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D-10 values of micro-organisms

Table 1 Dose in kGy for reducing the number by 10⁶

Microbial Species	Dose (kGy)
Gram-negative bacteria	
Facultative anaerobes	
Enterobacter (Aerobacter) aerogenes	< 0.5
Enterobacter (Aerobacter) aerogenes	1.0 – 1.5
Enterobacter (Aerobacter) cloacae	1.5 – 2.0
Escherichia coli	< 0.5
Escherichia coli I	1.5 – 2.0
Escherichia coli	2.0 – 3.0
Escherichia coli II	2.0 – 3.0
Proteus vulgaris	< 0.5
Proteus vulgaris	1.0 – 1.5
Salmonella cholerae-suis	3.0 – 5.0
Salmonella enteritidis	3.0 – 5.0
Salmonella gallinarum	3.0 – 5.0
Salmonella paratyphi A	3.0 – 5.0
Salmonella paratyphi B	5.0 – 7.0
Salmonella pullorum	2.0 – 3.0
Salmonella typhi	< 0.5
Salmonella typhimurium	3.0 – 5.0
Salmonella typhi (typhosa)	3.0 – 5.0
Salmonella wichita	3.0 – 5.0
Serratia marcescens	>0.5
Shigella dysenteriae	2.0 – 3.0
Shigella paradysenteriae	1.5 – 2.0
Shigella sonnei	1.5 – 2.0
Vibrio parahaemolyticus	> 0.5
Vibrio parahaemolyticus	0.5 – 1.0
Obligate anaerobes	
Bacteriodes fragilis subsp. Ovatus	< 0.5
Bacteriodes fragilis subsp. Vulgatus	< 0.5
Aerobes	
Acinetobacter sp.	0.5 – 1.0
Alcaligenes ammoniagenes ^C	1.0 – 1.5
Alcaligenes viscosus ^C	0.5 – 1.0
Brucella abortus	2.0 – 3.0
Moraxella	5.0 – 7.5
Pseudomonas aeruginosa	< 0.5
Pseudomonas aeruginosa	1.5 – 2.0
Pseudomonas fluorescens	0.5 – 1.0
Pseudomonas geniculata ^C	< 0.5
Gram-positive bacteria	
Bacillus (vegetative)	2.0 – 3.0



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Bacillus cereus	20.0 – 30.0
Bacillus coagulans	5.0 – 7.5
Bacillus coagulans	10.0 – 20.0
Bacillus pumilus	1.0 – 20.0
Bacillus pumilus	20.0 – 30.0
Bacillus stearothermophilus	10.0 – 20.0
Bacillus subtilis	10.0 – 20.0
Microbial Species	Dose (kGy)
Clostridium sp.	10.0 – 20.0
Clostridium botulinum A	20.0 – 30.0
Clostridium botulinum E	10.0 – 20.0
Clostridium perfringens	20.0 – 30.0
Lactobacillus (heterofermentative)	2.0 – 3.0
Lactobacillus (homofermentative)	5.0 – 7.5
Leuconostoc	2.0 – 3.0
Leuconostoc dextranicum	0.5 – 1.0
Leuconostoc mesenteroides	0.5 – 1.0
Micrococcus sp.	3.0 – 5.0
Micrococcus conglomeratus ^C	2.0 – 3.0
Micrococcus radiodurans ^C	> 30.0
Micrococcus roseus	> 30.0
Propionibacterium acnes	1.0 – 1.5
Micrococcus luteus (Sarcina lutea)	3.0 – 5.0
Staphylococcus aureus (albus)	< 0.5
Staphylococcus aureus	< 0.5
Staphylococcus aureus	0.5 – 1.0
Staphylococcus aureus	2.0 – 3.0
Staphylococcus aureus	3.0 – 5.0
Staphylococcus aureus	10.0 – 20.0
Streptococcus faecalis	3.0 – 5.0
Streptococcus faecalis	5.0 – 7.5
Streptococcus faecium	10.0 – 20.0
Actinomycetes	
Microbacterium thermosphactum ^C	2.0 – 3.0
Mycobacterium tuberculosis	1.0 – 1.5
Molds and Yeasts	
Aspergillus fischeri	2.0 – 3.0
Aspergillus flavus	2.0 – 3.0
Aspergillus fumigatus	1.5 – 2.0
Aspergillus niger	3.0 – 5.0
Aspergillus oryzae	1.5 – 2.0
Aspergillus terreus	2.0 – 3.0
Aspergillus versicolor	2.0 – 3.0
Candida sp.	3.0 – 5.0
Candida albicans	7.5 – 10.0

