Inactivation of Microorganisms in Nuts and Nut Pastes: Table and References

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Inactivation of microorganisms in nuts and nut pastes – published treatments

Process type	Treatment	Nut product tested	References
Chemical	Acid solutions or sprays	Almonds, Pecans, Pine nuts, Sesame seeds (tahini, hummus)	Beuchat et al., 2013; Ha and Kang, 2015; Olaimat et al., 2017a and 2017b; Pao et al., 2006; Salazar et al., 2018
	Chlorine (bleach, sodium hypochlorite)	Coconut, Hazelnuts, Pecans, Walnuts	Beuchat and Mann, 2011a; Beuchat et al., 2012; Beuchat et al., 2013; Blessington et al., 2013; Walter et al., 2009; Weller et al., 2013
	Chlorine dioxide gas	Almonds	Wihodo et al., 2005
	Cinnamon oil	Almonds	Tsai et al., 2017
	Ethanol spray(s)	Almonds	Salazar et al., 2018
	Hydrogen peroxide spray	Almonds	Salazar et al., 2018
	Methyl bromide	Almonds, Walnuts	Schade and King, 1977
	Ozone	Pistachios	Akbas and Ozdemir, 2006
	Peracetic acid	Almonds, Coconut, Hazelnuts, Pecans, Walnuts	Beuchat et al., 2012; Beuchat et al., 2013; Frelka and Harris, 2015; Pearson et al., 2018; Salazar et al., 2018; Walter et al., 2009; Weller et al., 2013
	Propylene oxide	Almonds, Cashews, Macadamias, Pecans	Beuchat, 1973; Blanchard and Hanlin, 1973; Danyluk et al., 2005; Saunders et al., 2018
Thermal	Controlled atmosphere + heat	Almonds (ground)	Cheng et al., 2017; Cheng and Wang, 2018
	Hot air (dry roasting)	Almonds, Peanuts, Pecans, Sesame seeds (and tahini)	Beuchat and Mann, 2011b; Poirier et al., 2014; Sanders and Calhoun, 2014; Torlak et al., 2013; Yang et al., 2010; Zhang et al., 2017
	Hot air + 70% ethanol spray(s)	Almonds, Pecans, Pistachios, Walnuts	Salazar et al., 2017
	Hot water	Almonds, Pecans	Beuchat and Mann, 2011a; Cuervo et al., 2016; Harris et al., 2012
	Chlorine + hot water	Pecans	Beuchat and Mann, 2011a
	Indirect heating (water or silicon oil bath)	Peanut butter, Tree nut butters (commercial: almond, almond + cashew, hazelnut)	He et al., 2011; Keller et al., 2012; Li et al., 2014; Ma et al., 2009; Shachar and Yaron, 2006; Wright et al., 2018
	Infrared heating (gas catalytic IR)	Almonds	Bingol et al., 2011; Brandl et al., 2008; Yang et al., 2010
	Distilled water + gas catalytic IR	Almonds	Bari et al., 2009

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Process type	Treatment	Nut product tested	References
	Dry roasting + gas catalytic IR	Almonds	Bari et al., 2009; Yang et al., 2010
	Electrolyzed water + gas catalytic IR	Almonds	Bari et al., 2009
	Hot water + gas catalytic IR	Almonds	Bari et al., 2009
	Ozonated water + gas catalytic IR	Almonds	Bari et al., 2009
	Superheated steam + gas catalytic IR	Almonds	Bari et al., 2010
	Infrared heating (near IR)	Almonds, Pine nuts	Ha and Kang, 2015
	Distilled water + near IR	Almonds, Pine nuts	Ha and Kang, 2015
	Lactic acid + near IR	Almonds, Pine nuts	Ha and Kang, 2015
	Infrared heating (quartz emitters)	Pistachios	Venkitasamy et al., 2017
	Dry heating + IR	Almonds, Pistachios	Venkitasamy et al., 2017, 2018
	Microwave heating (915 MHz)	Peanut butter	Song and Kang, 2016
	Moist air convection heating	Almonds	Jeong et al., 2009, 2011, 2017a
	Oil roasting	Almonds, Peanuts, Pecans, Walnuts	Abd et al., 2012; Beuchat and Mann, 2011b; Cuervo et al., 2016; Du et al., 2010; Meyer and Vaughn, 1969; Sanders and Calhoun, 2014
	Radio frequency (RF) heating	Almonds	Gao et al., 2011; Jeong et al., 2017b; Li et al., 2017; Salazar et al., 2018
	70% ethanol spray(s) + RF heating	Almonds, Pecans, Pistachios, Walnuts	Salazar et al., 2018
	Steam, saturated (≤100°C)	Almonds, Pecans, Pistachios	Ban and Kang, 2016; Ban et al., 2018; Chang et al., 2010; Lee at al., 2006
	Superheated steam (125–200°C)	Almonds, Pecans, Pistachios	Ban and Kang, 2016; Ban et al., 2018
Non-thermal	High-intensity 405-nm light	Almonds	Lacombe et al., 2016
	High pressure processing	Almonds, Peanut butter, Sesame seeds	D'Souza et al., 2012; D'Souza et al., 2014; Goodridge et al., 2006; Grasso et al., 2010; Willford et al., 2008; Wuytack et al., 2003
	Intense pulsed light (200–1100 nm)	Sesame seeds	Hwang et al., 2017
	Irradiation (electron beam)	Almonds, Peanut butter, Pecans	Cuervo et al., 2016; Duong and Foley, 2006; Hvizdzak et al., 2010; Karagöz et al., 2014
	Irradiation (gamma rays)	Almonds, Peanut butter, Walnuts, Sesame seeds	Ban and Kang, 2014; Osaili and Al-Nabulsi, 2016; Prakash et al., 2010; Wilson-Kakashita et al., 1995
	Irradiation (X-rays)	Almonds, Walnuts	Jeong et al., 2012
	Non-thermal plasma	Almonds, Pistachios	Deng et al., 2007; Hertwig et al., 2017; Niemira, 2012; Pignata et al., 2014

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