



# *Technews*

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For Efficient Dairy Plant Operation**

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## **PATHOGENS IN MILK & MILK PRODUCTS II**

This bulletin includes technical and latest development on products, systems, techniques etc. reported in journals, companies' leaflets and books and based on studies and experience. The technical information on different issues is on different areas of plant operation. It is hoped that the information contained herein will be useful to readers.

The theme of information in this issue is **Pathogens in Milk & Milk Products II**. It may be understood that the information given here is by no means complete.

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## 1. INTRODUCTION

The last issue of the Technews presented a brief account of seven important pathogens that infect milk and milk products. This issue includes details of six more pathogens. These details will help processors to take appropriate steps to control pathogens infection of milk and milk products and to destroy them.

## 2. *Escherichia coli*

	<b>Characteristics</b>	<b>Description</b>
<b>1</b>	<b>General</b>	Rod shaped, facultatively anaerobic, non spore forming, gram negative bacterium
<b>2</b>	<b>Source</b>	Intestinal tracts of humans and animals as primary reservoirs, faecal matter, mastitic animals, infected food handlers Water, sewage
<b>3</b>	<b>Pathogenicity</b> <ul style="list-style-type: none"> <li>• <b>Humans</b></li> <li>• <b>Infectious dose</b></li> <li>• <b>Animals</b></li> <li>• <b>Toxin type</b></li> </ul>	Food borne illness (infection) Gastroenteritis, hemorrhagic colitis, hemolytic uremic syndrome Pathogenic strains: 2000 cells or less <sup>(1)</sup> 10 <sup>8</sup> to 10 <sup>10</sup> cells <sup>(2)</sup> Acute mastitis, diarrheal disease Enterotoxin, cytotoxin (shiga toxins / verotoxin) (produced in host) <sup>(3)</sup>

4	<b>Growth parameters</b> <ul style="list-style-type: none"> <li>• Temperature</li> <li>• Water activity</li> <li>• pH</li> </ul>	8 °C to 45 °C (optimum 30 °C to 37 °C) (Mesophilic organism capable of growing at 8 °C to 12 °C) 0.95 5.5 to 7.5 (optimum 7.0) Minimum pH for <i>E. coli</i> O157:H7 is 4.0 to 4.5, survives in acidic foods for several weeks. <sup>(1)</sup>
5	<ul style="list-style-type: none"> <li>• Shedding in milk</li> <li>• Growth in milk</li> <li>• Associated dairy foods</li> </ul>	No Yes Milk and milk products. Being easily destroyed during pasteurization its presence in milk and products indicates post pasteurization contamination. <i>E. coli</i> under suitable condition can spoil milk and many dairy products usually with the production of gas. It causes early blowing of various types of cheese. Some encapsulated strains may cause ropiness of milk. <sup>(4)</sup>
6	<b>Inactivation parameters</b>	Readily destroyed in milk by minimum pasteurization (71.7 °C for 15 seconds)
7	<b>Control measures</b>	Good personal hygiene of food handlers particularly washing of hands after defecation., avoiding faecal contact of milk during milking activity, good manufacturing and hygienic

practices in the production and processing of milk and milk products.  
HACCP system continues to be the most effective means of food safety and reducing infection from this pathogen.

### ***3. Listeria monocytogenes***

	<b>Characteristics</b>	<b>Description</b>
<b>1</b>	<b>General</b>	Rod shaped, microaerophilic, motile, non spore forming, gram positive bacterium.
<b>2</b>	<b>Source</b>	Intestinal tracts of domestic and wild animals, faecal matter, soil and decaying vegetation, silage, stream water, sewage, mud, houseflies, ticks and human carriers.  This pathogen is most likely to be found in a wide variety of foods, food manufacturing environments and home refrigerators. Most effectively transmitted through the consumption of contaminated food.
<b>3</b>	<b>Pathogenicity</b>	Food borne illness (Listeriosis infection)
	• <b>Humans</b>	Meningitis or meningoen­cephalitis (infection of central nervous system), abortion in pregnant women.
	• <b>Animals</b>	Encephalitis, bovine mastitis

