CENTER for PRODUCE SAFETY

CPS – 2009 RFP

FINAL PROJECT REPORT

Project Title

Assessing postharvest risks for *Salmonella* in pistachios

Project Period

October 1, 2009 through June 30, 2012

Principal Investigator

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Objectives

Our overall objective was to generate data to support development of scientifically-based risk-reduction strategies for the pistachio industry.

The specific objectives were:

Objective 1. To identify points during post-harvest handling of pistachios where *Salmonella* may be reduced, controlled or amplified.

Objective 2. To develop a QMRA for *Salmonella* in pistachios.

FINAL REPORT

Abstract

Foodborne illness has not been associated with consumption of pistachios, however, *Salmonella* is of general concern in low-moisture foods and ingredients. The pistachio industry is interested in an increased understanding of the microbiology of postharvest practices, with the goal of implementing appropriate *Salmonella*-control strategies. Pistachios are harvested by shaking onto catch frames, hulled under wet, abrasive conditions, separated in float tanks, and dried with hot air before further drying at ambient temperature in storage silos. During the 2010 and 2011 harvest, pistachios from multiple locations were collected from collaborating processors. General microbial loads were evaluated for these samples. Pistachios were also inoculated with *Salmonella* under laboratory conditions designed to simulate postharvest handling and storage. Data generated from these studies and collected from industry collaborators were used to develop a quantitative microbial risk assessment for pistachios. The estimated risk of foodborne illness associated with consumption of pistachios in the U.S. predicted by this model is very low based on current industry practice.

Background

Nuts and other low-moisture foods have generally been considered low risks for foodborne illness because they are consumed in a dry state where water activity (available moisture) is too low to support microbial growth. However, many foodborne pathogens can cause illness at very low concentrations, such that microbial growth is not required. In the past decade, salmonellosis outbreaks associated with consumption of raw almonds, peanut butter, and pine nuts, have been documented in the U.S. In 2009 there was a large recall of pistachios when *Salmonella* was isolated from commercial products. In 2011, *E. coli* O157:H7 outbreaks were epidemiologically-linked to consumption of inshell hazelnuts in the U.S. and walnut kernels in Canada.

As a broad group, tree nuts share many characteristics. At the onset of this research, very little was known about the ecology of foodborne pathogens in nut production and processing environments with the exception of almonds. Since then, significant research has been conducted on the pecan and walnut harvesting and postharvest handling; these data support the value in evaluating unique characteristics of the postharvest handling of different type of nuts.

The goals of this proposal were to identify points during postharvest handling of pistachios where *Salmonella* may be reduced, controlled or amplified. Building upon a previously generated and updated raw almond quantitative microbial risk assessment (QMRA) laboratory data, industry data, and expert opinion were used to construct a pistachio QMRA. The overall goal of this research was to provide data that would allow the pistachio industry to develop scientifically-based food safety risk-reduction strategies.

Research Methods and Results

Bacterial cultures. Non-pathogenic *E. coli* K12 (ATCC 10798) was used in experiments where laboratory safety was an issue such as when monitoring the moisture content and water activity (a_w) of nuts or for preliminary recovery studies on pistachios (inshell and kernels). *Salmonella enterica* serovars were as follows: Enteritidis PT 9c (RM4635; clinical isolate from 2004 raw-almond outbreak; Enteritidis PT 30 (ATCC BAA-1045; almond isolate from 2000–2001 raw-almond outbreak); Tennessee (K4643; clinical isolate from 2006–2007 peanut butter outbreak; Oranienburg (#1839; pecan isolate; Anatum (almond survey isolate); and Montevideo (GRC1; pistachio isolate).

Pistachio inoculation and recovery. Previous studies from this laboratory have validated methods used to prepare *Salmonella*-inoculated almond kernels and other researchers have adapted these methods for use in pecan kernels and walnuts. The method used for almonds was adapted for inshell pistachios and pistachio kernels. Most of the studies were conducted on inshell pistachios because the majority of pistachios are stored and consumed in this form.

Objective 1. Identify points during post-harvest handling of pistachios where *Salmonella* may be reduced, controlled or amplified.

