Maintaining Quality of Bulk-handled, Unhulled Pistachio Nuts

J. F. Thompson, T. R. Rumsey, M. Spinoglio

Abstract. *Laboratory studies revealed that staining of pistachio nut shells increases with increasing temperature and increasing holding times. Unhulled pistachio nuts varied in their susceptibly to staining. Some nuts can be held for more than 32 h at 40°C without increases in shell staining, others are damaged after only 16 h. In solid-sided bulk trailers unhulled pistachio nuts were shipped to the processor with no average increase in shell staining. Nuts can cool in highway transport, particularly if they are shipped in pallet bins, mesh-sided trailers, or solid sided trailers with vent pipes. Highway transport can be a method of cooling nuts if processing equipment breakdowns cause hulling delays.*
Keywords. *Postharvest, Transportation, Processing.*

Pistachio nuts are harvested with a shake-catch system and shipped in bulk to a processing facility, where their green, fleshy hull is removed and the nuts are dried in-shell (Crane, 1979). In California, shipping times vary from one to eight hours and loads may be held for a number of hours at the processor before unloading. Unhulled pistachios are traditionally shipped from the orchard to the processor in wood pallet bins, but these are expensive to purchase and handle. Some farming operations are reducing costs by shipping in hopper-bottomed trailers, designed for grain and other bulk materials. Growers and processors are concerned that the unhulled nuts may heat more in the large trailers compared with the smaller pallet bins, causing nuts to lose value because of an increase in shell staining. This may be a problem particularly when hulling equipment breaks down and the nuts remain in the parked trailers at the processor.

The bin handled nuts are placed in the bins as they are collected by the harvester. A new handling system uses a self-propelled shuttle wagon to transfer the nuts from the harvester to the bulk highway trailer. The wagon uses open augers to move the nuts and the auger tears the hull. Growers are also concerned that hull damage may contribute to shell staining compared with the more gentle, traditional handling system.

The objectives of this project were to: (1) in laboratory tests, determine the effects of temperature, holding time, and hull condition on shell staining; (2) measure the temperature history of unhulled pistachio nuts that are transported and held temporarily in bulk trailers; (3) measure quality changes of the nuts in commercial transport and holding; and (4) evaluate methods of keeping nut temperatures below damaging levels.

Literature Review

Several investigators have shown that high moisture agricultural products heat when held in parked transport vehicles and air flow induced by transport or by fans can be used to cool them. Brusewitz et al. (1973) measured temperature rises of 0.09 to 0.43°C h^{-1} in stationary truck loads of undried peanuts held at night. Loads in trucks with hardware cloth covered frames cooled 8.3°C and solid bed trucks with fan ventilation cooled 14.3°C while being held over night. Wilhelm et al. (1975), Wilhelm and Jones (1977), and Wilhelm (1979) found that fresh snap beans could be cooled in transit with an air duct system. Air entered through a duct entrance installed above the trailer. Air was distributed through a screen-covered, lengthwise duct at the bottom of the bulk trailer. Slat sided trailers provided some cooling along the top and sides of the load and solid sided trailers allowed very little cooling in transport. At night, parked, solid-sided trailers caused bean heating rates of 0.4 to 0.9°C h^{-1}. Williamson and Smittle (1978) observed that stationary bins of shelled southern peas heated and ventilation systems could be used to cool them. In laboratory tests, Prussia and Shewfelt (1985) measured heating rates of 0.3 to 0.6°C h^{-1} for non ventilated, shelled southern peas and found that an air flow rate of 0.037 $m^3\ s^{-1}\cdot m^{-2}$ for a 1.6 m product depth would remove the heat of respiration. Studies with all three commodities have shown quality loss associated with prolonged exposure to conditions found in bulk handling.

Wilhelm et al. (1975) calculated that most of the heating of bulk snap beans was due to respiration. Toumadje et al. (1980) reported a maximum respiration rate of 125 $mLCO_2\ kg^{-1}\cdot h^{-1}$ at 20°C for unhulled kerman pistachio nuts with kernels. This is equivalent to 1.3 $kJ\ kg^{-1}\cdot h^{-1}$. Nuts without kernels had rates of 23 to 27 $mLCO_2\ kg^{-1}\cdot h^{-1}$. Assuming no heat transfer out of a mass of unhulled pistachio nuts, all nuts have kernels, and a specific heat of 2.0 $kJ\ kg^{-1}\cdot°C^{-1}$, this level of respiration would produce a heating rate of about 0.7°C$\cdot h^{-1}$.

