Surrogate Organisms for Low Moisture Foods: Tables and References

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Table 1. Studies that compare the survival of surrogate organisms to one or more target pathogens in low moisture foods under different processes

Table 2. Studies that use surrogate organisms to study different processes in low moisture foods

Table 1. Studies that compare the survival of a surrogate organism(s) to one or more target pathogens in low moisture foods under different treatment processes

Process type	Treatment	Surrogate organism	Target pathogen(s)	Matrix	Summary	References
Thermal	Vacuum-assisted steam	*Pediococcus acidilactici* ATCC 8042	*Salmonella* strains: Montevideo 1449, Newport, Tennessee K4643; *Escherichia coli* strains: O121:H19 FNW19M81, O157:H7 F4546; *Listeria monocytogenes* strains: 1/2a FSL R2-499, 1/2b FSL R2-502	Apricot halves (dried), raisins, macadamia nuts	Overall reductions of pathogens exceeded those of *P. acidilactici* on both dried fruits and the nuts. Differences were statistically significant at lower treatment temperatures. Reductions of tested pathogens were comparable. Bacterial inactivation was variable between commodities.	Acuff et al., 2020
	Extrusion	*Enterococcus faecium* NRRL B-2354	*Salmonella* strains: Branderup NVSL 96-12528, Oranienburg NSVL 96-12608, Typhimurium ATCC 14028, Enteritidis IV/NVSL 94-13062, Heidelberg/Sheldon 3347-1	Balanced carbohydrate-protein meal	Thermal resistance of *E. faecium* was greater than *Salmonella*. Extrusion led to a 5-log reduction of *Salmonella* at 60.6°C, or a 5-log reduction of *E. faecium* at 73.7°C.	Bianchini et al., 2014

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	Stagnant and forced dry air heating (peanuts), hot oil (pecan kernels), hot water (in-shell pecans)	*Enterococcus faecium* ATTC 8459[1]; *Enterococcus faecalis* ATTC 29212	*Salmonella* strains: Senftenberg 775W ATCC 43845, Enteritidis PT 30 ATCC BAA-1045, Tennessee K4643	Peanuts, pecans	In forced air processes, reductions of *E. faecium* were greater than for *Salmonella.* In all other methods, reductions of *E. faecium* were not significantly different or were significantly lower than for *Salmonella.*	Brar and Danyluk, 2019
	Heat process	*Pediococcus acidilactici* (from starter culture (Formula 100, Trumark, Linden, N.J.)	*Escherichia coli* O157:H7 strains: ATCC 43894, ATCC 51657, ATCC 51658, ATCC 43895; *Salmonella* strains: Typhimurium S9, Heidelberg S13, Enteritidis E40, Infantis S20, Hadar S21	Beef jerky	*P. acidilactici* displayed greater thermal resistance than all pathogens evaluated when reductions could be calculated.	Buege et al., 2006
	Water blanching, steam blanching	*Pediococcus acidilactici* ATCC 8042; *Enterococcus faecium* NRRL B-2354	*Salmonella* strains: Anatum, Montevideo, Senftenberg 775W, Tennessee, Schwarzengrund, Infantis, Mbandaka	Pet food	Both *P. acidilactici* and *E. faecium* showed greater thermal resistance than *Salmonella*; *E. faecium* had the greatest thermal resistance.	Ceylan et al., 2015
	Heat process	*Enterococcus faecium* ATTC 8459[1]; *Saccharomyces cerevisiae*	*Salmonella* strains: Typhimurium, Newport, Senftenberg 775W	Wheat flour	*E. faecium* had greater thermal resistance than *Salmonella.* *S. cerevisiae* had less thermal resistance than *Salmonella*.	Channaiah et al., 2016
	Radio-frequency (RF) heating	*Enterococcus faecium* NRRL B-2354	*Salmonella* strains: Agona 447967, Reading Moff 180418, Tennessee K4643, Montevideo 488275, Mbandaka 698538	Cumin seeds	*E. faecium* had more thermal resistance than *Salmonella.*	Chen et al., 2019

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	Heat process	*Escherichia coli* K12 LMM 1010, *Escherichia coli* P1 ATCC BAA-1427; *Listeria innocua* ATCC 33090; *Enterococcus faecium* NRRL B-2354; *Lactobacillus plantarum* ATCC 8014; *Bifidobacterium lactis*	22 Shiga toxin–producing *Escherichia coli* strains (STEC)	Wheat flour (8 or 13% moisture)	*E. faecium* had more thermal resistance to 5-min heat treatment at 82°C than the 22 STEC strains tested; *E. coli* P1 survival had similar thermal resistance as the most thermally resistant STEC strains. Moisture content impacted the survival of all organisms.	Daryaei et al., 2019
	Heat process	*Pediococcus acidilactici* ATCC 8042; *Enterococcus faecium* NRRL B-2354	*Salmonella* strains: Enteritidis 2415, Agona F5567, Typhimurium ATCC 14028, Tennessee K4643, Newport MH57137, Heidelberg MH27651	Toasted oat cereal, peanut butter	*P. acidilactici* and *E. faecium* had statistically equivalent thermal resistance in peanut butter; both had greater thermal resistance than the *Salmonella* cocktail. *P. acidilactici* and the *Salmonella* cocktail had statistically equivalent thermal resistance in toasted oat cereal treatment above 85°C.	Deen and Diez-Gonzalez, 2019
	Heat process	*Pantoea dispersa*; *Enterococcus faecium* 2B-I; *Escherichia coli* 3A-I	*Salmonella* Typhimurium phage type 42	Flour	Of ten different strains of non-pathogenic bacteria isolated from heat-treated flour, *P. dispersa* showed statistically equivalent thermal resistance to *Salmonella* Typhimurium; *E. faecium* has lower thermal resistance than *Salmonella.* D-values for *E. faecium* were 10 times lower than those for *Salmonella.*	Fudge et al., 2016
	Heat process	*Enterococcus faecium* NRRL B-2354	*Salmonella* strains: Agona 44767, Tennessee K4642, Montevideo 488275, Mbandaka 698538, Reading Moff 180418	Apple cubes	*E. faecium* had greater thermal resistance than *Salmonella* to hot-air drying treatment. Temperature and position in dryer impacted the time to reach reductions of 5 log CFU/sample.	Grasso-Kelley et al., 2021
	Moist-air convection heating	*Enterococcus faecium* NRRL B-2354	*Salmonella* Enteritidis phage type (PT) 30	Almond kernels	*E. faecium* had greater thermal resistance than *Salmonella*.	Jeong et al., 2011