Microbial loads in pistachios during the hulling process. For the 2010 and 2011 harvests a temporary laboratory was established on site at one of our collaborating pistachio processors. Samples were collected from three (2010) or one (2011) pistachio processing facilities to evaluate microbial loads throughout the hulling process and to collect raw materials for in-laboratory studies (Appendix A). In 2010 general microbial loads were assessed throughout postharvest handling of pistachios. Pistachio samples were collected weekly for 3 weeks during the time that facilities were operating at near capacity. The samples were collected beginning at receipt and through hulling and to initial and final drying pre- and post-silo (Appendix 1). Samples were available from facility A and C on weeks 1, 2, and 3 and from facility B on week 1. Similar microbial trends were observed among the three pistachio handlers surveyed as well among the three weeks of the study (Fig. 1). In general, APC, coliform, and presumptive *E. coli* levels were found to be the highest on the hulls discarded from the huller (6.8 ± 1.1, 5.9 ± 0.9, and 3.0 ± 1.8 log CFU/g, respectively). Similar APC and coliform counts were found on sinker and floater pistachios as well as in water collected from the float tank, indicating that this step may be a point of cross-contamination. Significant reductions in APC, coliforms, and presumptive *E. coli* were observed during drying (2.5, 2.9, and >1.0 log CFU/g, respectively, for float tank sinkers). These data were used to direct additional studies.

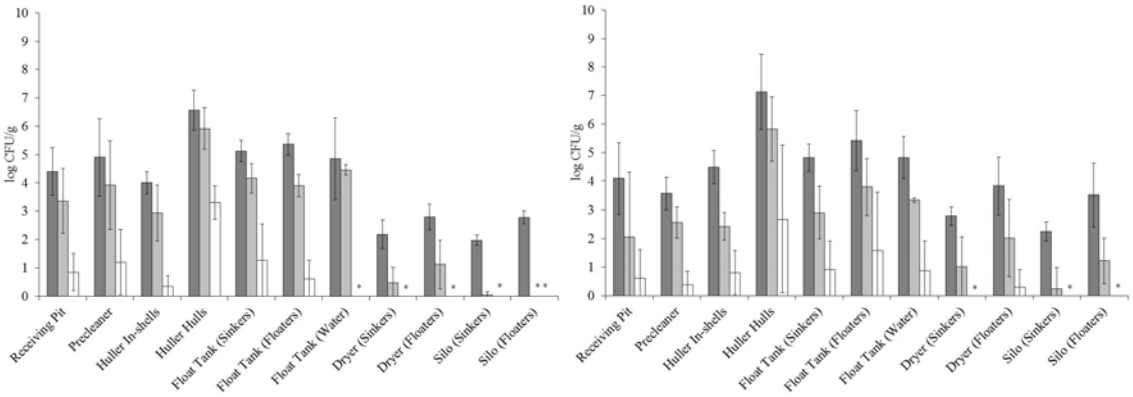


FIGURE 1. Average aerobic plate count (APC), coliform and presumptive *E. coli* levels found at handler A (left) or handler C (right) over a period of 3 weeks. Dark gray, light gray and white bars denote APC, coliforms, and presumptive E. coli, respectively. Error bars indicate standard deviation (n = 6 to 9). Asterisk (*) indicates samples were below the limit of detection (< 0.6 log CFU/g).

Temperatures in harvest trailers. Pistachios are harvested onto catchframes and then transferred to trailers for transport to the hulling facility. Under ideal conditions, the trailers are unloaded within a 3 to 4 h timeframe. However, there are circumstances where unloading is delayed (e.g., during periods of high volume or equipment breakdown. Temperature and humidity within loaded pistachio trailers was monitored (Fig. 2). Within the first 2 h the humidity in the pistachio trailers was over 90% and the temperature was above 30°C. By the end of the study (13 h) the humidity approached 100% and the temperature was near 37°C.

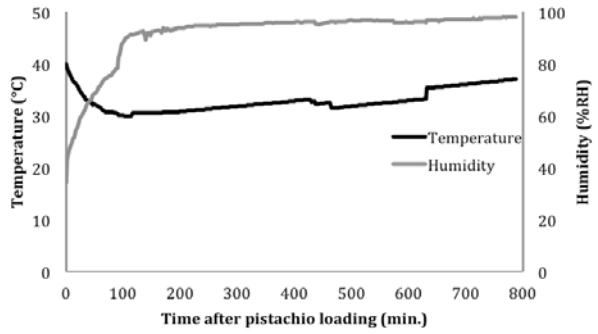


Figure 2. Average temperature and humidity in six separate loaded pistachio trailers.

Growth of *Salmonella* in in-hull pistachios. In-hull pistachios collected from the huller at the receiving (Appendix 1) were inoculated at a level of approximately 4 log CFU/g with a cocktail of *Salmonella* in the laboratory at Davis, CA. After inoculation, samples were dried briefly and then stored at 23 or 35°C and 50 or 90% RH. With the exception of 23°C and 50% RH, growth was observed within 6 but not 3 h (Fig. 2). At 35°C significant increases (2 log) were observed after 6 h with maximum populations of approximately 8 log CFU/g observed after 24 h (Fig. 3).