Literature: Microbial Ecology of foods, Volume 1, 1980

Factors affecting life and death of micro organisms, page 54/55



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Table 2 Salmonella

Micro-organism	Irradiation medium and temperature	Dose in kGy reducing the number by factor 10⁶
Salm. Heidelberg	Chicken 0°C	3.6
Salm. Heidelberg	Chicken -18°C	6.0
Salm. Oranienberg	Chicken 0°C	3.8
Salm. Oranienberg	Chicken -18°C	5.5
Salm. Typhimurium	Beef 5°C	3.5
Salm. Typhimurium	Beef -18°C	6.0
Salm. Thompson	Chicken 0°C	3.8
Salm. Thompson	Chicken -18°C	5.0
Salm. Newport	Chicken 0°C	3.0
Salm. Newport	Chicken -18°C	5.0
Salm. Gallinarum	Egg	2.6
Salm. Gallinarum	Egg frozen	3.4
Salm. Senftenberg	Egg	3.0
Salm. Senftenberg	Fish-meal	7.2
Salm. Pullorum	Shrimp 5°C	4.5
Salm. Choleraesuis	Oysters 5°C	4.5
Salm. Enteritidis	Oysters 5°C	3.0
Salm. paratyphia A	Shrimp 5°C	5.1
Salm. paratyphia B	Crabmeat 5°C	6.0
Salm. Paratyphia	Beef Liver 5°C	1.8
Salm. Paratyphia	Horse Meat Frozen	6.4
Salm. Typhosa	Crabmeat 5°C	6.0
Salm. Typhosa	Corned Beef 25°C	2.4 – 4.8
Salm. Wichita	Shrimp 5°C	6.0
Salm. Meleagridis	Meat	2.3
Salm. Meleagridis	Horse Meat Frozen	5.6
Salm. Anatum	Fish-meal	4.8
Salm. Tennessee	Fish-meal	4.8
Salm. pigmented str.	Fish-meal	6.6
Salm. Derby	Pork 10°C	2.0
Salm. Weltevreden	Pork 10°C	2.8
Salm. saint paul	Beef Liver 10°C	3.0
Salm. Manchester	Beef Liver 10°C	2.2

Literature: All Newsletter nr. 4, 1980



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Table 3 Vegetative Bacteria

Micro-organism	Irradiation medium and temperature	Dose in kGy reducing the number by 10⁶
Yersinia enterocolitica	Ground Beef 0°C	1.2
Yersinia enterocolitica	Ground Beef -30°C	2.3
Escherichia coli	Beef +25°C	2.1
Staphylococcus aureus	Beef	1.9 – 3.4
Staphylococcus aureus	Broth	2.7 – 3.1
Staphylococcus albus	Broth	2.4 – 3.1
Streptococcus faecalis	Broth	5.5
Streptococcus faecium	Broth	5.4 - 19
Streptococcus pyogenes	Oysters	6.0
Shigella sonnei	Crabmeat	1.6
Shigella paradysenteria	Oysters	1.6
Shigella dysenteria	Oysters	2.4
Mycobacterium tuberculosis	Broth +20°C	1.4
Aerobacter aerogenes	Broth +20°C	1.5
Aerobacter cloacae	Broth +20°C	1.6
Salmonella (diff. Str.)	Dif. Med. Unfrozen	2.3 – 6.0
Proteus vulgaris	Oyster	1.2
Serratia marcescens	Broth	0.8 – 1.3
Pseudomonas fluorescens	Beef	0.8
Pseudomonas aerogenes	Broth	1.3
Pseudomonas aeruginosa	Broth	0.4
Pseudomonas geniculata	Broth	0.8
Brucella abortus	Beef	2.0
Vibro parahaemolyticus	Phds. Butter	0.8
Vibro parahaemolyticus	Crabmeat	0.5 – 0.96
Lactobacillus heterofermentative	Broth	3.3 – 4.8
Lactobacillus homofermentative	Broth	4.9 – 6.6
Leuconostoc sp.	Broth	1.2 – 3.4
Sarcina flava	Broth	2.0
Moraxella-Acinetobacter	Beef	< 0.55
Micrococcus radiodurans	Broth	< 0.60