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	Heat process	*Enterococcus faecium* NRRL B-2354	*Salmonella* Enteritidis PT 30	Almond kernels	*E. faecium* and *Salmonella* had statistically equivalent thermal resistance, but *E. faecium* models showed high error. Methodology, a_w, and process humidity were important parameters when validating the thermal processes.	Jeong et al., 2017
	Heat process	*Enterococcus faecium* NRRL B-2354	*Salmonella* strains: Agona 447967, Mbandaka 698538, Montevideo 488275, Tennessee K4643, Reading ATCC 6967	Brown rice flour	*Salmonella* had greater thermal resistance at 80 or 85°C than *E. faecium*; *E. faecium* had greater thermal resistance at 70 and 75°C than *Salmonella*. For the study an improved isothermal test cell was designed and used.	Jin and Tang, 2019
	Hot water	*Enterococcus faecium* ATTC 8459[1]	*Salmonella* strains: Anatum, Enteritidis PT 30 ATCC BAA-1045, Enteritidis PT 9c, Oranienburg 1839, Tennessee K4643; *Escherichia coli* O157:H7 strains: Odwalla strain 223, CDC 658, H1730, F4546, EC4042; *Listeria monocytogenes* strains: 101M serotype 4b, Scott A serotype 4b, V7 serotype 1/2a, LCDC81-861 serotype 4b	Inshell pecans	*E. faecium* had the greatest thermal resistance of all organisms evaluated. The *Salmonella* cocktail had the next greatest thermal resistance of the organisms compared.	Kharel et al., 2018
	Heat process	*Enterococcus faecium* NRRL B-2354	*Salmonella* strains: Agona 447967, Mbandaka 698538, Montevideo 488275, Reading Moff 180418, Tennessee K4643	Chia seeds	*E. faecium* had greater thermal resistance than *Salmonella*. The Weibull model had a lower root mean square error than the log-linear model.	Lau et al., 2021
	Heat process	*Enterococcus faecium* NRRL B-2354	*Salmonella* Enteritidis PT 30	Wheat flour	*E. faecium* had equal or greater thermal resistance than *Salmonella*.	Liu et al., 2018

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	Hot water, hot oil	*Enterococcus faecium* NRRL B-2354	*Salmonella* strains: Enteritidis PT 30 (ATCC BAA-1045), Enteritidis PT 9c (RM4635), Montevideo (GRC1), Saintpaul (LJH1311-1), Senftenberg (LJH 1437-1), Tennessee (K4643); *Escherichia coli* O157:H7 strains: Odwalla strain 223, CDC 658, EC4042, EC1738, PT 4 NML 11-1865; *Listeria monocytogenes* strains: 4b LJH552, LIS0234, LIS0133, PTVS 308	Inshell pistachios	*E. faecium* had equal or greater thermal resistance than *Salmonella*. *Salmonella* Enteritidis PT 30 had similar or greater thermal resistance than all other pathogens compared.	Moussavi et al., 2020
	Radio-frequency heating and subsequent freezing	*Enterococcus faecium* NRRL B-2354	*Salmonella* Enteritidis PT 30	Corn flour	*E. faecium* had greater thermal resistance than *Salmonella*.	Ozturk et al., 2019
	Radio-frequency heating	*Enterococcus faecium* NRRL B-2354	*Salmonella* Enteritidis PT 30	Paprika, white pepper, cumin powders	*E. faecium* had greater thermal resistance than *Salmonella*.	Ozturk et al., 2020
	Heat process	*Enterococcus faecium* NRRL B-2354	*Salmonella* Enteritidis PT 30	Egg powder	*E. faecium* had greater thermal resistance than *Salmonella*.	Pérez-Reyes et al., 2021
	Heat process	*Enterococcus faecium* NRRL B-2354	*Salmonella* strains: Montevideo, Agona, Weltevreden ATCC BAA-2568, Senftenberg ATCC H385, Tennessee, Typhimurium PT 42; *Listeria monocytogenes* strains: 1/2b FSL J1-177, 1/2a FSL C1-056, 4b FSL N3-013, 1/2a FSL R2-499, 4b FLS N1-227, Scott A ATCC49594	Peanut butter, powder infant formula, wheat flour	*E. faecium* had greater thermal resistance than *Salmonella* and *Listeria*; resistance was significantly greater at most parameters. *Listeria* and *Salmonella* had statistically equivalent resistance in wheat flour, and in powder infant formula at 85°C.	Quinn et al., 2020

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	Heat process	*Enterococcus faecium* NRRL B-2354	*Salmonella* strains: Enteritidis PT 30, Senftenberg 775W, Typhimurium, Anatum, Montevideo, Tennessee; *Listeria monocytogenes* strains: ATCC 15313–53 XXIII, DSMZ 20600; ATCC 49594; ATCC 35152–NCTC 7973; ATCC 13932–LMG 21264, DSMZ 27575; FRRB 2542	Confectionery formulation, chicken meat powder, pet food, savory seasoning	*Salmonella* had greater thermal resistance in the confectionary formulation than *E. faecium*; *Listeria* had the least thermal resistance. *E. faecium* had the greatest thermal resistance of all organisms in the other products tested - chicken meat powder, pet food, and savory seasoning.	Rachon et al., 2016
	Oil roasting or dry roasting	*Enterococcus faecium* ATCC 8459[1], *Enterococcus faecium* ATCC 35667	*Salmonella* strains: Enteritidis PT 30, Tennessee (2006/2007 peanut outbreak strain), Typhimurium TM-1, Cubana G2:229, Newport C2:e,h:1,2, Redba, Bredeney	Peanuts	*E. faecium* had greater thermal resistance than *Salmonella*.	Sanders and Calhoun, 2014
	Vacuum steam	*Enterococcus faecium* NRRL B-2354	*Salmonella* Enteritidis PT 30, *E. coli* O157:H7	Quinoa, sunflower kernels, black peppercorns, whole flaxseed, milled flaxseed	*E. faecium* had greater thermal resistance than both *Salmonella* and *E. coli*. Vacuum steam treatment (75 or 85°C) effectively reduced pathogens on the matrices at parameters tested.	Shah et al., 2017
	Spray drying	*Enterococcus faecium* NRRL B-2354	*Salmonella* Enteritidis PT 30	Soy protein isolate	*E. faecium* had equal or greater thermal resistance than *Salmonella*.	Steinbrunner et al., 2021
	Heat process	*Enterococcus faecium* NRRL B-2354	*Salmonella* strains: Enteritidis PT 30, Tennessee K4643, Agona 447967	Cocoa powder	*Salmonella* had greater thermal resistance than *E. faecium* at a_w = 0.45. *E. faecium* had equal or greater thermal resistance than *Salmonella* at a_w = 0.30.	Tsai et al., 2019