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Laboratory tests done by Kader et al. (1978), indicated that unhulled pistachio nuts are subject to increased shell staining if they are held at 25°C for more than 48 h. Nuts held at 30°C for more than 18 h experienced substantial increases in shell staining. Incidence of visible decay increased when nuts were held for more than 24 h before hulling. No data has been published on the temperature conditions of pistachios during transport and temporary storage in transport vehicles.

Procedures

Laboratory Tests

Two seasons of laboratory tests were conducted to determine how pistachio shell staining is effected by: (1) holding time between harvest and hulling (up to 48 h); (2) nut temperature (25°, 30°, and 40°C); (3) nut maturity; and (4) hull condition associated with gentle or rough handling in the orchard. In 1992, nut samples were collected three times during the season, each from different orchards. Gently handled and roughly handled nuts were collected from the same orchard for the last two tests. Gently handled nuts were collected from the harvester before they were loaded into a shuttle wagon. Roughly handled nuts were collected in the highway trailer after the hulls had been subjected to the damage done by the shuttle wagon augers and a trailer loading elevator. In 1993, nuts were collected from a group of trees on three dates in order to determine the effect of nut maturity on staining susceptibility. Within a few hours after harvest, nuts were placed in one-gallon glass jars which were held in controlled temperature cabinets. Two, 200-g samples for each treatment were taken at the beginning of the tests and at 8- to 10-h intervals thereafter. Nut samples were hulled with an abrasive huller (commercial vegetable peeler) and dried with room temperature air. Shell quality, including proportions of nuts that were split and dark stained (dark brown, dark gray or black discoloration on at least one-eighth of the shell surface), split and light stained (yellow to light gray or brown discoloration on one-eighth of the shell surface), split and unstained, and non split, was evaluated by an expert panel of Dried Fruit Association (DFA) graders, using USDA standards (Anon., 1986).

Transport Tests

Tests were conducted to determine the temperature history and quality loss of unhulled pistachios during commercial shipment. During the 1992 season, eight, solid-sided, hopper-bottomed, 12 Mg capacity, trailer loads of nuts were monitored with 16 temperature sensors to determine nut temperature in transport and during holding prior to hulling. One thermocouple measured air temperature and the other 15 were positioned to measure a temperature distribution along a vertical transect, lengthwise or side-to-side within the load. Temperatures were recorded every 15 min using a Campbell Scientific CR21X logger. The monitored trailer was always the rear of a two trailer load and had 0.6 m high extension walls. A flat-bed trailer, holding twenty-four, 0.6-m high × 1.2 × 1.2-m horizontal dimension wood, pallet-bins of nuts was also monitored. Bins were made of plywood with six, 13 mm × 0.5 m vents cut into each side. Bins were stacked two high and two across on the trailer. Center temperatures of six randomly selected bottom and six randomly selected top bins were measured. Three, 9-kg quality samples were collected as each shipment was loaded and three, 9-kg samples were placed in mesh bags and put in the center of the trailer load or pallet bin. They were collected when the vehicle was unloaded. The trailers traveled about 400 km at highway speeds (85 to 95 km h^{-1}) from the orchard to processing facility and were uncovered during the trip. Nut quality samples were hulled in a sample huller, dried and evaluated in the same manner as the lab samples. Samples at unloading were dried in a heated air dryer.

In 1993, we tested hopper-bottomed trailers modified to increase transit cooling. Solid wall trailers were fitted with vertical air ducts and we tested trailers with expanded metal side walls (fig. 1). Effectiveness was measured by monitoring 9 or 10 center line load temperatures during transit. No quality samples were collected.

