Annual Report 1976

Correct Project Number 76-D2

TITLE : Navel Orangeworm Research - Project 75-D
Part 1 Controlled Atmospheres
Part 2 Varietal Resistance

PREPARED BY: Edwin L. Soderstrom

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Part 1 - Controlled Atmospheres

I. OBJECTIVES: 1) To determine whether a controlled atmosphere would be useful against insect infestations of stored almonds; 2) to determine the time necessary to obtain a complete kill of navel orangeworm in a controlled atmosphere; and 3) to determine that a controlled atmosphere does not alter taste or odor qualities of almonds stored therein for periods up to one year.

II. INTERPRETIVE SUMMARY:

Research in cooperation with Mr. Charles Storey, Mr. Dan Guadagni, Mr. Gary Gray, and Mr. Bill Dryden has shown no adverse effect of the controlled atmosphere on taste, odor, peroxide value, and free fatty acids when nonpariel almonds were stored therein for 9 months.

In a field test, it was shown that the controlled atmosphere did move through inshell nonpareil almonds. The dust from the almonds slowed the movement of the atmosphere, but penetration was accomplished. For the size of the test room (ca. 15,000 cu ft) the 500 cu ft controlled atmosphere generator was found to be undersized.

III. EXPERIMENTAL PROCEDURES:

Field test - a 22' x 22' x 30' (14,570 cu ft) almond storage bin was utilized in this test. The bin was filled to approximately

2/3 of its capacity with inshell nonpareil almonds. A 500 cu ft/hr. controlled atmosphere generator was utilized to provide the atmosphere containing < 1% O_2, 10% Co_2 and ca. 89% nitrogen. The atmosphere was released at the center of the bin ca. 6" above the floor. Gas samples and temperature probes were located vertically in the center and at one corner of the bin. Sample depths and times of sampling were as shown in the results section.

Almond quality testing was on almonds held under controlled atmosphere in small bins at Manhattan, Kansas. Samples were analyzed by standard taste panel methods devised by Mr. Dan Guadagni. Almond quality was also ascertained by standard industry techniques on file at this laboratory. Free fatty acids and peroxide values were determined for natural (after treatment) blanched, and roasted nutmeats. Another determination was made 1 month after the blanching and roasting process.

IV. RESULTS:

The oxygen concentration at the sample points in relation to time sampled are in table 1 & 2. The controlled atmosphere was sucessfully passed through the almonds. However, the 500 cu ft/hr. generator was found to be insufficient to fill the bin in a reasonable length of time.

Temperatures of the almonds were recorded and are shown in table 3. The average temperature of the nuts was 69^{o}F. Since this was a year of delayed harvest, these data need to be confirmed in other years.

Almond quality of almonds is shown in tables 4 & 5. Moisture content did not significantly change and the free fatty acids were within the industry standards. Peroxide values of controlled atmosphere treated almonds were within the industry standard except for those roasted and held at 80^{o}F for 1 month. Even so, the controlled atmosphere treated nuts 1 month after roasting, were lower than the controls.

V. DISCUSSION:

Controlled atmosphere did not adversely affect almond quality as has been shown by the previously reported test and this intermediate test. At this time, no further research on almond quality is planned.

Field testing has shown that the atmosphere will penetrate inshell nonpareil almonds and will fill the bin from the bottom upwards. Further research will be necessary utilizing a larger gas generator or a smaller storage unit, depending on availability. Also studies will include efficacy studies on natural infestations. Studies will be initiated to determine optimum gas composition and kill time. Factors associated with gas introduction need to be studied as well as the economics involved.

VI. PUBLICATIONS:

Storey, C. L. and E. L. Soderstrom. Mortality of navel orangeworm in a reduced oxygen controlled atmosphere. Accepted for publication in Journal of Economic Entomology.

Part 2 - Varietal Resistance

I. OBJECTIVES: 1) To determine almond variety resistance to the navel orangeworm; 2) to investigate the means by which varieties are resistant to the navel orangeworm; 3) to provide almond growers with an almond variety resistance rating to assist them in selecting suitable almond varieties; 4) to provide information to assist a plant breeder in developing new almond varieties that would be more resistant to navel orangeworm than the present varieties.