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	Radio-frequency heating	*Enterococcus faecium* NRRL B-2354	*Salmonella* strains: Agona 447967, Reading Moff 180418, Mbandaka 698538, Montevideo 488275, Tennessee K4643	Basil leaves, dried	*E. faecium* had greater thermal resistance than *Salmonella*.	Verma et al., 2021
	Radio-frequency heating	*Enterococcus faecium* NRRL B-2354	*Salmonella* Enteritidis PT 30	Wheat flour	*E. faecium* had greater thermal resistance than *Salmonella*.	Villa-Rojas et al., 2017
	Radio-frequency heating	*Enterococcus faecium* NRRL B-2354	*Salmonella* strains: Agona 447967, Reading, Mbandaka 698538, Montevideo 488275, Tennessee K4643	Black peppercorns	*E. faecium* had similar thermal resistance as the *Salmonella* cocktail for the treatment tested.	Wei et al., 2018
	Radio-frequency heating	*Enterococcus faecium* NRRL B-2354	*Salmonella* strains: Agona 447967, Reading, Mbandaka 698538, Montevideo 488275, Tennessee K4643	Egg white powder	*E. faecium* had higher thermal resistance than *Salmonella*, and similar inactivation kinetics.	Wei et al., 2020
	Heat process	*Enterococcus faecium* NRRL B-2354	*Salmonella* strains: Agona 447967, Reading Moff 180418, Mbandaka 698538, Montevideo 488275, Tennessee K4643	Nonfat dry milk, whole milk powder	*E. faecium* had greater thermal resistance than *Salmonella*. D-values for both organisms were higher in nonfat dry milk than in whole milk powder.	Wei et al., 2021
	Steam treatment	*Enterococcus faecium* ATTC 8459[1]; *Listeria innocua* ATCC 33090; *Escherichia coli* P1 ATCC BAA-1427, *Escherichia coli* K12 ATCC 23631	*Salmonella* strains: Senftenberg 775W ATCC 43845, Enteritidis PT 30 ATCC BAA-1045, Montevideo ATCC BAA-710, Thompson; *Listeria monocytogenes* strains: 4b LMG 23192, 4b LMG 23194, 1/2b LMG 26484; *Escherichia coli* O157:H7 strains: ATCC 700728, BRMSID 188, LFMFP 846	Black peppercorns	*E. faecium* had the greatest thermal resistance of the surrogate organisms tested. *Salmonella* had the greatest thermal resistance of the pathogens tested. *E. faecium* had greater thermal resistance in most (91%) of the tested conditions than *Salmonella*.	Zhou et al., 2019

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Thermal and Chemical	Hot water, calcium hypochlorite treatment	*Escherichia coli* strains: 080618-8, 080526-4, 080611-3, 080602-3, 080514-2	*E. coli* O157:H7strains: CR-3, MN-28, MY-29, DT-66; *Salmonella* Enteritidis strains: SE-1, SE-2 SE-3, SE-4	Mung bean seeds	Surrogate *E. coli* strains performed similarly to pathogen strains. Hot-water treatment led to greater reductions than calcium hypochlorite treatment.	Bari et al., 2009
	Product formulation: water activity and fat level, heat process	*Enterococcus faecium* NRRL B-2354	*Salmonella* Tennessee, *Salmonella* Typhimurium DT104	Peanut pastes	*Salmonella* survived in all formulations for >12 months. *E. faecium* survived at higher levels than *Salmonella* during storage.	Kataoka et al., 2014
	Ozone, heated brine and ozone	*Enterococcus faecium* OSY 31284	*Salmonella* Enteritidis ODA 99-30581-13	Inshell almonds, inshell pistachios	*E. faecium* had less resistance than *Salmonella* to ozone treatment alone on pistachios. *E. faecium* had significantly more resistance than *Salmonella* to heat and heat-ozone treatment on pistachios.	Perry et al., 2019
	Gaseous chlorine dioxide + moisture + mild heat	*Enterococcus faecium* NRRL B-2354	*Salmonella* strains: ATCC Typhimurium 14028, Heidelberg 45955, Enteritidis PT 30, Montevideo 51, Newport H1073	Almond kernels	Combination of gaseous chlorine dioxide, mild heat (40°C), and increased almond moisture (7%) led to the largest reductions of *Salmonella* and *E. faecium*; *Salmonella* and *E. faecium* reductions were statistically the same, but at most 2 log CFU/g.	Rane et al., 2021
	High-pressure carbon dioxide or pressurized nitrogen, + heat	*Enterococcus faecium* NRRL B-2354; *Escherichia coli* AW1.7; *Pediococcus acidilactici* FUA 3072; *Staphylococcus carnosus* R6 FUA 2133	*Salmonella* strains: Typhimurium ATCC 13311, Senftenberg ATCC 43845, FUA1934, FUA 1946, FUA 1955 *E. coli* strains: 03-2832 O121:H19, 05-6544 O26:H11, C0283 O157:H7, PARC 449 O145:NM, 03-6430 O145:NM	Beef jerky	Treatment of inoculated beef jerky with water-saturated gaseous carbon dioxide resulted in >5-log reductions of all *E. coli* and *Salmonella* strains. *E. faecium* had equal or greater resistance than *Salmonella* to high pressure CO_2; *S. carnosus* had equal or higher resistance than any other tested organism.	Schultze et al., 2020

