to the high counts of ACC and *B. cereus* in some of these products. Suggested analyses included ACC, *Salmonella*, *B. cereus*, *Escherichia coli*, and coliforms. Based on this survey, raw animal products, herbal products and a variety of 'health food' products were recommended for monitoring.

The purpose of the follow-up survey was to determine the microbiological quality of foods considered 'health foods' by expanding the sampling size in comparison to the preliminary study conducted in 1993. Further surveillance of this industry would provide a more accurate assessment of microbial loads in health food products. While the first study was conducted only in the province of Ontario, this survey included samples from across Canada.

2. Materials and methods

For the purpose of this survey, 'health foods' were divided into the following categories: animal products (e.g., liver, kidney, bone extracts), fruit and vegetable products, herbal products (e.g., alfalfa tablets), marine products (e.g., algae and kelp), protein products (both animal and vegetable), soybean products (e.g., tofu and soya flour), meal replacements and other dietary supplements.

During this survey, a sample was collected consisting of enough sample units (usually 3 to 5 sample units) from local retail outlets or manufacturers, so that the sample consisted of at least 200 g. The cost of these products often prevented the purchase of more than 200 g. Samples were randomly purchased across Canada by Health Canada inspectors.

The following microbiological analyses were conducted on the sample units from each lot: aerobic colony counts (ACC), aerobic and anaerobic sporeformers, coliforms, faecal coliforms, *B. cereus*, *E. coli*, and *Salmonella* following Health Protection Branch methods (MFHPB-17, MFHPB-18, MFHPB-19, MFHPB-20 and MFLP-42; Health Protection Branch, 1989). In cases where ACC counts were found to be out of compliance, bacteria were identified using appropriate methods. Up to five different colonies, representing the most predominant types, were purified on non-selective agar, such as tryptic soy agar (Oxoid Inc., Ottawa). After Gram staining, identification of bacteria was accomplished using the automated ID system Vitek (bioMerieux, Montreal, QU).

Table 1
Frequency distributions of aerobic colony counts of health foods

Sample type	The number of sample units containing specific ACC values (percent frequency distribution)							
	<10	$10–10^2$	$10^2–10^3$	$10^3–10^4$	$10^4–10^5$	$10^5–10^6$	$>10^6$	Total
Dietary and food supplements	6 (2.0%)	61 (20.3%)	87 (28.9%)	58 (19.3%)	44 (14.6%)	24 (8.0%)	21 (7.0%)	301 (100%)
Animal products	3 (4.1%)	36 (49.3%)	16 (21.9%)	7 (9.6%)	8 (11.0%)	3 (4.1%)	0	73 (100%)
Marine products	2 (1.4%)	14 (9.9%)	48 (34%)	42 (30%)	30 (21.3%)	1 (.7%)	4 (2.8%)	141 (100%)
Herbal products	4 (2.6%)	28 (18.0%)	44 (28.2%)	26 (16.7%)	19 (12.2%)	17 (11%)	18 (11.5%)	156 (100%)
Roots, seeds and nuts	5 (7.5%)	6 (9.0%)	17 (25.4%)	15 (22.4%)	8 (11.9%)	8 (11.9%)	8 (11.9%)	67 (100%)
Soybean products	2 (1.4%)	6 (4.2%)	23 (16.0%)	30 (20.8%)	31 (21.5%)	17 (11.8%)	35 (24.3%)	144 (100%)
Fruit and vegetable products	6 (2.8%)	14 (6.5%)	27 (12.6%)	58 (27.1%)	57 (26.6%)	27 12.6%)	25 (11.7%)	214 (100%)
Protein	0	14 (18.7%)	22 (29.3%)	29 (36.7%)	6 (8.0%)	4 (5.3%)	0	75 (100%)
Other food products	3 (4.9%)	8 (13.1%)	13 (21.3%)	17 (27.9%)	5 (8.2%)	11 (18.0%)	4 (6.6%)	61 (100%)
Total	31 (2.5%)	187 (15.2%)	297 (24.1%)	282 (22.9%)	208 (16.9%)	112 (9.1%)	115 (9.3%)	1232 (100%)

Survey results were assessed against guidelines suggested for 'health foods', soybean products, and dry-products (Table 6; Warburton et al., 1988).

3. Results and discussion

The results are summarized in Tables 1–5. Guidelines for these foods and associated foods are presented in Table 6 with rejection rates presented in Tables 7 and 8. A total of 1232 'health food' sample units were tested for ACC (Table 1). Two hundred and eight sample units (16.8%) exceeded the acceptable level of microorganisms as stipulated by the guidelines for ACC ($m = 10^4$), while 227 (18.4%) had M values greater than 1.0×10^5 and would be rejected for violation of the guideline.