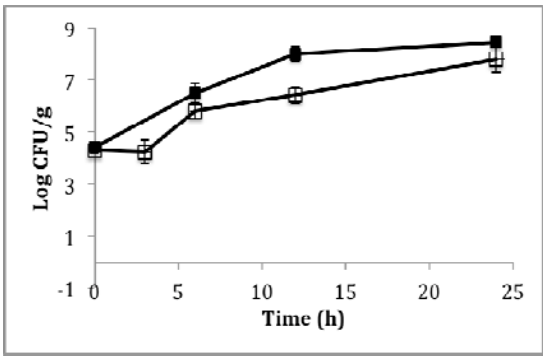


FIGURE 3. Growth of *Salmonella* on in-hull pistachios stored at 35°C and 90% RH (n=6); 2010 (solid symbol) and 2011 (open symbol).

Similar increases were seen when *Salmonella* was inoculated into fresh pistachio hulls (data not shown).

Survival of *Salmonella* in float-tank water. After hulling, pistachios are separated in a float tank. Although water in the float tank is supplemented continually, the organic load remains high. *Salmonella* was inoculated (approximately 200 CFU/ml) into float tank water at various total chlorine concentrations and ratios of well water (WW) to float tank water (FTW). The mixture was held from 1 to 30 min, the solution was neutralized and enriched for *Salmonella*. Even small volumes of FTW impacted the efficacy of total chlorine concentrations of 20 ppm (Appendix B). Higher concentrations of chlorine would need to be maintained under normal operating conditions.

Growth of *Salmonella* in pre-dryer inshell pistachios. Although drying of pistachios typically begins shortly after they leave the float tank there are circumstances where drying may be delayed (at beginning or end of the season when the dryer is not a full capacity and during equipment breakdown or power outages).

Salmonella was inoculated into high moisture in-shell pistachios collected immediately after the float tank. Inoculated pistachios were stored at 23 and 35°C and 50 and 90% RH. Very little growth was observed within the first 3 h but significant 1 to 2 log increases were observed after 6 h with maximum populations of 5 to 6 log CFU/g after 24 h (Fig. 4).

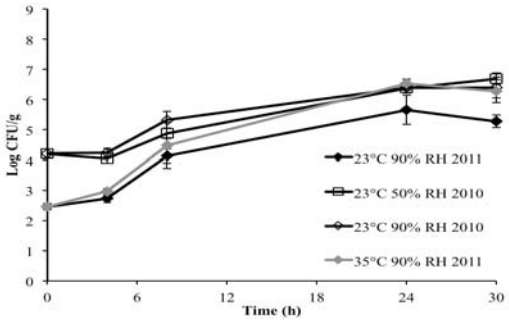


FIGURE 4. Growth of *Salmonella* on high moisture pistachios (predrying) stored at 23°C at 50% and 90% RH (2010) and 23°C and 35°C at 90% RH (2011).

Reduction of microbial loads during drying. After the float tank pistachios are dried to moisture levels below 15% (range 9 to 14%). Significant reductions of aerobic plate count and coliform levels (2.5 to 2.9 log) are observed during commercial drying (Figs. 1 and 5).

It is impossible to mimic commercial dryers (forced air, multiple stages/temperatures) under pilot or laboratory conditions, however, several approaches were taken to determine potential reductions of *Salmonella* during drying.

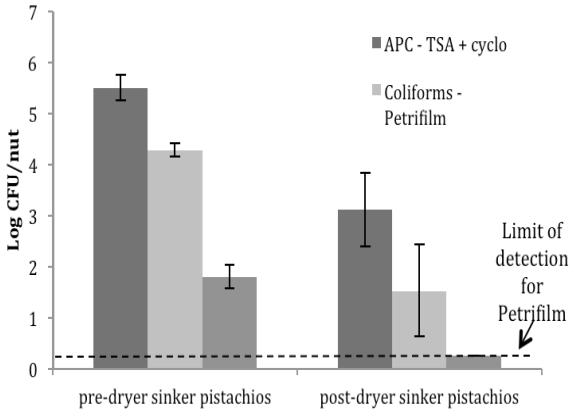


Figure 5. Aerobic plate count, coliform and presumptive *E. coli* counts before and after commercial drying, n = 6. The moisture levels were 34.5% (initial) to 10.5% (final) during an approximately 12-h of drying. Dryer settings were approximately 3-h times at 180, 160, 150, and 130°F (82, 71, 66, and 54°C).