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Chemical	Osmotic pressure and acid	*Enterococcus faecium* NRRL B-2354	*Salmonella* strains: , Enteritidis PT 30 ATCC BAA-1045, Tennessee K4643, Agona 447969	Honey, high fructose corn syrup	Whether cultures were prepared using a plate or a freeze-dried method, *E. faecium* had greater resistance than *Salmonella* in honey, and similar resistance in high fructose corn syrup. After 21 days of storage in both matrices, populations of both organisms declined more than > 5 log CFU/ml.	Alshammari et al., 2021
	Ethylene oxide	*Enterococcus faecium* NRRL B-2354	*Salmonella* strains: Agona 447967, Reading Moff 180418, Tennessee K4643, Montevideo 488275, Mbandaka 698538	Cumin seeds	*E. faecium* had greater resistance than *Salmonella* to treatments. Temperature and RH affected reductions of both organisms, with RH having the largest impact.	Chen et al., 2021
	Peracetic acid	*Enterococcus faecium* NRRL B-2354	*Salmonella* strains: Newport, Senftenberg 775W, Oranienburg, Saintpaul, Typhimurium DT104	Chia seeds, flax seeds	*E. faecium* had greater resistance than *Salmonella* to the sanitizing solution treatment.	Hylton et al., 2019
	Propylene oxide (PPO)	*Enterococcus faecium* ATCC 8459[1]; *Pediococcus acidilactici* ATCC 8042; *Staphylococcus carnosus* ATCC 51365	*Salmonella* strains: Senftenberg 775W, Montevideo 1449, Tennessee K4643, Johannesburg ARL-SE-013, Ball ARL-SE-085	Cashews, macadamia nuts	*E. faecium* and *P. acidilactici* had significantly more resistance than *Salmonella* to PPO fumigation on both nuts; *E. faecium* had the greatest resistance of all organisms tested. *S. carnosus* had statistically greater resistance than *Salmonella* on macadamia nuts; reductions for the two organisms were similar on cashews.	Saunders et al., 2018
	Ethylene oxide	*Enterococcus faecium* NRRL B-2354	*Salmonella* strains: Agona 447967, Montevideo 488275, Mbandaka 698538	Whole black peppercorns	*E. faecium* had greater resistance than *Salmonella* to fumigation treatments. Temperature and RH had significant effects on reductions of both organisms.	Wei et al., 2021

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Non-thermal	Intense pulsed light	*Enterococcus faecium* NRRL B-2354	*Cronobacter sakazakii* ATCC 29544	Non-fat dry milk, wheat flour, egg white powder	*E. faecium* had greater resistance than *C. sakazakii* to pulsed light treatments for each matrix.	Chen et al., 2019
	Electron beam (irradiation)	*Enterococcus faecium* NRRL B-2354; *Geobacillus stearothermophilus* ATCC 7953 spores; *Escherichia coli* strains: DSM 19206, DSM 5923, DSM 18039; *Deinococcus radiodurans* DSM 20539	*Salmonella* strains: Enteritidis (15-SA02843), Gaminara (05-01527), Oranienburg (17-SA01525), Rubislaw (07-01143), Typhimurium (10-01906)	Pumpkin seeds, golden flax seeds	*E. faecium* had greater resistance than *Salmonella* to electron beam treatment; *E. faecium* reductions were 2–3 log lower. *E. coli* DSM 18039 and *Salmonella* showed similar resistance. Results suggest that *E. coli* DSM 18039 could serve as a surrogate for *Salmonella* in validation trials, whereas *E. faecium* could serve as a process control indicator for seed decontamination.	Henz et al., 2020
	High-intensity 405-nanometer light	*Escherichia coli* K-12 ATTC SMG 123; *Salmonella* Typhimurium Chi 3985	*E. coli* O157:H7 strains: ATCC 35150, C9990, 43894; *Salmonella* Enteritidis PT 30	Almonds	Surrogates and pathogenic strains all showed similar resistance. Reductions were below 3 log for all processes.	Lacombe et al., 2016

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Table 2. Studies that use surrogate organisms to in low moisture foods subjected to different treatment processes

Process type	Treatment	Surrogate organism	Matrix	Summary	References
Thermal	Dry-heat process	*Enterococcus faecium* NRRL B-2354	Almond meal, talc	*E. faecium* had lower thermal resistance in talc alone than in almond meal or almond meal with talc (used as dry-inoculum carrier); residual talc affected thermal resistance of *E. faecium*.	Ahmad et al., 2019
	Superheated steam	*Enterococcus faecium* NRRL B-2354	Peanut butter	Increases in superheated steam temperature and a_w of peanut butter decreased the D-values.	Park et al., 2021
	Dry-heat process	*Enterococcus faecium* ATCC 8459[1], *Enterococcus faecium* ATCC 35667	Peanuts	5-log reduction of *E. faecium* was achieved using industrially relevant dry roasting parameters for peanuts.	Poirier et al., 2014
	Dry-heat process	*Enterococcus faecium* ATCC 8459[1]	Peanut butter (normal and high oleic)	High temperature (190°C) heat treatment reduced *E. faecium* by 6 log CFU/g without unacceptable quality loss.	Reed et al., 2020
	Oven roasting, microwave roasting, oven and microwave roasting	*Enterococcus faecium* OSY31284	Peanuts	A minimum 3-log reduction of *E. faecium* was achieved with the parameters tested.	Smith et al., 2014
	Sequential infrared hot air	*Enterococcus faecium* NRRL B-2354	Pistachios	Sequential infrared hot air treatment achieved faster drying of pistachios and >5-log reduction of *E. faecium.*	Venkitasamy et al., 2017
	Sequential infrared hot air	*Enterococcus faecium* NRRL B-2354	Almonds	Sequential infrared hot air treatment achieved faster drying of almonds and varied reductions of *E. faecium.*	Venkitasamy et al., 2018
	Radiofrequency heat	*Enterococcus faecium* NRRL B-2354	Wheat flour (a_w 0.45; 22°C)	Bigelow model showed a D-value of 8.3 min at 80°C with a z-value of 11.7°C (R^2 = 0.81).	Xu et al., 2020
Thermal and Chemical	Heat with or without controlled atmosphere	*Escherichia coli* ATCC 25922	Almond powder	Heat with controlled atmosphere (low oxygen) resulted in increased D-values below 1°C/min heating.	Cheng et al., 2017
	Modified atmosphere storage, heat process	*Escherichia coli* ATCC 25922	Almond powder	Long-term storage at 24°C in a modified atmosphere resulted in increased reductions. Holding at 75°C for 50.4 min achieved 4-log reductions.	Cheng et al., 2018
Non-thermal	Electron beam irradiation	*Salmonella* Typhimurium LT2; *Escherichia coli* BAA-1427, BAA-1428, BAA-1430	Pecans	Irradiation under modified atmosphere conditions showed similar lethality, but reduced rancidity.	Karagöz et al., 2014