II. INTERPRETIVE SUMMARY:

Shell seal quality was determined to generally correlate with the data from last year. The shell seal was poorer in most varieties compared to last years'. This may be due to the rains that soaked many of the nuts that we sampled.

A comparison of three years seal quality readings for Peerless, Mission, Neplus, and Nonpareil varieties were correlated with the percent industry rejects. The tighter the shell, the less rejects occurred. Ruby, Peerless, and Mission varieties appear to have the best sealed shells.

There appears to be a resistance factor in the hulls, but it is too early to identify the varieties at this time.

III. EXPERIMENTAL PROCEDURES:

Shell seal quality - Samples of almond varieties were obtained by our personnel and from Mr. Dutch Chamberlin of Calif. Almond Orchards. The hulls were removed and a 25 nut sample randomly selected. A 3/8" hole was drilled through each shell. Shell tightness was recorded using a seal quality meter. The average seal qualities of the 25 nuts were recorded.

Hull resistance - Hulls from the almond varieties were tempered to equal moisture and infested with equal numbers of navel orangeworm eggs. The cultures were held at 80^{o}F and 60% RH. The number of adults emerging from each variety was recorded.

IV. RESULTS:

Shell seal quality of the varieties tested in 1976 are shown in table 6. The lower leakage rates indicate tighter shells. Ruby, Peerless, and Mission were varieties with the tightest shells. Table 7 shows a comparison of four varieties of almonds with their percent industry rejects for 3 years. A high degree of correlation results in shell tightness and lowered industry rejects.

Resistance of almond hulls to navel orangeworms was as follows:

Variety (1975)	Navel orangeworm adults
Mission	0
Norman	0
LeGrand	3
Merced	7
Neplus	9
Nonpareil	9
Kern Royal	11
Thompson	13
Yosemite	16
Ruby	19

Thus, Mission and Norman varieties did not allow the navel orangeworm to survive in the hulls. Data from 1976 collected nuts are not complete at this time.

V. DISCUSSION:

Shell seal quality is starting to show a trend for the three years tested. Thus lower rejects may be expected from those varieties with a better seal rating. Hulls also show a resistance factor, however further research is needed for confirmation. Further research should include other commercial varieties as well as studying the environmental orchard factors associated with tight almond shells. Hull studies should be continued and expanded to include other varieties. Studies of the hull-moisture-variety relationship would be valuable.

VI. PUBLICATION:

Written - Soderstrom, E. L.

Almond Shell Seal Measurement and Resistance to Navel Orangeworm for Journal of Economic Entomology.

TABLE 1 --Percent Oxygen at Center of Bin Containing Nonpareil Almonds[1/]

Depth from top of bin (feet)

Date and Hour Oct. 25, 1976	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32
2 pm	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21
4 pm	21	21	21	21	21	21	21	21	21	21	21	18	19.5	20.0	19.8	0.35	0.05
5 pm	21	21	21	21	21	21	20.5	20.0	19.5	20.1	19.6	16.9	17.8	19.3	17.0	0.15	0.05
7 pm	20.8	20.8	20.8	20.8	20.8	20.8	19.4	18.5	17.5	18.0	17.5	14.5	14.8	16.8	10.2	0.10	0.05
9 pm	20.4	20.5	20.5	20.4	20.4	20.3	19.9	19.3	17.5	17.3	17.0	14.2	13.3	14.5	2.8	0.10	0.05
Oct. 26, 1976																	
3 am	19.5	19.4	19.4	19.4	19.4	19.4	18.3	16.8	14.7	14.7	15.3	13.3	12.3	7.8	0.4	0.10	0.10
9 am	18.3	18.2	18.2	18.2	18.2	18.2	17.5	15.9	12.7	12.9	13.6	11.4	8.6	4.3	0.4	0.15	0.10

Percent Oxygen at Left Front of Bin Containing Nonpareil Almonds[1/]

Depth from top of bin

Date and Hour Oct. 25, 1976	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32
2 pm	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	20.5
4 pm	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	21	12
5 pm	21	21	21	21	21	21	21	21	21	21	21	21	21	21	20.9	11.0	2.2
7 pm	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.8	20.5	20.2	18.4	2.3	1.7
9 pm	20.5	20.4	20.4	20.4	20.4	20.4	20.4	20.4	20.5	20.5	20.5	20.6	18.4	19.0	5.4	1.8	1.4
Oct. 26, 1976																	
3 am	19.3	19.3	19.3	19.3	19.3	19.3	19.3	19.6	19.7	19.7	19.7	19.7	1.8	3.0	1.3	0.6	0.4
9 am	18.2	18.2	18.2	18.2	18.2	18.2	18.3	18.2	18.2	18.2	18.3	2.2	1.3	1.7	0.7	0.4	0.3

