

Surveys for Foodborne Pathogens on Nuts: Tables and References

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Table 1. Prevalence of *Salmonella* on naturally contaminated nuts

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Table 4. Prevalence of other foodborne pathogens (non-*Salmonella*) or generic *E. coli* on naturally contaminated nuts and edible seeds

Table 1. Prevalence of *Salmonella* on naturally contaminated nuts

Type of nut	Where collected	Sample size (g) ^a	No. of samples tested (n)	No. positive for <i>Salmonella</i>	Percent positive (if n>50)	<i>Salmonella</i> serotype	References
Almond, raw kernel	Processor receiving, California	100	14,949	146	0.98 ± 0.29 (for 2001–07, 2010, and unpublished)	Enteritidis, Montevideo, Senftenberg, Thompson, Typhimurium, and 36 others	Bansal et al., 2010; Danyluk et al., 2007; Lambertini et al., 2012; Harris, unpublished [2013 data]; Santillana Farakos et al., 2017
Almond, raw inshell	Processor receiving, California	100	455	7	1.5 (for 2006–07)	Give, Muenchen, Newport, Thompson, Typhimurium, IIIa:18:z32	Bansal et al., 2010
Almond, raw kernel	Processor receiving, Australia	25	60	1	1.7	Fremantle subsp. II	Eglezos et al., 2008
Almond, treated	RTE packages at processor, Australia	25	42	0			Eglezos, 2010
Almond, roasted	Retail, UK	25	83	0	0		Little et al., 2009
Almond, treated (roasted and unknown)	Retail, UK	25	359	0	0		Little et al., 2010
Almond (packaged, unpackaged, and nut product)	Retail, manufacturers and growers, Australia	25	131	0	0		NSW Food Authority, 2012

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Type of nut	Where collected	Sample size (g) ^a	No. of samples tested (n)	No. positive for <i>Salmonella</i>	Percent positive (if n>50)	<i>Salmonella</i> serotype	References
Brazil nut shelled and whole inshell	Processor	50	20	0			Arrus et al., 2005
Brazil nut, roasted	Retail, UK	25	218	0	0		Little et al., 2009
Brazil nut	Retail, UK	25	469	2	0.4	Senftenberg, Tennessee	Little et al., 2010
Brazil nut	Processor receiving, Australia	25	60	0	0		Eglezos et al., 2008
Brazil nut	RTE packages at processor, Australia	25	40	0			Eglezos, 2010
Brazil nut	Retail, Brazil	not given	two 2-kg samples, subsample size not given	not given	not given	Typhimurium	Freire and Offord, 2002
Brazil nut	Retail, manufacturers and growers, Australia	25	62	0	0		NSW Food Authority, 2012
Cashew, roasted	Retail, UK	25	130	0	0		Little et al., 2009
Cashew	Retail, UK	25	459	0	0		Little et al., 2010
Cashew	Processor receiving, Australia	25	100	0	0		Eglezos et al., 2008
Cashew	RTE packages at processor, Australia	25	45	0			Eglezos, 2010
Cashew	Retail, manufacturers and growers, Australia	25	117	0	0		NSW Food Authority, 2012
Cashew, raw shelled	Retail, US (prepacked conventional and organically grown)	375	733	4	0.55	Brunei, Give, Nima, Weltevreden	Zhang et al., 2017
Coconut, desiccated (shred, flake, flour)	Imports from Sri Lanka (Ceylon), sampled in UK	20-25 g (duplicate samples)	851	76	9.2	Paratyphi B (15/78 isolates) and 17 others	Galbraith et al., 1960