Coliforms (Table 2) were detected in 197 samples of which 16.0% exceeded the $m = 10$ and 17.8% exceeded the $M = 10^2$ guidelines. *E. coli* was identified in 16 sample units; 5 (11.9%) exceeded the $m = 10$ and 11 (26.2%) exceeded the $M = 10^2$ guidelines. Aerobic sporeformers exceeding the $m = 10^3$ value were found in 35.7% of samples tested

Table 2
Frequency distributions of confirmed coliforms (CC) and fecal coliforms (FC) of health foods

Sample	The number of sample units containing specific values (percent frequency distribution)				
	<1.8	1.8–10	$10–10^2$	$>10^2$	Total
Dietary and food supplements	CC) 43 (43.4%)	CC) 12 (12.1%) FC) 1 (50%)	CC) 16 (16.2%) FC) 1 (50%)	CC) 28 (28.3%)	CC) 99 (100%) FC) 2 (100%)
Animal products	CC) 7 (38.9%)	CC) 7 (38.9%) FC) 4 (80%)	CC) 2 (11.1%) FC) 1 (20%)	CC) 2 (11.1%)	CC) 18 (100%) FC) 5 (100%)
Marine products	CC) 15 (50%)	CC) 13 (43.3%) FC) 2 (66.6%)	CC) 2 (6.7%) FC) 1 (33.3%)	0	CC) 30 (100%) FC) 3 (100%)
Herbal products	CC) 27 (48.2%)	CC) 7 (12.5%) FC) 1 (100%)	CC) 8 (14.3%)	CC) 14 (25%)	CC) 56 (100%) FC) 1 (100%)
Roots, seeds and nuts	CC) 10 (29.4%)	CC) 5 (14.7%) FC) 4 (50%)	CC) 8 (23.5%)	CC) 11 (32.4%) FC) 4 (100%)	CC) 34 (100%) FC) 4 (100%)
Soybean products	CC) 26 (57.8%)	CC) 9 (20%) FC) 4 (100%)	CC) 8 (17.7%)	FC) 2 (4.4%)	CC) 45 (100%) FC) 4 (100%)
Fruit and vegetable products	CC) 26 (48.1%)	CC) 7 (13%) FC) 6 (50%)	CC) 10 (18.5%) FC) 1 (8.3%)	CC) 11 (20.4%) FC) 5 (41.6%)	CC) 54 (100%) FC) 12 (100%)
Protein	CC) 9 (56.3%)	CC) 6 (37.5%)	CC) 1 (6.3%)	0	CC) 16 (100%)
Other food products	CC) 10 (50%)	CC) 6 (30%) FC) 4 (80%)	CC) 4 (20%) FC) 1 (20%)	0	CC) 20 (100%) FC) 5 (100%)
Total	CC) 173 (46.8%)	CC) 72 (19.5%) FC) 26 (62%)	CC) 59 (16%) FC) 5 (11.9%)	CC) 66 (17.8%) FC) 11 (26.2%)	CC) 370 (100%) FC) 42 (100%)

Table 3
Frequency distributions of aerobic (A) and anaerobic (AN) sporeformers found in health foods

Sample	The number of sample units containing specific values (percent frequency distribution)				
	<10	$10–10^2$	$10^2–10^3$	$>10^3$	Total
Dietary and food supplements	A) 12 (5%)	A) 86 (35.7%)	A) 55 (22.8%)	A) 88 (36.5%)	A) 241 (100%)
	AN) 3 (30%)	AN) 5 (50%)	AN) 2 (20%)		AN) 10 (100%)
Animal products	A) 7 (24.1%)	A) 17 (58.6%)	A) 0	A) 5 (17.2%)	A) 29 (100%)
Marine products	A) 9 (5.8%)	A) 17 (11%)	A) 71 (46.1%)	A) 57 (37%)	A) 154 (100%)
Herbal products	A) 2 (8.5%)	A) 31 (22%)	A) 40 (28.4%)	A) 58 (41.1%)	A) 141 (100%)
	AN) 2 (100%)				AN) 2 (100%)
Roots, seeds and nuts	A) 11 (20.8%)	A) 18 (34%)	A) 13 (24.5%)	A) 11 (20.8%)	A) 53 (100%)
Soybean products	A) 14 (12%)	A) 21 (18%)	A) 46 (39.3%)	A) 36 (30.8%)	A) 117 (100%)
	AN) 1 (100%)				AN) 1 (100%)
Fruit and vegetable products	A) 13 (7.9%)	A) 30 (18.2%)	A) 46 (27.9%)	A) 76 (46.1%)	A) 165 (100%)
			AN) 20 (50%)	AN) 20 (50%)	AN) 40 (100%)
Protein	A) 1 (2.2%)	A) 12 (26.7%)	A) 23 (51.1%)	A) 9 (20%)	A) 45 (100%)
			AN) 6 (100%)		AN) 6 (100%)
Other food products	A) 9 (17.3%)	A) 16 (30.8%)	A) 11 (21.1%)	A) 16 (30.8%)	A) 52 (100%)
Total	A) 88 (8.8%)	A) 248 (24.9%)	A) 305 (30.6%)	A) 356 (35.7%)	A) 997 (100%)
	AN) 6 (10.2%)	AN) 5 (8.5%)	AN) 28 (47.5%)	AN) 20 (33.9%)	AN) 59 (100%)