Results and Discussion

Laboratory Tests

Gently handled pistachio nuts varied in the holding time required for shell staining to develop. The 1992 tests showed that significant increases in dark staining could occur at 32 h with a 25°C holding temperature, at 24 h with a 30°C holding temperature and at 16 h with a 40°C

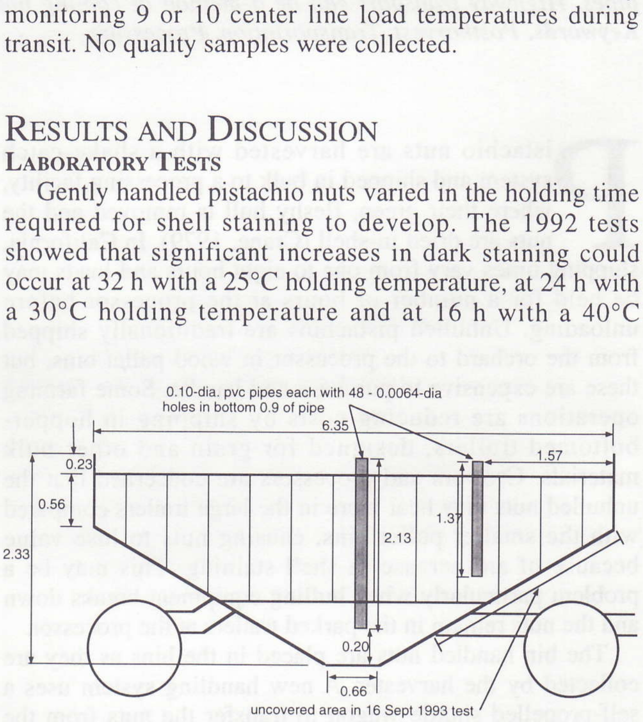

Figure 1–Schematic side view of trailers modified for improved air flow through the load.

Table 1. Laboratory evaluation of dark staining damage for gently handled pistachio nuts (1992)

1992 Tests		Dark Staining (% Total Sample Mass Basis)*						
		Holding Time (h)						
Temp.	Test No.	0	8	16	24	32	40	48
25° C	1	0.44	0.98	0.74	0.24	0.23	0.0	0.44
	2	0.68	0.48	0.93	1.6	2.7	2.2	
	3	1.3	2.1	2.5	5.7	15.1†		
30° C	1	0.44	0.27	0.44	0.11	0.24	0.87	0.38
	2	0.68	0.77	1.1	2.9	2.9	4.3†	
	3	1.3	1.6	3.2	12.3†	23.6†		
40° C	1	0.44	0.43	0.74	0.33	0.97	1.6†	4.4†
	2	0.68	1.6	3.6†	2.6	3.7†	10.6†	
	3	1.3	7.0	24.1†	17.1†	31.4†		

* Open cell indicates no data collected.

† Indicates damage level is statistically greater than the quality of the nuts held for 0 h using Fisher's PLSD, α = 0.05.

holding temperature (table 1). However, the data were variable and nuts used in the first test were less subject to staining damage compared to the later two tests. No statistically significant light staining occurred in tests at 25°C (table 2). At 30° and 40°C light stain increases were detected as early as 32 h.

There was a tendency for nuts to have lower light staining levels as dark staining levels increased over time. The dark stain damage may have masked the light stain damage because a nut is graded as dark stained if more than one-eighth of nut shell has a dark color without regard to any amount of light staining on the rest of the shell. Dark staining causes pistachio nuts to have very little commercial value, while light staining only slightly decreases the price paid to growers for their product.

Like gently handled nuts, roughly handled nuts developed stains faster at higher temperatures (tables 3, 4). There was a trend for roughly handled nuts to develop light staining faster than gently handled nuts, but it was not consistent in all tests and at all temperatures. They can be safely held for at least 24 h at 25°C and will be damaged in less than 16 h if held at 40°C.

The 1993 tests which lasted for 20 h showed no statistically significant increase in either light or dark staining when nuts were held at 25° or 40°C (tables 5, 6). There was a trend for the later harvested nuts to have higher initial levels of light and dark staining. Rate of staining was not noticeably affected by harvest date.

The DFA quality analysis includes the percentage of nuts with split shells. This was not affected by holding time, holding temperature, initial quality, or harvest handling (data not presented).

The two years of laboratory tests indicate that unhulled pistachio nuts can be held for at least 20 h at 25°C without significant increases in light or dark shell staining. At 40°C damage can occur in less than 16 h.