Type of nut	Where collected	Sample size (g) ^a	No. of samples tested (n)	No. positive for <i>Salmonella</i>	Percent positive (if n>50)	<i>Salmonella</i> serotype	References
Coconut, desiccated	Imports from Sri Lanka (Ceylon), sampled in Australia	not given	35	9		Paratyphi B (1/9 samples), Butantan, Edinberg, Perth	Kovacs, 1959
Coconut, desiccated	Port receiving, England	not given	8,265	479	5.8	Paratyphi B (42/479) and others	Summarized by Semple et al., 1961
Coconut, desiccated	Processing mills, Sri Lanka (Ceylon)	20	1,363	31	2.3	Paratyphi B, Typhimurium, Senftenberg, 6 others	Velaudapillai et al., 1963
Coconut	Husked nuts from 5 countries	25 ml of lactose broth rinse (from 100 ml/nut)	15	<4/shell			Kajs et al., 1976
Hazelnut, roasted	Retail, UK	25	38	0			Little et al., 2009
Hazelnut	Retail, UK	25	195	0	0		Little et al, 2010
Hazelnut	Processor receiving, Australia	25	48	0			Eglezos et al., 2008
Hazelnut	RTE packages at processor, Australia	25	51	0	0		Eglezos, 2010
Hazelnut	Retail, manufacturer, and grower, Australia	25	34	0			NSW Food Authority, 2012
Hazelnut, raw shelled	Retail, US (prepacked conventional and organically grown)	375	577	2	0.35	Escanaba, Typhimurium	Zhang et al., 2017
Hazelnut, inshell	Retail, US (prepacked conventional and organically grown)	375	80	0	0		Zhang et al., 2017
Macadamia, roasted	Retail, UK	25	14	0			Little et al., 2009
Macadamia	RTE packages, retail, UK	25	65	0	0		Little et al., 2010
Macadamia	Retail, manufacturer, and grower, Australia	25	76	1	3	Aberdeen	NSW Food Authority, 2012

Type of nut	Where collected	Sample size (g) ^a	No. of samples tested (n)	No. positive for <i>Salmonella</i>	Percent positive (if n>50)	<i>Salmonella</i> serotype	References
Macadamia	Processors	not given	93	1	N/A ^b		St. Clair and Klenk, 1990
Macadamia, raw shelled	Retail, US (prepacked conventional and organically grown)	375	355	15	4.20	Diarizonae, Florida, Gaminara, Heidelberg, Mbandaka, Orientalis, Plymouth, Shamba, Uzaramo, Worthington, II 42:r:-, IIIb	Zhang et al., 2017
Peanut, raw shelled (runner type)	Processors, US	350	10,162	68	0.67 (average for 2009–11)	Serotyping not done; PFGE indicated multiple serotypes	Miksch et al., 2013
Peanut, raw shelled	Processors, US	375	944	22	2.3	Agona, Anatum, Braenderup, Dessau, Hartford, Meleagridis, Muenchen, Rodepoort, Tennessee, Tornow, sp. C(1):m,t, sp. G(1):b;-	Calhoun et al., 2013
Peanut (raw whole 2; shelled 2)	Retail, Scotland	25	4	0			Candlish et al., 2001
Peanut, roasted	Retail, UK	25	26	0			Little et al., 2009
Peanut	Processor receiving, Australia	25	653	0	0		Eglezos et al., 2008
Peanut	RTE packages at processor, Australia	25	343	0	0		Eglezos, 2010
Peanut	RTE packages, retail, UK	25	148	0	0		Little et al., 2010
Peanut	Retail, manufacturer, and grower, Australia	25	196	0	0		NSW Food Authority, 2012
Pecan, roasted	Retail, UK	25	25	0			Little et al., 2009
Pecan	Retail, UK	25	151	0			Little et al., 2010
Pecan	Retail, manufacturer, and grower, Australia	25	12	0			NSW Food Authority, 2012

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Type of nut	Where collected	Sample size (g) ^a	No. of samples tested (<i>n</i>)	No. positive for <i>Salmonella</i>	Percent positive (if <i>n</i> >50)	<i>Salmonella</i> serotype	References
Pecan, inshell	Processors, US	25	4,641	44	0.95% (average for 2010–14)	31 serotypes, including: Braenderup (7%); Enteritidis (12%); Javiana (9%); Livingstone (5%); Newport (5%); Oranienburg (5%)	Brar et al., 2016
Pecan, raw shelled	Retail, US (prepacked conventional and organically grown)	375	623	0			Zhang et al., 2017
Pine nut, roasted	Retail, UK	25	29	0			Little et al., 2009
Pine nut, raw shelled	Retail, US (prepacked conventional and organically grown)	375	630	3	0.48	Baildon, Derby, Thompson	Zhang et al., 2017
Pistachio, raw whole	Retail, Scotland	25	2	0			Candlish et al., 2001
Pistachio, roasted	Retail, UK	25	25	1		Havana	Little et al., 2009
Pistachio (kernels only, 73; inshell, 111)	Retail, UK	25	184	0			Little et al., 2010
Pistachio	Retail, manufacturer, and grower, Australia	25	76	0	0		NSW Food Authority, 2012
Pistachio	Processor receiving, California	100	3,968	32	0.81 (average for 2010–12)	Enteritidis, Liverpool, Montevideo, Senftenberg, Tennessee, Worthington	Harris et al., 2016
Walnut	Retail, UK	25	74	0	0		Little et al., 2009
Walnut	Retail, UK	25	441	0	0		Little et al., 2010
Walnut	India (Kashmir and Jammu)	10	50	1	2	not determined	Riyaz-UI-Hassan et al., 2003
Walnut	Retail, manufacturer, and grower, Australia	25	80	0	0		NSW Food Authority, 2012

