TECHNICAL UPDATE

Comparison and Health Risk Assessment of HPC Present in Food and Drinking Water

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Water and food contain a natural autochonous flora known as Heterotrophic Plate Count (HPC) bacteria. All scientific studies regarding the pathogenicity of HPC bacteria show that they do not cause human disease. Accordingly, their presence or concentration should not be regulated for health effects purposes. The Drinking Water Research Foundation (DWRF) recently sponsored the development of a comparative analysis of the microbial content of food. The final peer-reviewed research paper will soon be published in *Critical Reviews in Microbiology.* A brief summary of this research is presented in this article.

Microbes that live in food and drinking water have evolved a distinctly different set of optimum conditions. For example, drinking water has no appreciable sugar or salt, and is of much lower temperature. Accordingly, it would not be expected that microbes that live and multiply in drinking water would be able to multiply and cause infections in humans. This hypothesis has been substantiated by experimentation (see references below).

Microbes from food face a different ecological situation from drinking water. Food is much more like the human physiological condition. It is generally much higher in sugar and salt content than drinking water. Accordingly, pathogens may multiply in food whereas they may not in drinking water. This amplification in food compared to drinking water is key to their differentiation for regulatory action. From drinking water, the naturally occurring microbes - called Heterotrophic Plate Count (HPC) bacteria in the United States and autochonous flora in Europe - do not cause infection. The HPC do not have the virulence characteristics necessary to cause infection. From food, the microbes that possess virulence characteristics can multiply and cause infection.

Accordingly, there is a significantly different nature and number of microbes that humans encounter from food compared to drinking water. Food contains higher numbers of pathogens, whereas drinking water does not. (See Table; Incidence of microorganisms of public health significance on raw, unprocessed vegetables. In order to cause infection, a microbe must possess virulence factors. In addition, it must contact the human in high numbers. As has been reviewed above, these conditions exist naturally in food but not in drinking water. While there has certainly been instances in which drinking water has served as a vehicle for pathogenic microbes, they do not amply in drinking water except as a secondary manifestation of filtration concentration in municipal supplies. Food, however, contains the ingredients to allow multiplication of microbes to the extent necessary to produce infection. If not stored at the proper temperature, these microbes can multiply rapidly.

In the 1980's it was estimated that in Africa, Asia excluding China and Latin America up to 5 million deaths and 1 billion cases of gastroenteritis occur every year among children under the age of five. In particular, convenience foods have grown markedly in the last decade. Western countries have been importing an increasing percentage of "fresh foods." To accommodate this need, food manufacturers have developed the means to partially process foods so that it appears to have a more "fresh" and natural appearance, but is, in fact, less well processed. Compounding the risk to the humans is the trend to use less preservatives in goods.

To assess and differentiate the risk of infection from food and drinking water, the components of the infection formula is examined:

$$\text{Infection risk} = \frac{[\text{number of microbes}] \times [\text{virulence factors}]}{\text{Immune status of the host}}$$

As discussed above, natural water and food contain a natural autochonous flora. This type of microbes may also be referred to as HPC and Standard Plate Count (SPC) bacteria. HPC are defined by the media and culture conditions in which the water or food sample is analyzed. Therefore, there is no universal definition of HPC. All studies regarding the pathogenicity of HPC show that they do not cause human disease. Accordingly, their presence or concentration should not be regulated for health effects purposes.

Table 17. Incidence of microorganisms of public health significance on raw, unprocessed vegetables

Vegetables	Place of Sampling	# of Samples	Microorganism	Incidence (%)	Number (cfu g^{-1})	Ref. #
Various vegetables	Retail (US)	21	*Aeromonas* spp. (cytotoxic & hemolytic)	99	$<10^2$ to 10^4	104
Lettuce, endive, watercress	Retail (Brazil)	90	*Aeromonas hydrophila, A. caviae*	47.8	10^2 to 10^6	248
Bean sprouts	At production (US)	16	*Bacillus cereus*	12.5	10^4	477
Seeds for salad sprouts	Retail (US)	98	*B. cereus*	69[a]	3 to >500	227
Various vegetables	Retail (UK)	100	*B. cereus*	35	>0.04	425
Mushrooms	Retail (US)	200	*Campylobacter jejuni*	1.5	>0.04	164