Table 2. Laboratory evaluations of light staining damage for gently handled pistachio nuts (1992)

1992 Tests		Light Staining (% Total Sample Mass Basis)*						
		Holding Time (h)						
Temp.	Test No.	0	8	16	24	32	40	48
25° C	1	0.26	0.0	0.43	0.18	0.0	0.26	0.13
	2	6.2	8.2	7.1	6.4	10.4	7.4	
	3	30.9	28.2	30.8	23.6	16.7		
30° C	1	0.26	0.0	0.2	0.2	0.4	0.5	1.6
	2	6.2	5.0	5.8	4.6	12.7†	11.9†	
	3	30.9	25.9	28.0	22.6	9.9		
40° C	1	0.26	0.5	5.1	0.78	4.5	10.2†	11.2†
	2	6.2	7.5	7.9	10.0	12.1†	14.7†	
	3	30.9	28.7	14.5	13.5	5.6		

* Open cell indicates no data collected.
† Indicates damage level is statistically greater than the quality of the nuts held for 0 h using Fisher's PLSD, $\alpha = 0.05$.

Table 3. Laboratory evaluation of dark staining damage for roughly handled pistachio nuts (1992)

1992 Tests		Dark Staining (% Total Sample Mass Basis)*					
		Holding Time (h)					
Temp.	Test No.	0	8	16	24	32	40
25° C	2	0.59	0.52	1.2	0.47	2.2	1.7
	3	0.88	0.52	0.85	3.2	6.5	
30° C	2	0.59	0.62	2.0	4.1	4.6†	10.3†
	3	0.88	3.8	3.0	13.9†	29.8†	
40° C	2	0.59	0.17	4.6†	6.3†	16.1†	35.7†
	3	0.88	0.71	6.9	28.3†	49.7†	

* Open cell indicates no data collected.
† Indicates damage level is statistically greater than the quality of the nuts held for 0 h using Fisher's PLSD, $\alpha = 0.05$.

Table 4. Laboratory evaluation of light staining damage for roughly handled pistachio nuts (1992)

1992 Tests		Light Staining (% Total Sample Mass Basis)*					
		Holding Time (h)					
Temp.	Test No.	0	8	16	24	32	40
25° C	2	6.4	9.1	13.7	12.8	11.9	17.6†
	3	18.8	21.0	18.7	23.5	27.9	
30° C	2	6.4	8.8	9.1	10.3	15.8†	23.4†
	3	18.8	22.0	21.1	23.5	17.0	
40° C	2	6.4	12.8	15.7†	17.4†	23.0†	14.3†
	3	18.8	23.1	24.8	13.2	3.9	

* Open cell indicates no data collected.
† Indicates damage level is statistically greater than the quality of the nuts held for 0 h using Fisher's PLSD, $\alpha = 0.05$.

Transport Tests

The 1992 bulk trailer monitoring data (table 7) show that transit time for nine loads ranged from 5.0 to 7.8 h. These times are close to the maximum expected in the state since we worked with two ranches that are very far from their processing facilities. Holding time at the plant before dumping ranged from 1.8 to 7.8 h. Shortest total time that the unhulled nuts were in a trailer was 6.8 h and longest was 14.2 h. Industry representatives indicate that nuts are

Table 5. Laboratory evaluation of dark staining damage for gently handled pistachio nuts (1993)

1993 Tests		Dark Staining (% Total Sample Mass Basis)*		
		Holding Time (h)		
Temp.	Test No.	0	10	20
25° C	1	0.11	0.12	0.31
	2	0.60	0.62	0.71
	3	1.1	1.1	0.71
40° C	1	0.11	0.14	0.37
	2	0.60	0.77	1.3
	3	1.1	0.46	0.97

* None of the quality loss data were statistically significant different using Fischer's PLSD, $\alpha = 0.05$.

Table 6. Laboratory evaluations of light staining damage for gently handled pistachio nuts (1993)

1993 Tests		Light Staining (% Total Sample Mass Basis)*		
		Holding Time (h)		
Temp.	Test No.	0	10	20
25° C	1	0.0	0.11	0.17
	2	0.98	0.65	0.74
	3	2.9	1.8	1.8
40° C	1	0.0	0.17	0.27
	2	0.98	0.74	1.8
	3	2.9	1.8	2.6

* None of the quality loss data were statistically significant different using Fischer's PLSD, $\alpha = 0.05$.

