PROJECT: 14105

TITLE: Environmental Effects on Treatment and Storage of Winter Pears

YEAR INITIATED: 1998-99 **CURRENT YEAR** 2000-01 **TERMINATING** 2001-02

PERSONNEL: Dr. Eric Curry, Plant Physiologist, USDA-ARS, Wenatchee, WA

JUSTIFICATION:

Generally, winter pears do not ripen acceptably without sufficient chilling. To compensate, fruit can be treated with 100 ppm ethylene at harvest, or before they meet their chilling requirement, to initiate softening and enable fruit to ripen whose chilling requirement hasn't been met. This procedure is useful because it substantially increases early marketing. A number of studies have been done to determine the nature of winter pear ripening. Generally, without meeting the chilling requirement, pears undergo an ethylene climacteric after about 12 weeks in storage. To a point, increasing the time in cold storage reduces the time to climacteric and visa versa. This may be due to altered gene expression resulting in differential synthesis of proteins needed for ethylene biosynthesis. When protein biosynthesis is blocked, fruit fail to ripen. Mellenthin and Wang also found that d'Anjou fruit high in protein N content failed to ripen after a prolonged storage period and that the protein N content was influenced by temperatures before harvest. Fruit taken from trees with high (68F) or low (53F) daily-hourly average (DHA) temperatures (more warm hours during a 24 hour period) failed to ripen properly after a 8 months in cold storage and had lower sugars and acids. For example, pears from the 68F DHA trees showed no ethylene climacteric when held for 10 days at 68F after 8 months cold storage whereas those from trees with the optimum DHA between 57F and 63F showed an ethylene climacteric at about 9 days. Fruit from trees with the coolest DHA of 53F had an uneven and accelerated climacteric but were reported as mealy in texture. Thus, the capacity for and quality of fruit ripening was dependent upon temperatures before harvest. (Incidentally, it was also noted that fruit from cool DHA trees were more susceptible to friction discoloration than those from warm DHA trees.) Scald also shows the tendency to develop more in orchards where there is a high DHA. For example, 45-50% of the fruit developed scald from the warm DHA trees, whereas only 3-8% showed scald from the cool DHA trees. Clearly, there are complex interrelationships between climate, ripening, and the development of storage disorders that have not been addressed, and which have led to incongruencies in reports of ripening behavior and scald development. This project is an attempt to pull these components together and make sense of the influence of preharvest temperature on fruit ripening potential and scald development.

OBJECTIVES:

Identify effects of preharvest temperature on protein N, ripening behavior, fruit quality and storage disorders.
Identify effects of preharvest temperature on cuticle development, wax accumulation, and antioxidant efficacy.

PROGRESS:

Effects of Elevation on Wax Development

Six orchards were initially selected as possible sites to include in the study. They ranged from Leavenworth North Road, Peshastin, Brender Canyon (Cashmere), Stemilt Heights, and Quincy. Both Quincy and Peshastin are located at PAWS weather stations. Three additional weather units were established at Leavenworth, Brender Canyon and Stemilt Heights. A temperature recording device was placed in the orchard in Monitor. This first year, I decided to harvest within a day of commercial harvest to establish a baseline from which to work. Thus, at harvest we sampled fruit, evaluated quality, took tissue samples, and analyzed tissue for peel nitrogen and cellular membrane lipids. The following table illustrates the nature of the data collected from fruit sampled at harvest from 1998.

Table 1a. Orchard/Fruit characteristics of d'Anjou pears harvested in 1998.