Pre-dryer pistachios were also inoculated with either *Salmonella* or *Enterococcus faecium*, a strain standardly used as a surrogate for in the nut industry. The *Salmonella*-inoculated nuts were dried in a laboratory oven at 160°F (71°C) to a target kernel moisture of 15% (actual moisture 12 and 15%) (Appendix C). At these moisture levels the water activity was below 0.88, lower than the water activity that will support the growth of *Salmonella* (0.94). The level of *Salmonella* decreased by 3 to 4-log CFU/g during drying. These nuts were then held at ambient temperature and 50% RH for up to 28 days; after drying levels of the organism did not increase during storage.

E. faecium-inoculated pistachios were dried on-site in a drying oven with forced air (160°F) that was able to better mimic commercial drying than a laboratory oven. This organism is widely used as a surrogate for *Salmonella* in thermal validation studies for tree nuts. A 2.3 log reduction of *E. faecium* was observed within the first hour of drying (Appendix E) (whole nut moisture fell from 30 to 18%). No further reductions of *E. faecium* were observed over the next 2 h of drying. Similar to the data collected for commercially dried pistachios (Fig. 5), aerobic plate counts of uninoculated pistachios fell by 2.6 log within 2 h or drying.

Reduction of *Salmonella* on dried inshell pistachios during storage. After initial drying pistachios are transferred to silos where they are further dried with ambient forced air to moisture levels of less than 7%. Pistachios may be stored in the silos for a few days after drying to more than a year. A cocktail of *Salmonella* was inoculated onto dry inshell pistachios. Inoculated pistachios were dried to the original moisture levels and then stored at ambient, refrigerated or under frozen storage.

Time did not significantly influence ($P > 0.05$) populations of *Salmonella* during frozen or refrigerated storage. In contrast, the linear rate of decline for *Salmonella* was 0.15 log CFU/g per month at ambient storage (24°C and 38% RH) (Fig. 6). After 14 months of storage samples held at frozen and ambient temperatures were plated and 100 colonies were selected for

identification of serotypes. The relative distribution of the six serovars remained was the same under both storage conditions (Appendix D).

Pistachio moisture content and a_w during storage. The moisture and a_w values at all three storage temperatures (initial 4.4% and 0.40, respectively) remained very similar until about month 7, at which point the values began to diverge. Average moisture contents at the storage temperatures 24, 4, and −19°C were 4.2, 5.9, and 5.1%, respectively, and the average a_w values were 0.34, 0.55, and 0.46, respectively (Fig. 7).

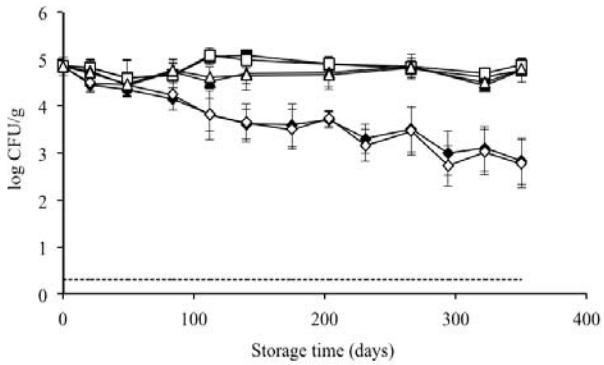


FIGURE 6. Survival of *Salmonella* on inoculated inshell pistachios stored at 24°C (diamond), 4°C (square), and −19°C (triangle). Counts were determined on TSAN+CYC (closed symbol) and BSAN+CYC (open symbol). Values are the average of triplicate samples from each of two experiments (n = 6), with standard deviation shown. Limit of detection was 0.3 log CFU/g (dashed line).

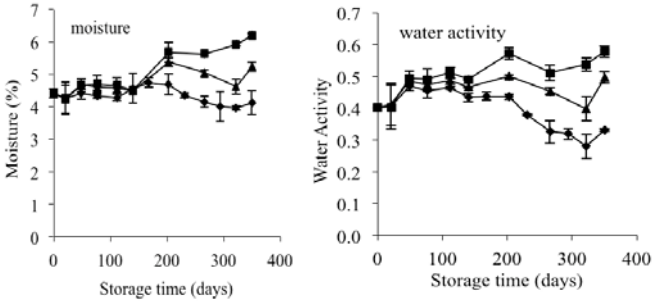


FIGURE 7. Moisture (%) and a_w of almonds and pistachios during 12 months of storage at 24°C (diamond), 4°C (square), and −19°C (triangle). Error bars indicate standard deviation (n = 6).

<u>Objective 2</u>: Develop a QMRA for *Salmonella* in pistachios.

A preliminary Quantitative Microbial Risk Assessment (QMRA) was established for North American pistachios that was based on an almond QMRA published by this group in 2011 (Lambertini et al., 2011).