Table 7. Transport and wait times for September 1992 pistachio transport tests

Test Number*	Date	Time from Field to Plant (h)	Wait Time at Plant (h)	Time on Truck (h)
1	5	5.0	1.8	6.8
2†	5	6.2	7.2	13.5
3	7	5.8	3.5	9.2
4	7	5.2	6.0	11.2
5	9	7.8	4.0	11.8
6	7	7.8	6.0	13.8
7	11	6.8	7.5	14.2
8†	11	6.2	6.5	12.8
9	16	5.2	1.0	6.2

* Tests 1 through 8 in bulk trailer, Test 9 in bins.
† Data logger failed to record temperatures on Tests 2 and 8.

Table 8. Temperature summary for 1992 pistachio transport tests

Test No.	Avg. Initial Temp. (°C)	Max. Arrival Temp. (°C)	Max. Final Temp. (°C)	Max. Temp. Increase (°C)	Avg. Ambient Temp. (°C)	Avg. Wet Bulb Temp. (°C)
1*	27‖	34	36	9	32	16††
3	26	31	31	5	34	13
4	32	38	40	8	26	13
5	24	32	35	11	32	15
6†	34	39	41	7	24	15
7	22	31	30	9#	26	16
9‡	30	28	28	7**	31	15
9§	26	26	26	3**	31	15

* Temperatures tests 1-5 in plane parallel to long axis along center of trailer.
† Temperatures tests 6-7 in plane perpendicular to long axis at center of trailer.
‡ Bins harvested 9/15/92. A 8° temperature gradient (28°C at top to 20°C at bottom) developed as these bins sat on the ground over night.
§ Bins harvested 9/16/92.
‖ Usual spread for initial temperatures was 1 to 2°C.
\# Maximum temperature increase occurred 5 h after start of travel.
** Maximum temperature increase occurred 2 h after start of travel.
†† 24 h mean for date based on data near processor (Firebaugh, Calif.).

rarely held in a trailer longer than this unless there is an equipment breakdown at the processing facility.

The initial load temperatures (table 8) were close to the air temperature of the nuts at the time of harvest. Tests 1, 3, 5, and 7 were loaded at 10:00 to 11:00 A.M. and initial nut temperature ranged from 22° to 27°C. Tests 4 and 6 were loaded from 2:00 to 13:00 P.M. and had initial temperatures of 32° and 34°C. Maximum temperature in individual trailers at unloading ranged from 30° to 41°C. Average wet bulb temperatures during the tests ranged from 13° to 16°C, indicating that was a great potential for evaporative cooling if outside air could have been forced through the product.

Quality analyses (table 9) showed that in eight shipments, bulk trailers did not cause an average increase the light or dark staining. This fits well with the laboratory data because maximum load temperatures were usually below 40°C and nuts were in trailers for less than the 16 h that caused damage in the 40°C laboratory tests.

In 1993, we evaluated nut cooling caused by several methods of increasing air flow through nut trailers when they were hauled at highway speeds (about 95 km h^{-1}). Cooling effect was measured by determining the temperature change rate for the first 1.3 to 2 h of transport. The 1993 test

Table 9. Nut quality analyses for September 1992 pistachio transport tests

Test	Date	Time	Trailer Time (h)	Initial Quality (% of Total Mass): Light Stain	Dark Stain	Split Nuts	Quality Change after Shipping (Increase in %)*: Light Stain	Dark Stain	Split Nuts
Bulk	5	am	6.8	1.2	0.34	78.2	0.67	–0.15	0.54
	5	pm	13.5	0.54	0.53	79.9	–0.54	1.1	2.6
	7	am	9.2	0.69	0.75	82.2	0.33	–0.43	–2.1
	7	pm	11.2	0.57	0.57	82.7	–1.2	–0.53	2.3
	9	am	11.8	1.1	1.1	89.2	–0.22	0.20	–2.0
	9	pm	13.8	1.5	1.0	87.5	–0.26	0.34	–0.38
	11	am	14.2	1.1	0.62	91.4	0.33	–0.17	–2.7
	11	pm	12.8	1.0	1.5	89.1	0.28	–0.16	–0.49
Bin	15	pm	6.2	4.6	6.4	72.1	–1.34	3.5	5.2
	16	pm	6.2	4.0	7.8	74.7	–2.2	3.7	–0.9

* None of the quality loss data were statistically significant different using Fischer's PLSD, α = 0.05.