4	<b>Growth parameters</b>	<p>Psychrotrophic pathogen, which grows well in damp environments.</p> <ul style="list-style-type: none"> <li>• <b>Temperature</b> -0.4 °C to 45 °C (optimum 37 °C) (Psychrotrophic organism capable of growing at temperatures of less than 5 °C) Grows twice as fast at 10 °C as at 4 °C <sup>(1)</sup></li> <li>• <b>Water activity</b> 0.92 minimum</li> <li>• <b>pH</b> Growth can occur in a pH range from 4.4 to 9.6 (optimum 7.0 to 7.5) Thrives in substrates of neutral to alkaline pH but not in highly acidic environments.</li> </ul>
5	<ul style="list-style-type: none"> <li>• <b>Shedding in milk</b></li> <li>• <b>Growth in milk</b></li> <li>• <b>Associated dairy foods</b></li> </ul>	<p>Dairy cattle can intermittently shed the organism in the milk up to 10<sup>4</sup> cfu / ml as a result of listeric mastitis, encephalitis, or a <i>listeria</i>-related abortion. <sup>(5)</sup></p> <p>Yes</p> <p>Milk, cheese, ice cream and other dairy products.</p> <p>It is a far more frequent post pasteurization contaminant in ice creams.</p> <p>Soft, surface ripened cheese varieties support growth of the organism during ripening.</p>
6	<b>Inactivation parameters</b>	<p><i>L. monocytogenes</i> is more heat tolerant than most other non-spore forming pathogens but LTLT and HTST pasteurization ensures inactivation of expected</p>

		<p>levels of the organism in raw milk, provided the raw milk is properly handled and refrigerated at 4 °C to minimize growth. <sup>(5)</sup></p> <p>It is reported to be destroyed at 58 to 59 °C in 10 minutes. <sup>(4)</sup></p>
7	<b>Control measures</b>	<p>It is considered a “super bacterium” that can survive environmental extremes that will eliminate other pathogenic bacteria.</p> <p><i>Listeria monocytogenes</i> can adhere to food contact surfaces by producing attachment fibrils, with the subsequent formation of a biofilm, which impedes removal during cleaning.</p> <p>A rigid environmental sanitation programme and HACCP for a controlled process can effectively control the pathogen.</p> <p>Avoid consumption of raw foods with contact with infected animals, store foods below 2 °C.</p>

**4. *Mycobacterium spp.***

	<b>Characteristics</b>	<b>Description</b>
1	<b>General</b>	Slender, straight or slightly rod shaped, non motile, non spore forming, aerobic and acid fast bacterium.

2	<b>Source</b>	Diseased animal or human, faecal matter, air. Dried faecal matter clinging to the udder, tail and flanks of cows is a major source of contamination of milk. <sup>(6)</sup>
3	<b>Pathogenicity</b> • <b>Humans</b> • <b>Animals</b>	Infection Tuberculosis ( <i>Mycobacterium tuberculosis: M. bovis</i> ) Tuberculosis, mastitis ( <i>Mycobacterium bovis</i> )
4	<b>Growth parameters</b> • <b>Temperature</b>	23 °C to 45 °C (optimum 37 °C)
5	• <b>Shedding in milk</b> • <b>Growth in milk</b> • <b>Associated dairy foods</b>	Yes through udder lesions and excretion No Raw milk and occasionally cottage cheese
6	<b>Inactivation parameters</b>	Pasteurization at 62.8 °C for 30 minute / 71.7 °C for 15 seconds will destroy the organism. <sup>(6)</sup> Safety factor (beyond that necessary to kill the organism) for pasteurized milk at 61.1 °C for 30 minute is reported to be 3.3 °C and 20 minutes and at 71.7 °C for 15 seconds it is reported to be 14 seconds. <sup>(6)</sup> Ultraviolet rays quickly kill the microbe.

7	<b>Control measures</b>	<p>General hygiene, systematic slaughter of tuberculosis positive animal, disinfection and mandatory pasteurization.</p> <p>Due caution is warranted during pasteurization on account of:</p> <ul style="list-style-type: none"> <li>a) Improper or less severe pasteurization due to errors in time measurement particularly in HTST type.</li> <li>b) Insufficient agitation allowing pellicle formation (denatured protein) on the surface of milk affords protection to the cells trapped therein</li> <li>c) Failure to maintain the temperature of foam which often forms on the surface of the milk</li> </ul>
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### ***5. Salmonella spp.***

	<b>Characteristics</b>	<b>Description</b>
1	<b>General</b>	Ova shaped, facultative anaerobe, motile, non spore forming, gram negative bacteria.
2	<b>Source</b>	Intestinal tract, faecal matter. Water contaminated with faecal matter, infected food handlers.