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Validation guidelines and key references

Almond Board of California. 2014. Guidelines for using *Enterococcus faecium* NRRL B-2354 as a surrogate microorganism in almond process validation. Almond Board of California, Modesto, CA.

- **The Almond Board of California's guidelines for using *Enterococcus faecium* NRRL B-2354 to validate dry-heat processes for control of *Salmonella* Enteritidis PT 30 (the pathogen of concern) on almonds.**

Anderson, D., N. Anderson, L. J. Harris, and W. Ocasio. 2017. Validation requirements in heat-processed low-moisture foods, p. 149–174. *In* R. Podolak and D. G. Black (ed.), Control of *Salmonella* and other bacterial pathogens in low-moisture foods. John Wiley & Sons, Hoboken, NJ.

- **Outlines the steps and requirements for validating heat processes for the control of pathogens in low moisture foods.**

Barouei, J., J. Frelka, L. J. Harris, B. Marks, R. Mashiana, and C. Theofel (contributing authors) 2018. Guidelines for using *Enterococcus faecium* NRRL B-2354 as a surrogate microorganism in pistachio process validation.

- **Guidelines for using *Enterococcus faecium* NRRL B-2354 to validate dry-heat processes for the control of *Salmonella* Enteritidis PT 30 (the target pathogen of concern) on pistachios.**

Chen, Y., V. N. Scott, T. A. Freier, J. Kuehm, M. Moorman, J. Meyer, T. Morille-Hinds, L. Post, L. Smoot, S. Hood, J. Shebuski, and J. Banks. 2009. Control of *Salmonella* in low-moisture foods III: Process validation and environmental monitoring. *Food Prot. Trends* 29:493–508.

- **Outlines steps in controlling *Salmonella* in low moisture foods including validation of *Salmonella* inactivation measures.**

Consortium of Food Process Validation Experts (CFPVE). 2013. Validation of antimicrobial interventions for small and very small processors: A how-to guide to develop and conduct validations. *Food Prot. Trends* 33(2):95–104.

- **Outlines steps for validating antimicrobial interventions for pathogen control in foods.**

Enache, L., A. Kataoka, D. G. Black, C. D. Napier, R. Podolak, and M. M. Hayman. 2015. Development of a dry inoculation method for thermal challenge studies in low-moisture foods by using talc as a carrier for *Salmonella* and a surrogate (*Enterococcus faecium*). *J. Food Prot.* 78:1106–1112. https://doi.org/10.4315/0362-028X.JFP-14-396

- **Describes procedures for obtaining a dry inoculum of *Enterococcus faecium* NRRL B-2354 or *Salmonella* Tennessee on talc. *E. faecium* had higher heat resistance than *Salmonella* under all parameters tested.**

Hu, M., and J. B. Gurtler. 2017. Selection of surrogate bacteria for use in food safety challenge studies: a review. *J. Food Prot*. 80:1506–1536. https://doi.org/10.4315/0362-028X.JFP-16-536

- **Outlines criteria for selecting a surrogate for process validation and lists surrogates that have been previously validated by pathogen.**

Kopit, L. M., E. B. Kim, R. J. Siezen, L. J. Harris, and M. L. Marco. 2014. Safety of the surrogate microorganism *Enterococcus faecium* NRRL B-2354 for use in thermal process validation. *Appl. Environ. Microbiol.* 80:1899–1909. DOI: 10.1128/AEM.03859-13

- ***E. faecium* NRRL B-2354 and clonal relative *E. faecium* ATTC 8459 are devoid of key antibiotic resistance and virulence genes and were considered safe to use in validation studies. The two strains share over 99% sequence identity.**

References cited – Tables 1 and 2

Acuff, J. C., J. Wu, C. Marik, K. Waterman, D. Gallagher, H. Huang, R. C. Williams, and M. A. Ponder. 2020. Thermal inactivation of *Salmonella*, Shiga toxin-producing *Escherichia coli*, *Listeria monocytogenes*, and a surrogate (*Pediococcus acidilactici*) on raisins, apricot halves, and macadamia nuts using vacuum-steam pasteurization. *Int. J. Food Microbiol.* 333:108814. https://doi.org/10.1016/j.ijfoodmicro.2020.108814

Ahmad, N. H., C. Öztabak, B. P. Marks, and E. T. Ryser. 2019. Effect of talc as a dry-inoculation carrier on thermal resistance of *Enterococcus faecium* NRRL B-2354 in almond meal. *J. Food Prot.* 82:1110–1115. https://doi.org/10.4315/0362-028X.JFP-18-543

Alshammari, J., N. Dhowlaghar, Y. Xie, J. Xu, J. Tang, S. Sablani, and M. J. Zhu. 2021. Survival of *Salmonella* and *Enterococcus faecium* in high fructose corn syrup and honey at room temperature (22°C). *Food Control*. 123:107765. https://doi.org/10.1016/j.foodcont.2020.107765

Bari, M. L., K. Enomoto, D. Nei, and S. Kawamoto. 2010. Practical evaluation of mung bean seed pasteurization method in Japan. *J. Food Prot.* 73:752–757. https://doi.org/10.4315/0362-028X-73.4.752

Bianchini, A., J. Stratton, S. Weier, T. Hartter, B. Plattner, G. Rokey, G. Hertzel, L. Gompa, B. Martinez, and K. M. Eskridge. 2014. Use of *Enterococcus faecium* as a surrogate *for Salmonella enterica* during extrusion of a balanced carbohydrate-protein meal. *J. Food Prot.* 77:75–82. https://doi.org/10.4315/0362-028X.JFP-13-220