Table 10. Pistachio temperature change during first 1.3 to 2.0 h of transport

Test No.	Date	Trailer Description (Side Wall/Extensions/ Position/Special Test)	Avg. Nut Temp. Change (°C h)	Standard Deviation of Nut Temp. Change (°C h)	Wet Bulb Temp. - Initial Nut Temp. (°C)
1	5 Sept. 92	Solid/yes/rear	0.1	1.4	11
3	7 Sept. 92	Solid/yes/rear	–0.4	1.4	9
4	7 Sept. 92	Solid/yes/rear	–0.6	1.8	12
5	9 Sept. 92	Solid/yes/rear	0.3	1.1	7
1	14 Sept. 93	Solid/no/rear	–0.3	4.4	12
1	14 Sept. 93	Solid/no/front	–1.8	3.4	14
2	15 Sept. 93	Solid/no /front/pipes	–2.1	2.2	11
3	16 Sept. 93	Mesh/no/front/tarp*	–1.8	3.1	12
3	16 Sept. 93	Mesh/no /rear*	–2.1	1.8	11
1	16 Sept. 92	Pallet bins	–3.1	2.7	11

* Nuts transported on 16 Sept. 1993 were roughly handled all other tests were with gently handled product.

loads traveled less than 2 h from field to processing facility. Table 10 shows the 1993 test results and the temperature data from the 1992 tests for comparison. (Only four tests in 1992 had complete temperature records.)

The solid-sided trailers used in 1992 caused nut temperature to drop by an average of only 0.15°C h^{-1}. Figure 2 shows a typical pattern of ambient and load temperatures in the center of a trailer at four elevations. Nuts in the top of the load cooled, while nuts deeper in the

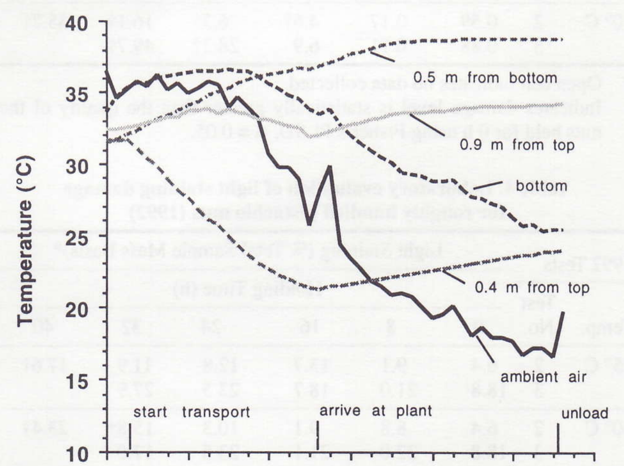

Figure 2–Temperatures in the center of a hopper-bottomed trailer of unhulled pistachio nuts, test 4, 1992.

load warmed during transport. Air flowing over the load in solid-sided trailer induces very little air flow through the load except in the top half meter of product.

The 1993 tests showed that nut cooling in transport appears to be influenced by trailer position, but not by the use of wall extensions. A single test of a front solid-sided trailer (14 Sept. 93) cooled at a rate of 1.8°C h^{-1}, far greater than any of the five tests with a rear trailer. The first 1993 shipment had a rear trailer with no extensions and it had a temperature loss rate of 0.3°C h^{-1}. This is within the range of the 1992 tests, suggesting that the wall extensions on rear trailers did not influence transit cooling.

The high standard deviations of the temperature change indicate that all loads had areas where the nuts warmed in transit. An improved trailer design would eliminate the locations within trailers that had nut heating. The top graphic in figure 3 shows the distribution of temperature change in a front and rear solid-sided trailer load. Shaded areas have temperature increases during the first two hours of transport. Although installing ventilation pipes in a solid-sided trailer increased the average cooling rate only slightly, it reduced the portion of nuts that heated in transport. Only nuts in the bottom and bottom rear of the trailer warmed during transit. Although we did not test it, installing pipes in the back quarter of the trailer may have cooled nuts these locations.