		(Salmonella transferred by fingertips are capable of surviving for several hours and still infect foods) <sup>(1)</sup>
<b>3</b>	<b>Pathogenicity</b> <ul style="list-style-type: none"> <li>• <b>Humans</b></li> <li>• <b>Infectious dose</b></li> <li>• <b>Animals</b></li> <li>• <b>Toxin type</b></li> </ul>	Food borne illness (infection) Enteric fever or typhoid ( <i>S. typhi</i> , <i>S. paratyphi</i> ) Gastro enteric infection ( <i>S. typhimurium</i> ) <sup>(4)</sup> More than one million cells <sup>(1)</sup> Gastroenteritis, septicemia and abortion. Thermolabile enterotoxin, thermostable cytotoxin <sup>(2)</sup> (produced in host)
<b>4</b>	<b>Growth parameters</b> <ul style="list-style-type: none"> <li>• <b>Temperature</b></li> <li>• <b>Water activity</b></li> <li>• <b>pH</b></li> </ul>	5.2 °C to 45 °C (optimum 30 °C to 37 °C) (Mesophilic organism capable of growing at 5.2 °C to 12 °C) 0.94 minimum 4.0 to 9.6 (optimum 6.5 to 7.5)
<b>5</b>	<ul style="list-style-type: none"> <li>• <b>Shedding in milk</b></li> <li>• <b>Growth in milk</b></li> <li>• <b>Associated dairy foods</b></li> </ul>	Although <i>salmonellae</i> are seldom associated with mastitis and thereby not generally shed in milk, <i>S. dublin</i> and <i>S. muenster</i> can colonise the udder and be shed in milk at levels up to 2000 organisms /ml) <sup>(5)</sup> Yes Milk powder, cheese, butter, ice cream.

		<p>These organisms generally gain access to milk through direct or indirect faecal contamination.</p> <p>Contamination of all dairy products with <i>S. typhi</i> is assumed to be exclusively of human origin. <sup>(5)</sup></p>
<b>6</b>	<b>Inactivation parameters</b>	<p>Standard LTLT and HTST pasteurization destroys expected levels of salmonellae i.e. less than 100 cfu / ml <sup>(5)</sup></p> <p>Most salmonellae are significantly reduced at 60 °C for 1 to 15 minutes. <sup>(6)</sup></p>
<b>7</b>	<b>Control measures</b>	<p>Good hygienic practices of food handlers particularly washing of hands after defecation, cleanliness and sanitation of equipment, pasteurization, proper refrigeration and packing.</p> <p>Because of their origin and sensitivity to cold temperature the main reason for Salmonellosis is poor sanitation and temperature abuse. Salmonellosis has been most commonly traced to raw milk, and consumption of such milk is best avoided.</p> <p>Use of raw eggs (a potential source of <i>S. enteritidis</i>) in home made ice creams is strongly discouraged as evidenced from a series of recent outbreaks. <sup>(5)</sup></p>

## **6. *Shigella* spp.**

	<b>Characteristics</b>	<b>Description</b>
<b>1</b>	<b>General</b>	Rod shaped, anaerogenic, non-motile, non-spore forming, gram negative bacteria.
<b>2</b>	<b>Source</b>	Intestinal tract of human and animals, faecal matter. Water contaminated with faecal matter, flies, infected food serve as vectors
<b>3</b>	<b>Pathogenicity</b> • <b>Humans</b>  • <b>Infective dose</b>  • <b>Toxin type</b>	Food borne illness (infection) Bacillary dysentery (shigellosis) – acute but self limiting infection of intestinal tract Minimum of 10 <sup>1</sup> to 10 <sup>4</sup> organisms depending upon the strain. <sup>(6)</sup> Cytotoxin
<b>4</b>	<b>Growth parameters</b> • <b>Temperature</b>  • <b>Water activity</b>  • <b>pH</b>	6 °C to 46 °C (Mesophilic organism capable of growing at 6 °C to 12 °C) 0.97 minimum 4.9 to 9.3
<b>5</b>	• <b>Shedding in milk</b> • <b>Growth in milk</b>  • <b>Associated dairy foods</b>	No Yes  Raw milk, cheese etc.
<b>6</b>	<b>Inactivation parameters</b>	Pasteurization

7	<b>Control measures</b>	Improved hygienic practices of food handlers particularly washing hands after defecation, pasteurization practices and proper cold storage conditions serve to keep dairy product related shigellosis outbreaks as relatively rare. <sup>(5)</sup>
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### ***7. Staphylococcus aureus***