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Type of nut	Where collected	Sample size (g) ^a	No. of samples tested (n)	No. positive for <i>Salmonella</i>	Percent positive (if n>50)	<i>Salmonella</i> serotype	References
Walnut, raw inshell	Processor, California	100	935	0	0 (2010)		Davidson et al., 2015
Walnut, raw inshell	Processor, California	375	2,903	4	0.14 (average for 2011–13)	Bovismorbificans, Enteritidis, Muenchen, Saintpaul	Davidson et al., 2015
Walnut, raw shelled	Retail, US (prepacked conventional and organically grown)	375	658	8	1.22	Irumu, Montevideo, Muenchen, Oranienburg, Thompson	Zhang et al., 2017
Mixed nuts, roasted	Retail, UK	25	63	0	0		Little et al., 2009
Mixed nuts (almond, Brazil nut, cashew, peanut, walnut)	Retail, UK	25	105	1	1	Anatum	Little et al., 2010
Mixed nuts	Retail, manufacturer, and grower, Australia	25	131	0	0		NSW Food Authority, 2012
Other – 13 unpackaged nuts, seeds and snacks ^c	Retail, Turkey	10	217			<i>Salmonella</i> and <i>E. coli</i> were found in 2.77% of samples; incidence of <i>Salmonella</i> alone not given	Vural and Erkan, 2008

^a Sample size is the size of the sample that was enriched and used to determine the prevalence (percent positive samples). ^b N/A, not applicable. The study was designed to compare the performance of several methods for recovering *Salmonella* from food; samples of macadamia included in the study were from lots that had already tested positive for *Salmonella*. ^c Nuts incl. almond, hazelnut, peanut, walnut, Antep [Turkish] pistachio, and mixed nuts; seeds incl. Dakota sunflower, melon, pumpkin, and watermelon; samples also incl. roasted chickpea, sauced roasted chickpea, and sauced roasted corn.

Table 2. Prevalence of *Salmonella* on naturally contaminated edible seeds

Type of seed or product	Where collected	Sample size (g) ^a	No. of samples tested (n)	No. positive for <i>Salmonella</i>	Percent positive (if n>50)	<i>Salmonella</i> serotype	References
Alfalfa	Retail, UK	25	58	1	1.7	not given	Willis et al., 2009
Flax (linseed)	Retail, UK	25	284	1	0.4	not given	Willis et al., 2009
Hemp	Retail, UK	25	121	0	0		Willis et al., 2009
Melon	Retail, UK	25	47	4	8.5	Unnamed (47:z4,z23:-)	Willis et al., 2009
Poppy	Retail, UK	25	202	0	0		Willis et al., 2009
Pumpkin	Retail, UK	25	886	0	0		Willis et al., 2009
Sesame	Retail, UK	25	771	13	1.7	Drypool Unnamed (47:z4,z23:-)	Willis et al., 2009
Sesame	Retail, Germany	25	16	2		Offa, Tennessee	Brockmann et al., 2004
Sesame	US points of entry (country of origin not specified)	375	177	20	11	Anatum, Bonn, Cerro, Give, Glostrup, Havana, Kentucky, Idikan, Llandoff, Mbandaka, Newport, Potsdam, Senftenberg, Tennessee, Weltevreden, Westminster, 3,10:b:-, <i>S. enterica</i> subspecies arizonae serotype 48:z4,z24:-	Van Doren et al., 2013a
Sesame	US points of entry (country of origin not specified)	1500	233	23	9.9	not given	Van Doren et al., 2013b
Sunflower	Retail, UK	25	976	1	0.1	not given	Willis et al., 2009