1/ C/A introduction started at 3 pm

TABLE 2 -- Percent Oxygen in Bin Containing Nonpareil Almonds

Time	Floor Level		1 foot below top of nuts
Oct. 25	Right rear	Left rear	Right rear
2 pm	21	21	21
4	20.5	20.8	21
5	20.4	20.6	21
7	20.3	5.0	20.6
9	20.3	3.4	20.4
Oct. 26			
3	3.3	1.3	19.3
9	2.2	0.9	18.2

TABLE 3 -- TEMPERATURE (^{o}F) IN STORED NONPAREIL ALMONDS[1/]

DATE AND HOUR	Depth from Bottom										
	CENTER						SIDE				
OCT. 25, 1976	32	30	28	14	0	:	32	30	28	14	0
1 PM	69.5	69.0	68.5	69.0	67.0	:	69.0	69.0	69.0	68.0	72.0
4 PM	71.0	70.0	70.0	69.0	67.0	:	70.0	70.0	70.0	68.0	71.5
5 PM	71.5	70.0	70.0	70.0	68.0	:	71.0	70.5	71.0	68.0	72.0
7 PM	71.5	71.0	70.5	70.0	68.0	:	71.0	71.0	71.0	69.0	72.0
9 PM	71.0	71.5	70.0	69.5	68.0	:	70.5	OUT	71.5	69.0	72.5
OCT. 26, 1976											
3 AM	70.5	70.0	70.0	69.0	67.5	:	70.0	-	71.5	69.0	72.5
9 AM	67.5	67.0	67.0	66.0	65.0	:	67.0	-	69.0	67.0	70.5

1/ GAS TEMP AT ENTRANCE $63^{o}F$

TABLE 4 - FREE FATTY ACIDS (% OLEIC) OF ALMONDS AFTER PROCESSING AND STORAGE

Time Exposed to Atmosphere	Atmosphere Treatment	Type of Processing: Natural 0 mo.[1]	Natural 1 mo.	Blanched 0 mo.	Blanched 1 mo.	Roasted 0 mo.	Roasted 1 mo.	Moisture Content % for Natural
1 mo.	Static Air	.35[2]	.30	.17	.20	.30	.20	4.8
	Flowing Air	.20	.25	.33	.20	.40	.30	4.0
	Controlled Atmosphere	.40	.15	.20	.20	.45	.20	5.5
	Cold Storage-Static	.30	.40	.40	.20	.35	.20	5.5
3 mos.	Static Air	.22	.25	.15	.15	.25	.30	4.5
	Flowing Air	.10	.15	.15	.15	.30	.30	4.3
	Controlled Atmosphere	.25	.15	.60	.25	.35	.35	4.9
	Cold Storage-Static	.20	.15	.20	.15	.30	.20	6.0
6 mos.	Static Air	.20	.30	.15	.20	.25	.30	5.8
	Flowing Air	.15	.25	.20	.25	.25	.25	4.4
	Controlled Atmosphere	.25	.30	.25	.25	.30	.30	6.0
	Cold Storage-Static	.20	.20	.15	.15	.20	.25	7.4
9 mos.	Static Air	.30	.75	.30	.30	.35	.30	5.8
	Flowing Air	.20	.15	.20	.25	.30	.40	4.3
	Controlled Atmosphere	.40	.30	.20	.30	.40	.30	5.3
	Cold Storage-Static	.25	.35	.30	.30	.25	.30	7.4
12 mos.	Static Air							6.0
	Flowing Air							5.2
	Controlled Atmosphere							5.7
	Cold Storage-Static							8.6

1/ Storage time after processing, after which chemical analyses were determined.