For the preliminary QMRA for pistachios we used the following data:

1) Industry expert opinion and data:
   a) Estimates for portion of the crop that are floaters (kernels) and sinkers (in-shell)
      i) The data available for 2010 was used for the baseline. 122.5 million pounds (inshell weight with 50% of the weight as kernel and 50% as shell) were consumed domestically and all of these were sinkers; 14.5 million pounds were kernels of which 50% were derived from sinkers, 50% from floaters – risk assessment was run separately for the two streams and results were combined.
   b) Pistachio storage time in silos and temperature of silos (pre-process handler storage)
      i) 1 to 14 months variable temperature - 24°C used in model
   c) Post-process storage time and temperatures

    i) 1 month fixed length (62% at 4°C and 38% at 24°C)
d) Proportion of crop roasted in North American market
    i) 100% was estimated for the purposes of the risk assessment
e) Retail storage time and temperature
    i) Triangular distribution (min 1 day, maximum 6 weeks, mode 2 weeks) 24°C
f) Roaster validation data
    i) Industry blinded validation data was received for several roasters and included two types of flat bed roasters and rotary roasters. These data were modeled and portions of the crop exposed to each roaster type was estimated with industry input. The practice of double treating kernels by some companies was also estimated and evaluated.

2) Data generated in the current proposal:
    a) Concentrations in positive samples from the 2010 crop year (both floaters and sinkers)
        i) 0.71% positive (0.1 to 1.8 MPN/100 g) and 2.4% positive (0.24 to 8.0 MPN/100 g)
    b) Rates of decline of *Salmonella* in pistachios at three different temperatures (Fig. 6).

3) Data analyzed in the current proposal:
    a) 2010 prevalence data for the pistachio industry
    b) Consumer storage temperature and storage time (Lee et al., 2011)
        i) Portion consumed immediately or refrigerated or frozen (53%). Portion eaten after ambient storage (47%).
    c) Roaster validation data
        i) Validation data for each type of roaster was pooled and the data was fit to distributions for inclusion in the model.

The model predicted a mean number of cases per billion serving of less than 1 and a corresponding estimated mean number of estimated illnesses in the U.S. of less than 1 per year (Table 1). Estimated arithmetic mean cases per year increased to over 1 per year with: a two-fold increase in either prevalence or concentration or combined two-fold increase in both prevalence and concentration; leaving 1% of the crop untreated also significantly increased the number of predicted illnesses per billion servings or estimated cases per year. The overall model outputs were similar to that predicted for almonds (Lambertini et al., 2011).

Table 1. Scenario exploration. Effect of change in prevalence, concentration, or portion of untreated crop consumed on the estimated risk of illness.

Scenario	Mean (inshell) Number of cases per billion servings[a]	Mean (kernel) Number of cases per billion servings[a]	Arithmetic mean Number of cases per year	Geometric mean Number of cases per year
Baseline[b]	0.12	0.27	0.62	0.01
Prevalence (%)				
2-fold increase	0.25	0.60	1.2	0.02
10-fold increase	1.4	3.0	6.1	0.10
Concentration (MPN/100 g)				
2-fold increase	0.29	0.55	1.2	0.02
10-fold increase	1.5	3.1	6.1	0.11
Prevalence and concentration				
2-fold increase	0.45	1.1	2.5	0.04
10-fold increase	14	28	60	1.0
Percent untreated				
1%	15	56	12	0.01
5%	50	76	52	0.02
10%	90	177	100	0.03
Increase in consumption				
30%	0.14	0.27	0.25	0.01
50%	0.14	0.26	0.28	0.02
100%	0.12	0.24	0.38	0.02

[a] The total number of servings consumed per year in North America was estimated as approximately 1.2 billion (mode serving size 30 g).
[b] The baseline scenario is based on current data and industry practices.

Outcomes and Accomplishments

The outcomes of this research are described in the results section above. All objectives were met and the data generated by the laboratory research provided information used for the QMRA. The development of the QMRA would not have been possible without the collaborative efforts of Drs. Don Schaffner, Rutger's University, Michelle Danyluk, University of Florida, and Carl Winter, UC Davis. Also critical to the success of the project was the high level of cooperation among the pistachio industry. We were able to establish a temporary laboratory on-site at one pistachio handler (Nichols Farms) for two harvest seasons and were given access to a wide arrange of samples from this and two additional facilities (Paramount Farms and Horizon Nut Company). They also provided support with sample collection and access to a number of employees for discussions on research approaches, to answer questions, and for assistance with equipment set up. Dr. Bob Klein, Administrative Committee for Pistachios, collected, coordinated and blinded data provided by the industry and arranged multiple meetings with the ACP technical committee (with representatives from the entire California pistachio industry) for presentation and discussion of results. These meetings were important in elicitation of expert opinion at points in the risk assessment where data was unavailable. Also critical to the research were the large number of students (graduate and undergraduate), postdoctoral associates, and technicians who collected and processed samples, analyzed data and assisted in writing reports and publications.