Brar, P. K., and M. D. Danyluk. 2019. Validation of *Enterococcus faecium* as a surrogate for *Salmonella* under different processing conditions for peanuts and pecans. *Food Microbiol.* 80:9–17. https://doi.org/10.1016/j.fm.2018.12.006

Buege, D. R., G. Searls, and S. C. Ingham. 2006. Lethality of commercial whole-muscle beef jerky manufacturing processes against *Salmonella* serovars and *Escherichia coli* O157:H7. *J. Food Prot.* 69:2091–2099. https://doi.org/10.4315/0362-028X-69.9.2091

Ceylan, E., and D. A. Bautista. 2015. Evaluating *Pediococcus acidilactici* and *Enterococcus faecium* NRRL B-2354 as thermal surrogate microorganisms for *Salmonella* for in-plant validation studies of low-moisture pet food products. *J. Food Prot.* 78:934–939. https://doi.org/10.4315/0362-028X.JFP-14-271

Channaiah, L. H., E. S. Holmgren, M. Michael, N. J. Sevart, D. Milke, C. L. Schwan, M. Krug, A. Wilder, R. K. Phebus, H. Thippareddi, and G. Milliken. 2016. Validation of baking to control *Salmonella* serovars in hamburger bun manufacturing, and evaluation of *Enterococcus faecium* ATCC 8459 and *Saccharomyces cerevisiae* as nonpathogenic surrogate indicators. *J. Food Prot.* 79:544–552. https://doi.org/10.4315/0362-028X.JFP-15-241

Chen, D., Y. Cheng, P. Peng, J. Liu, Y. Wang, Y. Ma, E. Anderson, C. Chen, P. Chen, and R. Ruan. 2019. Effects of intense pulsed light on *Cronobacter sakazakii* and *Salmonella* surrogate *Enterococcus faecium* inoculated in different powdered foods. *Food Chem*. 296:23–28. https://doi.org/10.1016/j.foodchem.2019.05.180

Chen, L., X. Wei, B. D. Chaves, D. Jones, M. A. Ponder, and J. Subbiah. 2021. Inactivation of *Salmonella enterica* and *Enterococcus faecium* NRRL B2354 on cumin seeds using gaseous ethylene oxide. *Food Microbiol.* 94:103656. https://doi.org/10.1016/j.fm.2020.103656

Chen, L., X. Wei, S. Irmak, B. D. Chaves, and J. Subbiah. 2019. Inactivation of *Salmonella enterica* and *Enterococcus faecium* NRRL B-2354 in cumin seeds by radiofrequency heating. *Food Control* 103:59–69. https://doi.org/10.1016/j.foodcont.2019.04.004

Cheng, T., R. Li, X. Kou, and S. Wang. 2017. Influence of controlled atmosphere on thermal inactivation of *Escherichia coli* ATCC 25922 in almond powder. *Food Microbiol.* 64:186–194. https://doi.org/10.1016/j.fm.2017.01.007

Cheng, T., and S. Wang. 2018. Influence of storage temperature/time and atmosphere on survival and thermal inactivation of *Escherichia coli* ATCC 25922 inoculated to almond powder. *Food Control* 86:350–358. https://doi.org/10.1016/j.foodcont.2017.11.029

Daryaei, H., Q. Sui, H. Liu, A. Rehkopf, W. Peñaloza, A. Rytz, Y. Luo, and J. Wan. 2019. Heat resistance of Shiga toxin-producing *Escherichia coli* and potential surrogates in wheat flour at two moisture levels. *Food Control* 108:106788. https://doi.org/10.1016/j.foodcont.2019.106788

Deen, B., and F. Diez-Gonzalez. 2019. Assessment of *Pediococcus acidilactici* ATCC 8042 as potential *Salmonella* surrogate for thermal treatments of toasted oats cereal and peanut butter. *Food Microbiol.* 83:187–192. https://doi.org/10.1016/j.fm.2019.05.015

Fudge, J., M. Dunn, O. Pike, R. Robison, and F. Steele. 2016. The isolation and identification of *Pantoea dispersa* strain JFS as a non-pathogenic surrogate for *Salmonella* Typhimurium phage type 42 in flour. *Int. J. Food Microbiol.* 219:1–6. https://doi.org/10.1016/j.ijfoodmicro.2015.11.012

Grasso-Kelley, E. M., X. Liu, L. A. Halik, and B. Douglas. 2021. Evaluation of hot-air drying to inactivate *Salmonella* and *Enterococcus faecium* on apple pieces. *J. Food Prot.* 84:240–248. https://doi.org/10.4315/JFP-20-167

Henz, S., R. Nitzsche, M. Kiessling, K. Aganovic, V. Heinz, and C. Hertel. 2020. Surrogate for electron beam inactivation of *Salmonella* on pumpkin seeds and flax seeds. *J. Food Prot.* 83:1775–1781. https://doi.org/10.4315/JFP-20-088

Hylton, R. K., A. F. Sanchez-Maldonado, P. Peyvandi, F. Rahmany, F. Dagher, C. G. Leon-Velarde, K. Warriner, and A. M. Hamidi. 2019. Decontamination of chia and flax seed inoculated with *Salmonella* and surrogate, *Enterococcus faecium* NRRL B-2354, using a peracetic acid sanitizing solution: antimicrobial efficacy and impact on seed functionality. *J. Food Prot.* 82:486–493. https://doi.org/10.4315/0362-028X.JFP-18-381

Jeong, S., B. P. Marks, and E. T. Ryser. 2011. Quantifying the performance of *Pediococcus* sp. (NRRL B-2354: *Enterococcus faecium*) as a nonpathogenic surrogate for *Salmonella* Enteritidis PT30 during moist-air convection heating of almonds. *J. Food Prot*. 74:603–609. https://doi.org/10.4315/0362-028X.JFP-10-416

Jeong, S., B. P. Marks, and M. K. James. 2017. Comparing thermal process validation methods for *Salmonella* inactivation on almond kernels. *J. Food Prot*. 80:169–176. https://doi.org/10.4315/0362-028X.JFP-16-224