2/ Industry standard < 1.5

TABLE 5- PEROXIDE VALUES (me/kg OF OIL) OF ALMONDS AFTER PROCESSING AND STORAGE

Time Exposed to Atmosphere	Atmosphere Treatment	Type of Processing: Natural 0 mo.[1]	Natural 1 mo.	Blanched 0 mo.	Blanched 1 mo.	Roasted 0 mo.	Roasted 1 mo.	Moisture Content % for Natural
1 mo.	Static Air	1.10[2]	2.80	1.40	1.00	1.60	2.60	---
	Flowing Air	1.10	1.00	1.80	0.70	1.30	8.90	---
	Controlled Atmosphere	1.30	2.20	3.10	0.60	0.90	3.90	
	Cold Storage-Static	1.40	1.10	0.80	0.80	1.60	5.90	---
3 mos.	Static Air	0.50	0.80	1.20	1.90	1.90	4.40	---
	Flowing Air	0.50	0.40	0.60	0.60	0.20	1.90	---
	Controlled Atmosphere	0.95	0.30	0.60	0.30	0.50	4.30	---
	Cold Storage-Static	0.60	0.40	0.40	0.30	0.80	3.00	---
6 mos.	Static Air	1.20	2.90	1.10	1.20	1.80	2.30	---
	Flowing Air	1.60	0.50	0.80	0.75	1.90	6.40	---
	Controlled Atmosphere	2.00	1.20	1.00	0.40	2.10	2.30	---
	Cold Storage-Static	1.00	1.00	0.80	0.80	1.50	3.00	---
9 mos.	Static Air	2.00	2.70	0.70	2.60	0.65	3.75	---
	Flowing Air	1.90	1.90	0.45	3.70	0.50	4.40	---
	Controlled Atmosphere	1.80	2.80	0.45	2.95	0.50	3.65	---
	Cold Storage-Static	2.60	3.10	0.25	1.40	0.30	5.20	---
12 mos.	Static Air							
	Flowing Air							
	Controlled Atmosphere							
	Cold Storage-Static							

1/ Storage time after processing, after which chemical analyses were determined.

2/ Industry standard - < 3.0

TABLE 6 -- ALMOND SEAL QUALITY 1976

AVERAGE LEAKAGE (CC/MIN)	VARIETY
22	RUBY
56	PEERLESS
86	MISSION
92	TOKYO
94	EMPIRE
110	YOSEMITE
115	RIPON
138	BUTTE
158	TIOGA
164	LE GRAND
211	MONO
213	JORDANOLO
285	EMERALD
297	NORMAN
419	DRAKE
458	NEPLUS
625	MERCED
647	THOMPSON
730	NONPAREIL

TABLE 7--COMPARISON OF INDUSTRY PERCENT INEDIBLE NUTS AND SHELL SEALS OF ALMONDS[1/]

CULTIVAR	1974-1975		1975-1976		1976-1977	
	INDUSTRY PERCENT REJECTS	SEAL QUALITY (CC/MIN)	INDUSTRY PERCENT REJECTS	SEAL QUALITY (CC/MIN)	INDUSTRY PERCENT REJECTS[2/]	SEAL QUALITY (CC/MIN)
'PEERLESS'	0.3	22	0.5	18	1.8	56
'MISSION' (TEXAS)	1.2	11	1.4	32	1.4	86
'NEPLUS ULTRA'	3.6	258	3.2	226	4.3	458
'NONPAREIL'	4.2	537	4.2	461	6.2	730

1/ APPROXIMATELY 80 PERCENT OF INEDIBLE NUTS WERE DUE TO NAVEL ORANGEWORM DAMAGE.

2/ AS OF 31 OCTOBER L976

76-D2

UNITED STATES DEPARTMENT OF AGRICULTURE
AGRICULTURAL RESEARCH SERVICE

Western Region
California-Nevada-Hawaii Area
Stored-Product Insects Research Laboratory
5578 Air Terminal Drive
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December 30, 1976

Mr. Dale Morrison
Director ~~- Special~~ Projects
ALMOND CONTROL BOARD
P.O. ~~Box 15920~~
Sacramento, CA 95813

Dear Dale:

Forwarded herewith are 3 cys of the Annual Report covering all projects except for Dr. Curtis' projects.

Each project report is separated by plain green paper for your convenience.

Dr. Curtis will be submitting his portion of the report early next week.

Sincerely,

D. K. Hunter
Acting-in-Charge

Enclosures

RECEIVED
JAN 3 1977