Summary of Findings and Recommendations

The following summarizes the findings of this study.

1. The results of the QMRA suggest that risk of salmonellosis from consumption of pistachios is very low based on current industry practice and currently-available data. The risk assessment model can be updated as new data (e.g., prevalence and concentration) become available. However, the current model can be used to support food safety programs for the pistachio industry.
2. *Salmonella* will multiply at ambient temperatures and above in in-hull pistachios, pistachio hulls and pre-dryer pistachios. Increases in populations of *Salmonella* are minimal in the first 3 hours but can be significant after 6 h. Holding pre-dryer pistachios for long periods of time should be avoided when possible.
3. The float tank is an opportunity for cross contamination of pistachios. Further studies should evaluate means to reduce this potential (e.g., by treating the wash water with antimicrobials that are maintained at an appropriate active level; by applying a rinse after the pistachios leave the float tank).
4. Microbial populations are reduced in the dryer by approximately 2 to 3 log CFU/g. Most of the reduction occurs in the initial stages of drying. Greater reductions in the dryer may be possible with optimization of the drying times/temperatures. The potential for recontamination after the dryer should be considered.

APPENDICES

Publications and Presentations (required)

The following publications were funded, in part, by this grant:

Kimber, Martha. 2011. Changes in total aerobic, coliform, and presumptive *Escherichia coli* counts on pistachios during postharvest handling and survival of *Salmonella* spp., *Escherichia coli* O157:H7, and *Listeria monocytogenes* on almond kernels and inshell pistachios. M.S. Thesis, UC Davis (available from the UC Davis library).

Lambertini, E., M.D. Danyluk, D.W. Schaffner, C.K. Winter, and L.J. Harris. 2011. Risk of salmonellosis from consumption of almonds in the North American market. Food Res. Int. doi:10.1016/j.foodres.2011.05.039.

The following published abstracts and their poster presentations were funded, in part, by this grant:

Lambertini, E., M.D. Danyluk, D.W. Schaffner, C.K. Winter, and L.J. Harris. 2011. Risk of salmonellosis from consumption of almonds in the North American market. American Society for Microbiology, New Orleans, LA, May 21-24 (Abstract 4512).

Kimber, M.A., and L.J. Harris. 2011. Changes in total aerobic and coliform counts on pistachios during postharvest processing. Institute of Food Technologists, New Orleans, LA, June 11-14 (Abstract 199-06).

Kaur, H, M. Kimber, M.D. Danyluk, and L.J. Harris. 2011. Long-term survival of *Salmonella* spp., *Escherichia coli* O157:H7, and *Listeria monocytogenes* on inoculated almonds and in-shell pistachios at three storage temperatures. IAFP Annual Meeting, Milwaukee, WI. (P3-114).

Morales, V.M., H. Kaur, I.Y. Zhao, and L.J. Harris. 2011. Behavior of inoculated *Salmonella* spp. in postharvest pistachio handling. IAFP Annual Meeting, Milwaukee, WI. (P3-115)