Table 4
Frequency distributions of *Bacillus cereus* found in health foods

Sample	The number of sample units containing specific values (percent frequency distribution)				
	<50	$50–10^2$	$10^2–10^3$	$>10^3$	Total
Dietary and food supplements	1 (12.5%)	2 (25%)	1 (12.5%)	4 (50%)	8 (100%)
Animal products	2 (28.6%)	5 (71.4%)	0	0	7 (100%)
Marine products	2 (40%)	2 (40%)	1 (20%)	0	5 (100%)
Herbal products	2 (66.7%)	1 (33.3%)	0	0	3 (100%)
Soybean products	13 (59.1%)	2 (9.1%)	4 (18.2%)	3 (13.6%)	22 (100%)
Fruit and vegetable products	7 (58.3%)	0	5 (41.6%)	0	12 (100%)
Protein	4 (80%)	1 (20%)	0	0	5 (100%)
Other food products	5 (38.5%)	0	8 (61.5%)	0	13 (100%)
Total	36 (46.8%)	13 (16.9%)	19 (27.3%)	7 (9.1%)	77 (100%)

Table 5
Identification of other bacteria found in health foods

Sample	Identification
Dietary and food supplements	*B. licheniformis*, *B. megaterium*, *B. subtilis*, *S. aureus*, yeast and mould
Animal products	*B. subtilis*, *Bacillus* sp.
Marine products	*B. firmus*, *B. licheniformis*, *B. megaterium*, *B. pumilus*, *B. sphaericus*, *B. subtilis*, *Bacillus* sp., *E. faecium*, *E. gallinarum*, *S. capitus*, *S. haemolyticus*, *S. sciuri*
Spices and soup mixes	*B. licheniformis*, *B. subtilis*
Herbal products	*B. licheniformis*, *B. megaterium*, *B. pumilus*, *B. subtilis*, *B. thuringensis*, *Bacillus* sp., *E. agglomerans*, *E. sakazakii*, *E. cloacae*, *E. taylorae*, *E. vulneris*, *K. pneumoniae*, *Klebsiella* sp., *Serratia*, *Pantoea agglomerans*, *Pasteurella haemolyticus*
Soybean products	*B. cereus*, *B. circulans*, *B. licheniformis*, *B. megaterium*, *B. polymiyxa*, *B. sphaericus*, *B. subtilis*, *E. faecium*, *Salmonella* spp.
Fruit and vegetable products	*B. cereus*, *B. licheniformis*, *B. megaterium*, *B. pumulis*, *B. subtilis*, *E. agglomerans*, *E. cloacae*, *E. vulneris*
Roots, seeds and nuts	*B. pumilis*, *B. sphaericus*, *B. subtilis*, *E. durans*, *S. warneri*
Other food products	*B. megaterium*, *B. pumilus*, *B. subtilis*, *B. thuringensis*, *Bacillus* sp.

Table 6
Guidelines for health foods and related products

Bacteria	*n*	*c*	*m*	*M*
Health foods				
ACC	5	3	10^4	10^5
Coliforms	5	3	10	10^2
E. coli	5	3	10	10^2
C. perfringens	5	2	10	10^2
Yeast and mold	5	3	5×10^2	10^4
S. aureus	5	2	10^2	10^4
Salmonella	5	0	0	
B. cereus	5	2	10^3	10^4
Soybean products				
Psychrotrophs	5	2	10^6	10^8
E. coli	5	2	10^2	10^3
S. aureus	5	2	10^2	10^4
Salmonella	5	0	0	
Yersinia	5	0	0	
Spices[a]				
C. perfringens	5	2	10^4	10^6
B. cereus	5	2	10^4	10^6
E. coli	5	2	10^2	10^3
S. aureus	5	2	10^2	10^3
Salmonella	5	0	0	
Dry mixes				
ACC				
Non-heated	5	3	10^4	10^5
Heated before use	5	3	10^5	10^6
Coliforms	5	3	10	10^2
E. coli	5	2	10	10^2
C. perfringens	5	2	10	10^2
Yeast and mold	5	3	10^2	10^4
S. aureus	5	2	10^2	10^4
Salmonella	5	0	0	

[a]Guidelines apply to all spices that will not be used in foods that will be further heat processed (i.e. canned).

lot: all packages of a product that have been produced, handled and stored under uniform conditions, which is identified by a code. When there is no code identification, a lot may be considered as (a) that amount of product representing one shift's or one day's production; or (b) the product available for sampling at a fixed location.