Type of seed or product	Where collected	Sample size (g) ^a	No. of samples tested (<i>n</i>)	No. positive for <i>Salmonella</i>	Percent positive (if <i>n</i> >50)	<i>Salmonella</i> serotype	References
Other – 13 unpackaged nuts, seeds and snacks ^b	Retail, Turkey	10	217		<i>Salmonella</i> and <i>E. coli</i> were found in 2.77% of samples; incidence of <i>Salmonella</i> alone not given	not determined	Vural and Erkan, 2008

^a Sample size is the size of the sample that was enriched and used to determine the prevalence (percent positive samples).

^b Nuts incl. almond, hazelnut, peanut, walnut, Antep [Turkish] pistachio, and mixed nuts; seeds incl. Dakota sunflower, melon, pumpkin, and watermelon; samples also incl. roasted chickpea, sauced roasted chickpea, and sauced roasted corn.

Table 3. Levels of *Salmonella* in positive samples of naturally-contaminated nuts and edible seeds

Type of nut or seed	Where collected	Sample size (g)	<i>Salmonella</i> levels (MPN/g)	References
Nut				
Almond, raw kernel	Processor receiving, California	100 × 1 and 3 each: 25, 2.5, 0.25	96 samples: 0.0044 to 0.15 for 2002–06; 4 samples: 0.00080, 0.00080, 0.00095, 0.0034 for 2010 10 samples: 0.002 to 0.032 for unpublished [2013 data]	Bansal et al., 2010; Danyluk et al., 2007; Lambertini et al., 2012; Harris, unpublished [2013 data]
Brazil nut	Retail, UK	10 tube: 10	2 samples: 0.23, 0.09	Little et al., 2010
Coconut, desiccated (shred, flake, flour)	Imports from Sri Lanka (Ceylon), sampled in UK	Not given	<0.03 MPN/g	Galbraith et al., 1960
Mixed nuts (almond, Brazil nut, cashew, peanut, walnut)	Retail, UK	10 tube: 10	<0.010	Little et al., 2010
Peanut, raw shelled	Processors, US	3 tube: 10, 1, 0.1	22 samples: <0.030 to 2.4	Calhoun et al., 2013
Peanut, raw shelled	Processors, US	350 × 1 and 3 each: 100, 10, 1	65 samples: 56: 0.0020 9: 0.0048 to 0.015	Miksch et al., 2013
Pecan, inshell	Processors, US	100 × 1 and 3 each: 25, 2.5, 0.25	44 samples: <0.0047 to 0.39 for 2010–14	Brar et al., 2016
Pistachio	Processors, US	100 × 1, multiple 50, and 3 each: 5.6, 0.56	11 samples (sinkers): 0.0046 21 samples (floaters): 0.012 to 0.43	Harris et al., 2016
Walnut	Processors, US	375 × 1 and: 2 × 50 or 10 × 50 or 1 × 120	3 samples: 0.0032, 0.0038, 0.0042	Davidson et al., 2015
Seed				
Sesame	US points of entry	375 × 4 and 12 each: 100, 10, 1, 0.1	23 samples: 0.0006 to 0.042	Van Doren et al., 2013b
Mixed seeds (alfalfa, flax [linseed], melon, sesame, sunflower)	Retail, UK	10 tube: 10	<0.1 in 4/6 samples; 0.1 and 0.2 in 2/6 samples	Willis et al., 2009

Table 4. Prevalence of other foodborne pathogens (non-*Salmonella*) or generic *E. coli* on naturally contaminated nuts and edible seeds