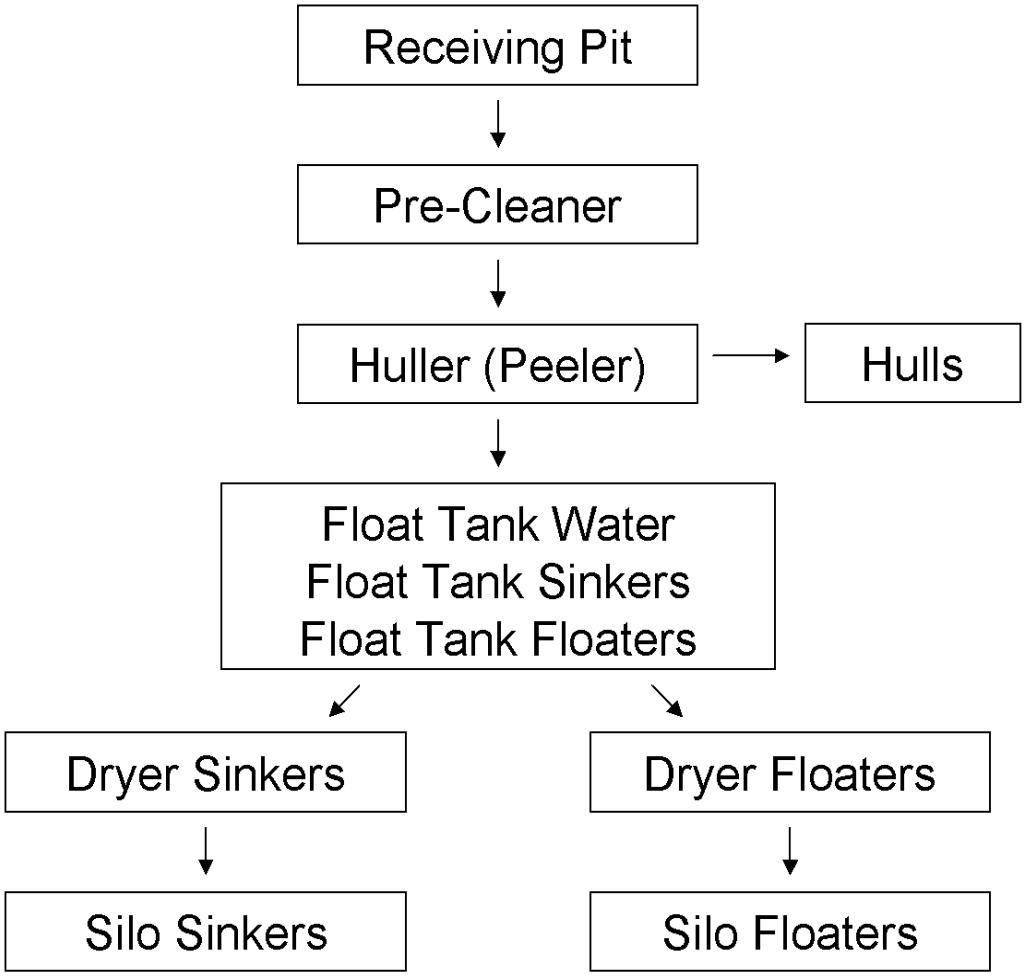
Budget Summary (required)

The funds expended were for salary and benefits for Chris Theofel (preliminary data for fall trial in 2009, fall trial 2010, 2011) and Rama Devadi (preliminary data for fall trial and inoculation study), Elisabetta Lambertini (microbial risk assessment), Chris Theofel (dry roasting and field support) and Susan Geiger (for field support 2010), Neha Dhawan (inoculation studies in the laboratory) and Vanessa Morales (for inoculation studies in the laboratory and fall trial 2010 and 2011), Martha Kimber (for coordination of the field work and inoculation studies in 2010 and for long-term survival study 2010-2011), and Luxin Wang for determination of *Salmonella* serovar distribution in stored pistachios. Several undergraduate students were also paid for their support in media preparation and laboratory analysis.

Travel expenses have been used to travel to Fresno to attend industry advisory committee meetings and for travel to the processing facilities (Hanford, Lost Hills, Visalia area) for collecting and analyzing samples. In addition, travel funds have been used to facilitate meetings between collaborators Danyluk (University of Florida) and Schaffner (Rutger's University). Note that UC Davis charges car rental and gas from fleet services to the "supply" category rather than to "travel".

Supply expenditures have been used for media and disposables used for microbiological analysis, rent on the trailer for the temporary laboratory facilities in 2010 and 2011.

Tables and Figures (optional)



Appendix A. Flow chart of postharvest handling of pistachios. Samples were collected for this study at each of the locations indicated in the diagram.

Appendix B. Survival of *Salmonella* in float tank water with varying levels of chlorine (A) 2010 data (n=2) and (B) 2011 data (n=6). *Salmonella* was inoculated at a level of approximately 200 CFU/ml. Positive symbol indicates that *Salmonella* was detected in the sample after the treatment times and chlorine concentrations indicated.

		Treatment time				
Sample	Total Sodium Hypochlorite (ppm)	1 min	5 min	10 min	20 min	30 min
WW	0	+ + + + + +	+ + + + + +	+ + + + + +	+ + + + + +	+ + + + + +
FTW	0	+ + + + + +	+ + + + + +	+ + + + + +	+ + + + + +	+ + + + + +
WW	10	+ - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -
WW	20	- - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -
1:9 FTW:WW	9	+ - - - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -
1:9 FTW:WW	18	+ - + - - -	- - - - - -	- - - - - -	- - - - - -	- - - - - -
5:5 FTW:WW	5	+ + + + + +	+ + + + + +	+ + + + + +	- + - - + -	- - - - - -
5:5 FTW:WW	10	+ + + - - -	+ + + - - -	+ + + - - -	+ + + - - -	- - + - - -
9:1 FTW:WW	1	+ + + + + +	+ + + + + +	+ + + + + +	+ + + + + +	+ + + + + +
9:1 FTW:WW	2	+ + + + + +	+ + + + + +	+ + + + + +	+ + + + + +	+ + + + + +