Jin, Y., and J. Tang. 2019. Improved design of aluminum test cell to study the thermal resistance of *Salmonella enterica* and *Enterococcus faecium* in low-water activity foods. *Food Control* 104:343–348. https://doi.org/10.1016/j.foodcont.2019.05.008

Karagöz, I., R. G. Moreira, and M. E. Castell-Perez. 2014. Radiation D_{10} values for *Salmonella* Typhimurium LT2 and an *Escherichia coli* cocktail in pecan nuts (Kanza cultivar) exposed to different atmospheres. *Food Control* 39:146–153. https://doi.org/10.1016/j.foodcont.2013.10.041

Kataoka, A., E. Enache, D. G. Black, P. H. Elliott, C. D. Napier, R. Podolak, and M. M. Hayman. 2014. Survival of *Salmonella* Tennessee, *Salmonella* Typhimurium DT104, and *Enterococcus faecium* in peanut paste formulations at two different levels of water activity and fat. *J. Food Prot.* 77:1252–1259. https://doi.org/10.1016/j.foodcont.2013.10.041

Kharel, K., V. K. Yemmireddy, C. J. Graham, W. Prinyawiwatkul, and A. Adhikari. 2018. Hot water treatment as a kill-step to inactivate *Escherichia coli* O157:H7, *Salmonella enterica*, *Listeria monocytogenes* and *Enterococcus faecium* on in-shell pecans. *LWT – Food Sci. Technol.* 97:555–560. https://doi.org/10.1016/j.lwt.2018.07.048

Lacombe, A., B. A. Niemira, J. Sites, G. Boyd, J. B. Gurtler, B. Tyrell, and M. Fleck. 2016. Reduction of bacterial pathogens and potential surrogates on the surface of almonds using high-intensity 405-nanometer light. *J. Food Prot.* 79:1840–1845. https://doi.org/10.4315/0362-028X.JFP-15-418

Lau, S. K., R. Panth, B. D. Chaves, C. L. Weller, and J. Subbiah. 2021. Thermal inactivation kinetics of *Salmonella* and *Enterococcus faecium* NRRL-B2354 on whole chia seeds (*Salvia hispanica* L.). *J. Food Prot.* (in press, accepted April 12, 2021). https://doi.org/10.4315/JFP-20-468

Liu, S., R. V. Rojas, P. Gray, M.-J. Zhu, and J. Tang. 2018. *Enterococcus faecium* as a *Salmonella* surrogate in the thermal processing of wheat flour: Influence of water activity at high temperatures. *Food Microbiol.* 74:92–99. https://doi.org/10.1016/j.fm.2018.03.001

Moussavi, M., J. C. Frelka, I. M. Hildebrandt, B. P. Marks, and L. J. Harris. 2020. Thermal resistance of foodborne pathogens and *Enterococcus faecium* NRRL B-2354 on inoculated pistachios. *J. Food Prot.* 83:1125–1136. https://doi.org/10.4315/JFP-19-561

Ozturk, S., F. Kong, and R. K. Singh. 2020. Evaluation of *Enterococcus faecium* NRRL B-2354 as a potential surrogate of *Salmonella* in packaged paprika, white pepper and cumin powder during radio frequency heating. *Food Control* 108:106833. https://doi.org/10.1016/j.foodcont.2019.106833

Ozturk, S., S. Liu, J. Xu, J. Tang, J. Chen, R. K. Singh, and F. Kong. 2019. Inactivation of *Salmonella* Enteritidis and *Enterococcus faecium* NRRL B-2354 in corn flour by radio frequency heating with subsequent freezing. *LWT – Food Sci. Technol.* 111:782–789. https://doi.org/10.1016/j.lwt.2019.04.090

Park, H. W., J. Xu, V. M. Balasubramaniam, and A. B. Snyder. 2021. The effect of water activity and temperature on the inactivation of *Enterococcus faecium* in peanut butter during superheated steam sanitation treatment. *Food Control* 125:107942. https://doi.org/10.1016/j.foodcont.2021.107942

Pérez-Reyes, M. E., X. Jie, M. J. Zhu, J. Tang, and G. V. Barbosa-Cánovas. 2021. Influence of low water activity on the thermal resistance of *Salmonella* Enteritidis PT30 and *Enterococcus faecium* as its surrogate in egg powders. *Food Sci. Technol. Int.* 27:184–193.

https://doi.org/10.1177/1082013220937872

Perry, J. J., M. Peña-Melendez, and A. E. Yousef. 2019. Ozone-based treatments for inactivation of *Salmonella enterica* in tree nuts: Inoculation protocol and surrogate suitability considerations. *Int. J. Food Microbiol.* 297:21–26. https://doi.org/10.1016/j.ijfoodmicro.2019.02.025

Poirier, D., T. H. Sanders, and J. P. Davis. 2014. *Salmonella* surrogate reduction using industrial peanut dry roasting parameters. *Peanut Sci.* 41(2):72–84. https://doi.org/10.3146/PS13-21.1

Quinn, A. R., R. F. Liao, F. M. Steele, L. K. Jefferies, and B. J. Taylor. 2021. Isothermal inactivation of *Salmonella, Listeria monocytogenes, and Enterococcus faecium* NRRL B-2354 in peanut butter, powder infant formula, and wheat flour. *Food Control* 121:107582. https://doi.org/10.1016/j.foodcont.2020.107582

Rachon, G., W. Peñaloza, and P. A. Gibbs. 2016. Inactivation of *Salmonella, Listeria monocytogenes* and *Enterococcus faecium* NRRL B-2354 in a selection of low moisture foods. *Int. J. Food Microbiol.* 231:16–25. https://doi.org/10.1016/j.ijfoodmicro.2016.04.022

Rane, B., A. Lacombe, S. Sablani, D. F. Bridges, J. Tang, J. Guan, and V. C. H. Wu. 2021. Effects of moisture content and mild heat on the ability of gaseous chlorine dioxide against *Salmonella* and *Enterococcus faecium* NRRL B-2354 on almonds. *Food Control* 123:107732. https://doi.org/10.1016/j.foodcont.2020.107732