	<b>Characteristics</b>	<b>Description</b>
1	<b>General</b>	Spherical shaped, facultative anaerobe, non-spore forming, coagulase positive, gram positive bacterium
2	<b>Source of contamination</b>	Skin, skin glands, mucous membrane (nasal membranes) of mammals and birds, infected mammary glands and lesions of teats. Staphylococcal lesions of the skin in food handlers provide a source of <i>S. aureus</i> , which is mainly responsible for Staphylococcal infection and intoxication. Most contamination occurs during milking <sup>(2)</sup>
3	<b>Pathogenicity</b> • <b>Humans</b>	Food borne illness (intoxication) Gastroenteritis (inflammation of stomach and intestine caused by ingesting preformed enterotoxin) of short duration
	• <b>Infective dose</b>	Enterotoxigenic <i>S. aureus</i> 10 <sup>6</sup> cfu/g <sup>(5)</sup>

	<ul style="list-style-type: none"> <li>• <b>Animals</b></li> <li>• <b>Toxin type</b></li> </ul>	Mastitis or skin disease in milk producing animals. <i>S. aureus</i> is being widely recognized as a common cause of clinical and subclinical mastitis in dairy cattle. Haemolysins, heat stable enterotoxins (produced in food) Toxin is detectable in foods when the cell count reaches a level of $10^6$ / gm of food <sup>(2)</sup>			
4	Growth parameters	For Growth <sup>(2)</sup>		For Toxin Production <sup>(2)</sup>	
		Aerobic state	Anaerobic state	Aerobic state	Anaerobic state
	<ul style="list-style-type: none"> <li>• <b>Temperature</b></li> <li>• <b>Water activity</b></li> <li>• <b>pH</b></li> </ul>	7 <sup>0</sup> C to 46 <sup>0</sup> C	7 <sup>0</sup> C to 46 <sup>0</sup> C	10 <sup>0</sup> C to 45 <sup>0</sup> C	10 <sup>0</sup> C to 45 <sup>0</sup> C
		0.83 min.	0.90 min.	0.84 min.	0.90 min.
		4.0 to 10.0	Not below 4.6	Not below 4.0	Not below 5.3
		(Mesophilic organism capable of growing at 10 <sup>0</sup> C to 12 <sup>0</sup> C)			
5	<ul style="list-style-type: none"> <li>• <b>Shedding in milk</b></li> <li>• <b>Growth in milk</b></li> <li>• <b>Associated dairy foods</b></li> </ul>	Yes  Yes  <i>Staphylococci</i> are frequent contaminants of raw milk Found in dairy products including cream, cheese and non-fat dry milk. Milk concentrate for feeding to spray drier, if contaminated, supports growth and enterotoxin production by <i>S. aureus</i>			

<b>6</b>	<b>Inactivation parameters</b>	Vegetative cells:	66 °C for 12 minutes <sup>(1)</sup> 72 °C for 15 seconds (0.38 % survival) <sup>(2)</sup> 72 °C for 35 seconds (no survival) <sup>(2)</sup>
		Toxin:	131 °C or 30 minutes <sup>(1)</sup> 121 °C or 3 to 8 minutes <sup>(2)</sup>
		Multiplication of germs and toxins formation is almost completely inhibited below 7 °C	
<b>7</b>	<b>Control measures</b>	<p>The <i>staphylococci</i> are ubiquitous organisms that are impossible to eliminate from our environment. Anytime a food is exposed to human handling, there is a good possibility the food will be contaminated with <i>staphylococci</i>.</p> <p>Pasteurization of susceptible foods, proper refrigeration below 7 °C and proper hygiene and sanitation is important in controlling the staphylococcal food poisoning.</p>	

## 8. EPILOGUE

Several pathogens produce heat resistant toxins which cause food poisoning. Many form spores which survive pasteurization and, under favourable conditions, change into vegetative cells and grow. Higher the initial count of such

pathogens, higher would be the production of toxins and the number of spores formed. Pasteurization would not destroy them. It is, therefore, of utmost importance to implement the principles of good hygienic practices in the

entire milk-chain. Atmospheric temperatures are favourable to the growth of pathogens, and temperatures below 10°C are inhibitory for most of them. Hence unchilled raw-milk should be collected and transferred to the dairy plant as soon as possible and chilled immediately. Pathogens are destroyed by pasteurization. It is however, important to ensure that the pasteurization equipment functions properly. Equally important is to ensure to prevent post-process contamination. Application of HACCP would minimize the risk of product being unsafe. If all these measures are taken, then milk products would be safe for human consumption

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