Literature: All Newsletter nr. 4, 1980



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Table 4 Fungi

Micro-organism	Irradiation medium and temperature	Dose in kGy reducing the number by factor 10⁶
Trichoderma viride	Citrus fruit	1.0
Trichoderma viride	Water	1.6
Phomopsis citri	Citrus fruit	1.2
Phomopsis citri	Water	1.5
Penicillium italicum	Citrus fruit	1.7
Penicillium italicum	Water	2.1
Penicillium expansum	Prunus fruit	2.3
Penicillium expansum	Water	2.1
Penicillium digitatum	Citrus fruit	1.9
Penicillium digitatum	Water	2.8
Penicillium camembertii	Water	1.2
Penicillium notatum	Water	1.8
Geotrichum candidum	Citrus fruit	2.5
Geotrichum candidum	Water	2.9
Monilinia fructicola	Prunus fruit	3.0
Monilinia fructicola	Water	3.1
Botrytis cinerea	Prunus fruit	3.2
Botrytis cinerea	Water	3.8
Diplodia natalensis	Prunus fruit	4.5
Diplodia natalensis	Water	4.5
Rhizopus stolonifer	Prunus fruit	4.1
Rhizopus stolonifer	Water	6.5
Alternaria citri	Citrus fruit	7.4
Alternaria citri	Water	9.0
Cladosporium herbanum	Prunus fruit	6.1
Cladosporium herbanum	Water	7.5
Gilbertella persicaria	Water	8.0
Saccharomyces cerevisiae	0.85 NaCl ½% gel	3.0
Saccharomyces cerevisiae	Water	2.5 – 3.6
Candida species	Broth	7.5
Torulopsis candida	Broth	3.6
Aspergillus niger	Water	2.7
A. flavus (spores)	Water	2.5

Literature: All Newsletter nr. 4, 1980



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Table 5 Spores

Micro-organism	Irradiation medium and temperature	Dose in kGy reducing the number by factor 10⁶
Bacillus subtilis	Dried Broth (N ₂)	18.0
Bacillus subtilis	Dried Broth (O ₂)	12.0
Bacillus pumilus	Buffer	18.0
Bacillus stearothermophilus	Broth	18.0
Bacillus cereus	Physiol. NaCl Sol.	14.0
Bacillus anthracis	Physiol. NaCl Sol.	12.0
Bacillus globigii		18.0
Cl. sporogenes	Buffer	13.0
Cl. welchii	Broth	8.0 – 22.0
Cl. botulinum 33A	Beef – frozen	24.5
Cl. b. 36A, 33A,40B, 41B, 53B	Phos. Buffer	20.0 – 19.0
Cl. b. 77A,12885A, 9B, 62A	Phos. Buffer	15.0 – 13.0
Cl. b. E, 51B	Phos. Buffer	8.0 – 10.0
Cl. b. 33A-36A	Bacon 15°C	12.5
Cl. b. 62A (most resist.)	Ham 15°C	15.5
Cl. b. 12885A	Pork 15°C	21.5
Cl. b. mix. of 10 most resist str.	Ham –30°C	18.0
CL. b. mix of 10 most resist str.	Beef –30°C	20.0
Cl. b. 77A	Corned beef –30°C	12.0
Cl. b. 41B	Pork sausage –30°C	13.5
Cl. b. 53B	Codfish cake –30°C	16.0
Cl. b. E, Beluga, incub. 8°C	Haddock	9.7
Cl. b. E. Beluga, incub 20°C	Haddock	17.1
Cl. b. F.Eklund, 83F – 80°C	Phos. Buffer	13.0

Literature: All Newsletter nr. 4, 1980



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Table 6 Viruses

Micro-organism	Irradiation medium and Temperature	Dose in kGy for reducing the number by 10⁶
Foot-and-mouth disease virus (FMDV) Types O, A and C	Calf kidney-cells lactalbumin	36.0
FMDV Type D	As above – wet	30.0
FMDV Type O	Frozen –60°C	36.0
FMDV Type O	20% peptone	36.0
FMDV Type O	0.1% peptone	10.0
Teschen disease virus	20% peptone	26.0
Vesicular stomatitis virus	20% peptone	12.3
Rinderpest virus	Frozen	Expected
Swine fever virus	Frozen	Less than 36.0
African swine fever	Frozen	
Adenovirus	Eagle's minimum	25.0 - 30.0
Coxsachievirus	Essential medium	25.0 - 30.0
Echovirus	Plus 2% fetal	26.0 - 33.0
Poliovirus	Bovine serum pH=7	26.0 - 31.0
Herpes simplex virus		26.0
Influenza virus A		28.0
Reovirus I		26.0
Simian virus		24.0
Rabies virus	10% brain emulsion	6.0

Literature: All Newsletter nr. 4, 1980