Type of nut or seed	Where collected	Sample size (g) ^a	No. of samples tested (<i>n</i>)	Assay	References
Almond, raw kernel	Processor receiving, California	MPN (limit of detection 0.3 MPN/g)	2,718	Generic <i>E. coli</i> (2580 negative; 95 positive at 0.3 to 46 MPN/g [two samples])	Bansal et al., 2010; Danyluk et al., 2007
Almond, raw inshell	Processor receiving, California	MPN (limit of detection 0.3 MPN/g)	15	Generic <i>E. coli</i> (13 negative; 2 positive at 0.3 to 0.7 MPN/g)	
Almond, raw kernel	Processor receiving, Australia	25	60	Generic <i>E. coli</i> (none positive)	Eglezos et al., 2008
Almond, treated	RTE packages at processor, Australia	25	42	Generic <i>E. coli</i> , <i>Listeria monocytogenes</i> and coagulase-positive staphylococci (none positive)	Eglezos, 2010
Brazil nut	Processor receiving, Australia	25	60	Generic <i>E. coli</i> (none positive)	Eglezos et al., 2008
Brazil nut	RTE packages at processor, Australia	25	40	Generic <i>E. coli</i> , <i>Listeria monocytogenes</i> , coagulase-positive staphylococci (none positive)	Eglezos, 2010
Brazil nut	Retail, Brazil	not given	two 2-kg samples, subsample size not given	Generic <i>E. coli</i> , <i>Bacillus cereus</i> , and <i>Staphylococcus aureus</i> isolated from at least one sample	Freire and Offord, 2002
Cashew	Processor receiving, Australia	25	100	Generic <i>E. coli</i> (none positive)	Eglezos et al., 2008
Cashew	RTE packages at processor, Australia	25	45	Generic <i>E. coli</i> , <i>Listeria monocytogenes</i> and coagulase-positive staphylococci (none positive)	Eglezos, 2010
Coconut	Husked nuts from 5 countries	25 ml of lactose broth rinse (from 100 ml/nut)	15	Coagulase-positive staphylococci (none positive)	Kajs et al., 1976
Hazelnut	Processor receiving, Australia	25	48	Generic <i>E. coli</i> (none positive)	Eglezos et al., 2008
Hazelnut	RTE packages at processor, Australia	25	51	Generic <i>E. coli</i> , <i>Listeria monocytogenes</i> and coagulase-positive staphylococci (none positive)	Eglezos, 2010
Peanut, raw shelled (runner)	Processors, US	350	10,162	Enterohemorrhagic <i>E. coli</i> (3/10,162 positive)	Miksch et al., 2013
Peanut (raw whole 2; shelled 2)	Retail, Scotland	25	4	<i>Listeria</i> spp. and <i>Staphylococcus aureus</i> (none positive)	Candlish et al., 2001

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Type of nut or seed	Where collected	Sample size (g) ^a	No. of samples tested (<i>n</i>)	Assay	References
Peanut	Processor receiving, Australia	25	653	Generic <i>E. coli</i> (negative)	Eglezos et al., 2008
Peanut	RTE packages at processor, Australia	25	343	Generic <i>E. coli</i> , <i>Listeria monocytogenes</i> and coagulase-positive staphylococci (none positive)	Eglezos, 2010
Pistachio, raw whole	Retail, Scotland	25	2	<i>Staphylococcus aureus</i> (350 CFU/g)	Candlish et al., 2001
Walnut, raw inshell	Processor, California	375	2,903	<i>E. coli</i> O157:H7 (none positive)	Davidson et al., 2015
Walnut, raw inshell	Processor, California	MPN (limit of detection 0.3 MPN/g)	386	Generic <i>E. coli</i> (10 positive; 0.4 to 110 MPN/g)	Davidson et al., 2015
Walnut	India (Kashmir and Jammu)	10	50	<i>Staphylococcus</i> spp. (5 positive) and <i>Bacillus cereus</i> (3 positive)	Riyaz-UI-Hassan et al., 2003
Other – 13 unpackaged nuts, seeds and snacks ^b	Retail, Turkey	10	217	<i>E. coli</i> and <i>Salmonella</i> were found in 2.77% of samples; incidence of each microorganism alone not given <i>Staphylococcus</i> , <i>Micrococcus</i> , <i>Clostridium perfringens</i> , <i>Bacillus cereus</i> (negative)	Vural and Erkan, 2008

^a Sample size is the size of the sample that was enriched and used to determine the prevalence (percent positive samples).

^b Nuts incl. almond, hazelnut, peanut, walnut, Antep (Turkish) pistachio, and mixed nuts; seeds incl. Dakota sunflower, melon, pumpkin, and watermelon; samples also incl. roasted chickpea, sauced roasted chickpea, and sauced roasted corn.

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