The mesh-sided trailer test on 16 Sept. 1993 had substantial temperature decreases in all locations except the bottom center of the trailer. The hulls of the pistachios in this test were thoroughly damaged by harvesting equipment. A

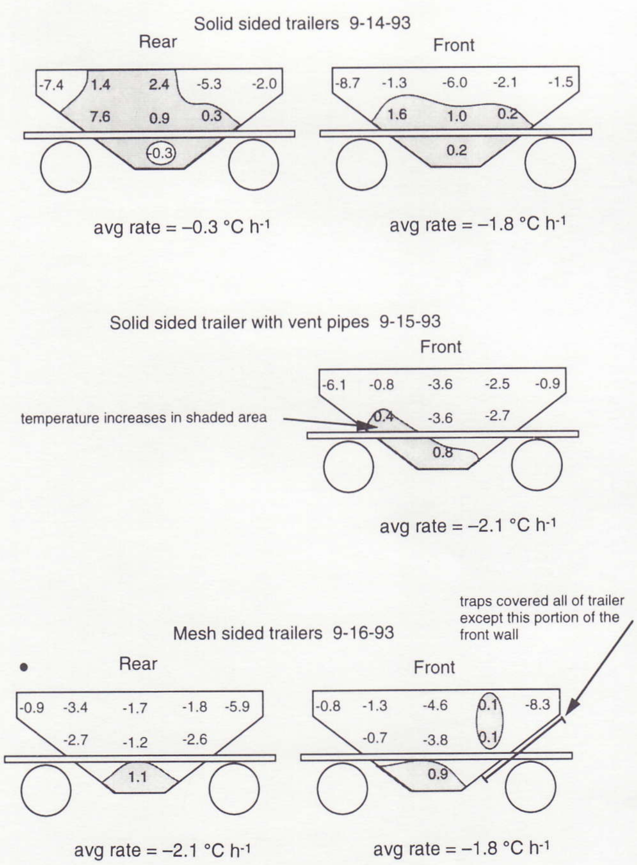

Figure 3–Temperature drop (°C h) in the centerline of bulk loads of unhulled pistachios during the first 1.3 to 2 of transport.

lab test showed that damaged hulls reduced air flow through a bed of nuts compared with nuts with undamaged hulls, so these temperature drops probably under estimate the drop that would occur in gently handled nuts. The tarp test showed that installing a small area of expanded metal on the front of a solid-sided, hopper-bottomed trailer could cause nearly as much cooling as was achieved by a trailer constructed entirely of expanded metal.

The single test with vented pallet bins loaded on a flat bed trailer showed the greatest rate of cooling. Bin transport appears to allow nuts better access to air flow and more evaporative cooling compared with bulk transport. This verified the potential of forcing air through unhulled pistachio nuts during transport.

In 1993 we attempted to determine the air flow pattern in the load of nuts. We installed probes to measure static air pressure at various positions in and above load during transport. The pressure data were highly variable, but above the load we saw a pressure increase from front to back. About half a meter deep in the load, static pressure was lower than that above the load in the rear and higher than above the load in the front. Air apparently flows across the top of the load, flows down into the load in the rear of the trailer, then flows forward through the nuts and up and out near the front of the load. In the tarped load, the air appeared to flow into the load in the rear and forward through the load, and exit out of the untarped area in the front inclined wall. The vent pipes appeared to cause air to flow from the product to the pipes and out of the trailer.

Most of the trailers were held at the plant for several hours during night before unloading. Nut temperature increased fairly uniformly at a rate of 0.4° to 0.6°C h^{-1}. A typical heating pattern in a stationary trailer is shown in figure 2 after the truck arrived at the processor at 5 h elapsed time. Nuts may warm at greater rates during the day and prolonged holding with these warming rates may expose nuts to conditions that increase shell staining.

Conclusions

Transport in solid-sided bulk trailers does not cause measurable damage to unhulled pistachio nuts under the conditions encountered in the tests. Conditions which might cause quality loss in the nuts and would require special handling are: (1) high nut temperatures at trailer loading; (2) long travel times in solid-sided trailers; and (3) long wait periods at the processor. At 40°C nuts can be damaged by holding times between 8 and 16 h.

The detrimental effects of high nut temperature at loading or long travel times can be reduced by hauling unhulled pistachio nuts in mesh sided trailers, installing vent pipes in solid-sided trailers or transporting in vented pallet bins.

If processing capacity becomes limited, there are two strategies that can reduce damage caused by prolonged storage in transport vehicles: (1) give highest processing priority to nuts that have highest temperatures; and (2) if warm loads cannot be hulled quickly, put them back on the highway and to allow cooling. Nuts benefit most from this if they are in pallet bins, in solid-sided trailers with vent pipes, or in mesh-sided trailers.

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