(packaged)						
Various vegetables	Outdoor markets (Canada)	533	*Campylobacter* thermotolerant	1.7	>0.04	390
	Supermarket (Canada)	1031	*Campylobacter* thermotolerant	0	<0.04	
Various vegetables	Retail (UK)	100	*Campylobacter* spp.	0	<0.04	425
Cabbage	Retail (US)	88	*Clostridium botulinum* (type A)	13.6	NS	469
Mushroom	At production (Netherlands)	50	C. botulinum	0	<0.01	384
Onion	Restaurant (US)	75	*C. botulinum* (type A)	6.7	NS	467
Garlic	NS	115	C. botulinum	4.3	NS	468
Various vegetables	Retail (UK)	100	*Clostridium perfringens*	34	>0.04	425
Bean sprouts	At production (UK)	104	*Escherichia coli*	38	NS	386
Iceberg lettuce	Retail (Norway)	42	*E. coli*	0.4	10 to 10^4	271
Celery	At production (UK)	90	*E. coli*	50	0.001 to 0.004	426
Various vegetables	Retail (UK	100	*E. coli*	14	0.3 to 460	425
	At production and retail[b] (Spain)	345	*E. coli*	86	>10 for 83% of positive samples	197
	Retail (Netherlands)	260	*E. coli*	26	0.03 to 1	494
				22	10 to >10^6[c]	
	NS (Mexico)	89	*E. coli* 0157:H7	19	NS	540
Unspecified raw vegetables	Retail (UK)	64	*Listeria monocytogenes*	6.2	0.04 to 50	328
Leafy vegetables	Retail (Malaysia)	22	*L. monocytogenes*	22	>0.05	29
Bean sprouts	Idem	7	*L. monocytogenes*	85	Idem	29
Iceberg lettuce	Retail (US)	22	*L. monocytogenes*	9	NS	486
Lettuce, endive	Raw material for processing (France)	89	*L. monocytogenes*	0	<0.3	216
Various vegetables	Retail (Germany)	103	*L. monocytogenes*	2	>0.1	91
	Retail (Canada)	110	*L. monocytogenes*	0	<0.1	183

Potatoes and radishes	Retail (US)	264	*L. monocytogenes*	25 to 30	>0.04	231
Other vegetables	Idem	736	*L. monocytogenes*	0 to 2	Idem	231
Unspecified	NS (UK)	279	*L. monocytogenes*	9	NS	353
Various vegetables	Retail (Spain)	103	*L. monocytogenes*	7.8	>0.04	147
	NS	20	*L. monocytogenes*	0	<0.04	500
	Retail (UK)	108	*L. monocytogenes*	1.8	>0.04	513
Bean sprouts	At production (France)	31	*L. monocytogenes*	3.1	0.04 to 100	358
	Retail (France)	102	*L. monocytogenes*	19	0.04 to 100	399
Various vegetables	At production (US)	1120	*Pseudomonas aeruginosa*	0.1	NS	218
Bean sprouts	At production (US)	13	*Salmonella*	0	<0.02	477
	At production (France	31	*Salmonella*	0	<0.04	358
Iceberg lettuce	Retail (Norway)	57	*Salmonella*	5.3	NS	271
Lettuce and fennel	Retail (Italy)	209	*Salmonella* (various serotypes)	69.9	0.01 to 0.4	179
Various vegetables	Retail (US)	50	*Salmonella* (various serotypes)	8	NS	430
	Retail (UK)	100	*Salmonella*	1	>0.04	425
	At production and retail[b] (Spain)	345	*Salmonella* (various serotypes)	7.5	>0.2	197
	Retail (Egypt)	71	*Salmonella*	2.8	>0.04	437
	Retail (Netherlands)	103	*Salmonella*	22.3	<1[e]	494
	At production and retail[b] (Spain)	849	*Salmonella* (various serotypes)	1.7 to 8.3	>0.2	196
Bean sprouts	Retail (Thailand)	344	*Salmonella* (various serotypes)	8.7	>0.04	258
Iceberg lettuce	Retail (Norway)	57	*Shigella sonnei*	0	NS	271
Various vegetables	Retail (UK)	100	*Shigella* spp.	0	<0.04	425
	Retail (Egypt)	71	*Shigella* spp.	2.8	>0.04	437

Bean sprouts	At production (US)	10	*Staphylococcus* spp. (coagulase positive)	10	10^4	477
Various vegetables	Retail (UK)	100	*Staphylococcus aureus*	0	<0.04	425
Various salad sprouts (packaged)	Retail (US)	54	*Staphylococcus aureus*	24	>100	407
Various vegetables	Retail (UK)	100	*Vibrio* spp.	0	<0.04	425
Unspecified vegetables	Retail (Italy)	16	*Yersinia enterocolitica*[d]	12.5	>0.04	69
Various vegetables	Retail (UK)	100	*Y. enterocolitica*[d]	0	<0.04	425
	Retail (UK)	65	*Y. enterocolitica*[d]	3.2	>0.1	149
Leafy vegetables	Retail (Brazil)	30	*Y. enterocolitica*[d]	3.3	<0.04	161
Unspecified vegetables	NS	86	*Y. enterocolitica*[d]	43	>2.5	144
Leafy vegetables	Retail (Brazil)	200	*Ascaris* eggs	17.5	0.1 to 0.3	146
Various vegetables	At production and retail (Korea)	1305	*Ascaris* eggs	22 to 96	0.002 to 0.04	129
	Retail (US)	568	*Ascaris* eggs and larvae	3.3	NS	430
		276	Active amoebic forms	38.4	NS	430
		292	*Giardia* spp.	0	NS	430
	Retail (Costa Rica)	640	*Cryptosporidium* oocysts	2.8	NS	366
	Gardens (Brazil)	NS	*Giardia* spp.	13	NS	341

[a]Contaminated seeds gave sprouts with numbers of *B. cereus* ranging from <10^3 to >10^6 cfu g^{-1}. [b]No differences between vegetables sampled at production and at retail. [c]Vegetables imported from tropical countries. [d]Serotypes not pathogenic to man. [e]One sample with 240 *Salmonella* per g. NS, not specified.

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