Reed, L., K. R. Schneider, A. J. MacIntosh, and P. J. Sarnoski. 2020. Determination of *Enterococcus faecium* thermal reduction in normal and high oleic peanut products. *J. Food Saf.* 40:e12801. https://10.1111/jfs.12801J

Sanders, T. H., and R. S. Calhoun. 2014. Effect of oil and dry roasting of peanuts at various temperatures and times on survival of *Salmonella* and *Enterococcus faecium*. *Peanut Sci.* 41(2):65–71. https://doi.org/10.3146/PS13-16.1

Saunders, T., J. Wu, R. C. Williams, H. Huang, and M. A. Ponder. 2018. Inactivation of *Salmonella* and surrogate bacteria on cashews and macadamia nuts exposed to commercial propylene oxide processing conditions. *J. Food Prot.* 81:417–423. https://doi.org/10.4315/0362-028X.JFP-17-252

Schultze, D. M., R. Couto, F. Temelli, L. M. McMullen, and M. Gänzle. 2020. Lethality of high-pressure carbon dioxide on Shiga toxin-producing *Escherichia coli*, *Salmonella* and surrogate organisms on beef jerky. *Int. J. Food Microbiol.* 321:108550. https://doi.org/10.1016/j.ijfoodmicro.2020.108550

Shah, M. K., G. Asa, J. Sherwood, K. Graber, and T. M. Bergholz. 2017. Efficacy of vacuum steam pasteurization for inactivation of *Salmonella* PT 30, *Escherichia coli* O157:H7 and *Enterococcus faecium* on low moisture foods. *Int. J. Food Microbiol.* 244:111–118. https://doi.org/10.1016/j.ijfoodmicro.2017.01.003

Smith, A. L., J. J. Perry, J. A. Marshall, A. E. Yousef, and S. A. Barringer. 2014. Oven, microwave, and combination roasting of peanuts: Comparison of inactivation of *Salmonella* surrogate *Enterococcus faecium*, color, volatiles, flavor, and lipid oxidation. *J. Food Sci.* 79:S1584–S1594. https://doi.org/10.1111/1750-3841.12528

Steinbrunner, P., B. P. Marks, E. T. Ryser, Q. J. Suehr, and S. Jeong. 2021. Fate of *Salmonella* and *Enterococcus faecium* during pilot-scale spray drying of soy protein isolate. *J. Food Prot.* 84:674–

679. https://doi.org/10.4315/JFP-20-284

Tsai, H.-C., K. F. Ballom, S. Xia, J. Tang, B. P. Marks, and M.-J. Zhu. 2019. Evaluation of *Enterococcus faecium* NRRL B-2354 as a surrogate for *Salmonella* during cocoa powder thermal processing. *Food Microbiol.* 82:135–141. https://doi.org/10.1016/j.fm.2019.01.005

Venkitasamy, C., M. T. Brandl, B. Wang, T. H. McHugh, R. Zhang, and Z. Pan. 2017. Drying and decontamination of raw pistachios with sequential infrared drying, tempering and hot air drying. *Int. J. Food Microbiol.* 246:85–91. https://doi.org/10.1016/j.ijfoodmicro.2017.02.005

Venkitasamy, C., C. Zhu, M. T. Brandl, F. J. A. Niederholzer, R. Zhang, T. H. McHugh, and Z. Pan. 2018. Feasibility of using sequential infrared and hot air for almond drying and inactivation of *Enterococcus faecium* NRRL B-2354. *LWT – Food Sci. Technol.* 95:123–128. https://doi.org/10.1016/j.lwt.2018.04.095

Verma, T., B. D. Chaves, S. Irmak, and J. Subbiah. 2021. Pasteurization of dried basil leaves using radio frequency heating: A microbial challenge study and quality analysis. *Food Control* 124:107932. https://doi.org/10.1016/j.foodcont.2021.107932

Villa-Rojas, R., M.-J. Zhu, B. P. Marks, and J. Tang. 2017. Radiofrequency inactivation of *Salmonella* Enteritidis PT 30 and *Enterococcus faecium* in wheat flour at different water activities. *Biosyst. Eng.* 156:7–16. https://doi.org/10.1016/j.biosystemseng.2017.01.001

Wei, X., L. Chen, B. D. Chaves, M. A. Ponder, and J. Subbiah. 2021. Modeling the effect of temperature and relative humidity on the ethylene oxide fumigation of *Salmonella* and *Enterococcus faecium* in whole black peppercorn. *LWT* 140:110742. https://doi.org/10.1016/j.lwt.2020.110742

Wei, X., S. K. Lau, J. Stratton, S. Irmak, A. Bianchini, and J. Subbiah. 2018. Radio-frequency processing for inactivation of *Salmonella enterica* and *Enterococcus faecium* NRRL B-2354 in black peppercorn. *J. Food Prot.* 81:1685–1695. https://doi.org/10.4315/0362-028X.JFP-18-080

Wei, X., S. K. Lau, B. S. Reddy, and J. Subbiah. 2020. A microbial challenge study for validating continuous radio-frequency assisted thermal processing pasteurization of egg white powder. *Food Microbiol.* 85:103306. https://doi.org/10.1016/j.fm.2019.103306

Wei, X., S. Vasquez, H. Thippareddi, and J. Subbiah. 2021. Evaluation of *Enterococcus faecium* NRRL B-2354 as a surrogate for *Salmonella* in ground black pepper at different water activities. *Int. J. Food Microbiol*. 344:109114. https://doi.org/10.1016/j.ijfoodmicro.2021.109114

Xu, J., R. Yang, Y. Jin, G. Barnett, and J. Tang. 2020. Modeling the temperature-dependent microbial reduction of *Enterococcus faecium* NRRL B-2354 in radio-frequency pasteurized wheat flour. *Food Control* 107:106778. https://doi.org/10.1016/j.foodcont.2019.106778

Zhou, Z., S. Zuber, M. Campagnoli, T. Putallaz, F. Devlieghere, and M. Uyttendaele. 2019. Effect of mild steaming treatment on the inactivation of *Salmonella*, *Listeria monocytogenes*, *Escherichia coli* O157:H7 and their surrogates on black peppercorns. *Food Control* 106:106726. https://doi.org/10.1016/j.foodcont.2019.106726