Sample: a portion of a lot taken for examination, consisting of several sample units.

Sample unit: the smallest portion of a sample taken from a lot.

n: the number of sample units, usually selected at random, from a lot and examined in order to satisfy the requirements of a plan.

c: the maximum allowable number of marginally acceptable sample units per lot.

m: the maximum number of microorganisms per unit (ml or g) that is of no concern or is an acceptable level.

M: the number of microorganisms per unit (ml or g) that indicates a potential health hazard, imminent spoilage or gross insanitation, and if exceeded in any one sample unit renders the lot in question in violation of the guideline or standard.

(Table 3), although none of the sample units exceeded the $M = 10^4$ guideline. Anaerobic sporeformers were found in 53 of the 59 samples tested of which 81.4% exceeded the $M = 10^2$ guideline, while 8.5% were found to be higher than the $m = 10$ guideline. Approximately 9% of samples tested were found to contain *B. cereus* exceeding the $m = 10^3$ guideline (Table 4).

Table 5 lists other bacteria that were identified by further analyses conducted on samples where ACC counts exceeded standards. Common isolates in a variety of 'health foods' were *Bacillus* species, which can be correlated with poor product quality and non-adherence to Good Manufacturing Practices (GMPs). *B. cereus*, *B. licheniformis*, *B. megaterium*, *B. sphaericus*, *B. subtilis*, and *B. pumilus* were frequently isolated from the health foods. *B. cereus* causing foodborne illness is well documented (Granum, 1997) while *B. lichenformis*, *B. subtilis* and *B. thuringensis* have been linked to outbreaks of food poisoning (Granum, 1997; Kramer and Gilbert, 1989). In addition, *B. polymyxa* is found in decomposing foods and *B. pumilis* is a common food contaminant (Lennette et al., 1980).

Although consumption of 'health foods' has not resulted in major foodborne outbreaks, except in the case of alfalfa sprouts (Anonymous, 1996), these products are often involved in sporadic cases or small outbreaks where two individuals are involved (E. Todd, Health Canada, personal communication). However, our results (Tables 1–5) indicate that 'health foods' continue to contain high levels of bacteria and have the potential to be hazardous to certain segments of the Canadian population. A majority of the bacteria identified in Table 5 are potential opportunistic pathogens (Lennette et al., 1980; Warburton, 1993; Warburton and Austin, 1997) that can cause severe problems with susceptible populations, particularly the young, elderly, immunocompromised, and pregnant women, who may consume such products to improve their health.

The rejection rates found (Table 7) for the foods studied in this survey are generally higher than those found in the survey published by Warburton and Brodsky (Table 8). This indicates that (i) health food products are not being consistently produced under GMPs, and (ii) since the last study, there has been little or no improvement in the GMPs of these products.

Table 7
Rejection rates for health foods[a]

Bacteria	Total sample units tested	Total sample units marginally acceptable (or possibly rejected) due to exceeding m[a] (%)	Total sample units rejected due to exceeding M[a] (%)
ACC	1239	208 (16.8)	227 (18.3)
Coliforms	371	59 (15.9)	66 (17.8)
E. coli	97	5 (5.2)	11 (11.3)
Anaerobic sporeformers[b]	59	5 (8.5)	48 (81.4)
B. cereus	77	7 (9.1)	0
Aerobic sporeformers[c]	997	356 (35.7)	0

[a]Using health food guidelines (Table 6).
[b]Using *C. perfringens* guidelines (Table 6).
[c]Using *B. cereus* guidelines (Table 6).

Table 8
Rejection rates for health foods from a previous study[a]

Bacteria	Total sample units tested	Total sample units marginally acceptable (or possibly rejected) due to exceeding m[b] (%)	Total sample units rejected due to exceeding M[b] (%)
ACC	166	34 (20.5)	19 (11.5)
Coliforms	166	21 (12.7)	9 (4.5)
E. coli	166	5 (3.0)	11 (6.6)
B. cereus	160	14 (8.8)	1 (0.6)

[a]Using Health Food Guidelines (Table 6).
[b]Warburton and Brodsky (1993).

In conclusion, further surveillance of 'health food' products is needed with special emphasis on dietary supplements, raw animal products, marine products (algae and spirulina, etc.), soybean products (tofu and soybean flour, etc.) and dried fruit and vegetable products. These particular products had extremely high bacterial loads when tested (Tables 1–5). Soybean products were particularly 'dirty' with one sample containing salmonellae, along with high levels of sporeformers, coliforms and ACC.

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