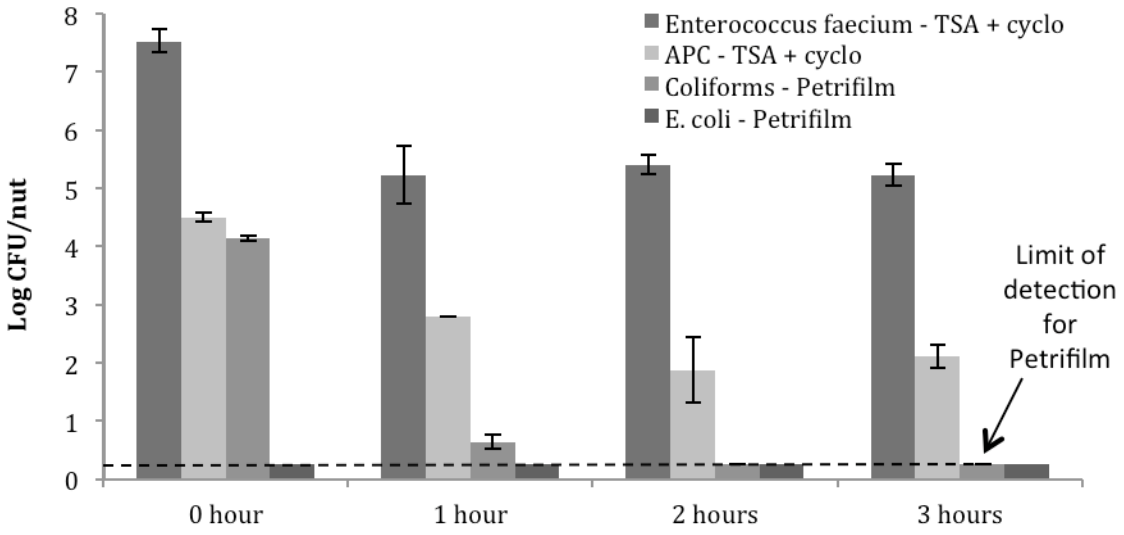
Appendix C. Moisture and water activity and counts of *Salmonella* on in-shell pistachios after drying in a laboratory oven at 160°F (71°C) (n=6).

Time	2010				2011			
	Moisture	Water Activity	Log CFU/g (positive 10-g enrichments)		Moisture	Water Activity	Log CFU/g (positive 10-g enrichments)	
Pre-dry	49	0.99	8.2	4.2	45.0	0.98	8.1	4.1
Post-dry	15	0.86	4.3	<0.3 (6/6)	12.0	0.83	5.3	<0.3 (6/6)
1 day	10	0.71	4.3	<0.3 (6/6)	12.0	0.76	5.9	<0.3 (6/6)
5 days	7	0.56	3.8	<0.3 (6/6)	ND	ND	ND	ND
7 days	ND	ND	ND	ND			5.6	<0.3 (6/6)
14 days	ND	ND	ND	ND	7.0	0.56	4.9	ND
28 days	ND	ND	ND	ND	6.0	0.48	3.8	ND

ND, Not done.

Appendix D. Distribution of *Salmonella* serovars among 100 colonies isolated pistachio samples after storage for 14.5 months at −19 or 24°C

Salmonella serovar	Original inoculum (log CFU/ml)		Pistachio kernels (no. of isolates)	
	TSA	BSA	−19°C	24°C
Anatum	7.7 ± 0.1	7.8 ± 0.1	13	16
Enteritidis PT 9c	7.8 ± 0.1	7.8 ± 0.1	29	33
Enteritidis PT 30	7.2 ± 0.1	7.8 ± 0.1	11	12
Montevideo	7.7 ± 0.0	7.8 ± 0.1	22	20
Oranienberg	7.4 ± 0.1	7.4 ± 0.1	0	0
Tennessee	7.8 ± 0.1	7.8 ± 0.1	25	19
Total	NA	NA	100	100



Appendix E. Survival *E. faecium* (n=6), aerobic plate count, coliforms and presumptive *E. coli* on freshly harvested sinker pistachios during drying in a pilot scale forced air dryer set at 160°F (72°C). After 0, 1, 2, and 3 h of drying, moisture levels were 30, 18, 16, and 11%, respectively.

Suggestions to CPS (optional)
None.