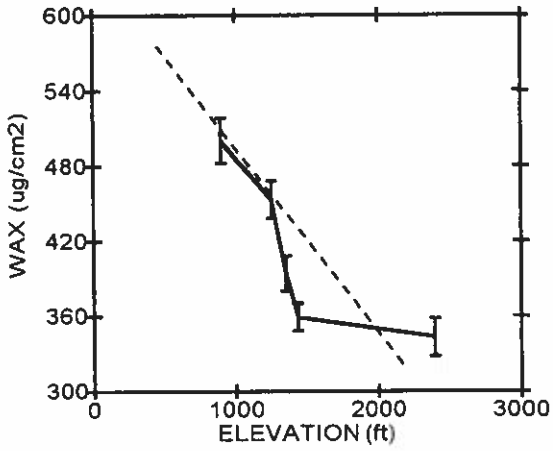
Location	Harv. Date 1998	Elevation (feet)	Color (AH)	Nitrogen Peel (%)	Firmness (LB)	Starch Rating	Extractable Wax ($\mu g/cm^2$)
Leavenworth	9/3	1250	-17.4	2.79	15.3	3.5	453
Peshastin	9/8	900	-17.3	2.72	9.8	3.9	500
Brender Cany	9/14	1350	-17.5	2.72	9.5	2.9	394
Quincy	9/3	1430	-17.7	2.77	13.6	4.0	359
Stemilt Hgts	9/14	2400	-18.1	2.74	9.5	2.7	343

Table 1b. Orchard/Fruit characteristics of d'Anjou pears harvested in 1999.

Location	Harv. Date 1999	Elevation (feet)	Color (AH)	Nitrogen Peel (%)	Firmness (LB)	Starch Rating	Extractable Wax ($\mu g/cm^2$)
Leavenworth	9/15	1250	-6.7	2.76	12.2	2.6	*
Peshastin	9/21	900	-17.1	2.95	12.3	4.4	*
Brender Cany	9/20	1350	-17.0	2.80	11.9	5.3	*
Quincy	9/9	1430	-8.9	2.63	10.4	3.7	*
Stemilt Hgts	9/23	2400	-16.8	3.11	11.3	4.7	*

*Samples not completed.

There are several observations from these data. First, harvest in 1999 was delayed about 7-10 days resulting in more even firmness across orchards. Second, it appears from the wax extraction in 1998 that more wax accumulates in lower elevations. Samples for 1999 are being processed (r = -0.81). This may prove to be the most significant aspect regarding how the peel (wax + cuticle) responds to environmental factors. Future experiments are planned to evaluate this possibility. A study of wax development and cuticle structure is currently in progress.



Delayed DPA or Ethoxyquin to Control Scald

DPA is used in a number of countries to control scald on d'Anjou Pears. It may become desirable or necessary to do so in the US. The work done in the past two years identifies conditions, rates and timings for using DPA successfully to control scald.

Table 2. Firmness and scald of d'Anjou pears treated with ethoxyquin or DPA.

PPM ETHOXYQ.	PPM DPA	WEEK TRTD	STORAGE REGIME	MONTHS STORAGE	FIRM. LB*	% SRFC W/SCALD	TOTAL SCALD %
UNTRTD	UNTRTD	--	RS	6	6.65	37	92*
2700	0	0	RS	6	6.71	0	3
2700	0	2	RS	6	7.01	2	12
2700	0	4	RS	6	7.12	2	8
2700	0	8	RS	6	6.99	1	8
0	2000	0	RS	6	7.08	11	52
0	2000	2	RS	6	6.69	20	73
0	2000	4	RS	6	6.53	25	82
0	2000	8	RS	6	6.71	17	70
UNTRTD	UNTRTD	--	CA	8	6.93	0	3
2700	0	0	CA	8	7.14	0	0
2700	0	2	CA	8	6.70	0	0
2700	0	4	CA	8	7.02	0	0
2700	0	8	CA	8	6.40	0	2
0	2000	0	CA	8	7.21	0	0
0	2000	2	CA	8	7.23	0	0
0	2000	4	CA	8	7.16	0	0
0	2000	8	CA	8	7.11	29	82

*Total Scald is (Intensity) X (Percent of Fruit Surface Covered with Scald); 0 – 200.

This trial indicates that delaying treatment with Ethoxyquin as long as 8 weeks before treatment still provides a strong measure of scald protection. When DPA was applied at a rate of 2000 ppm, best results were obtained when fruit was treated at harvest. CA imposed immediately at harvest was effective in controlling scald for 8 months. In addition, of the three orchards used in this study, the Total Scald of untreated pears after 6 months was 58, 68, 117, for Monitor, Leavenworth, Quincy which is the same order of elevation from lowest to highest as described above.

Delayed DPA or Ethoxyquin Plus Delayed CA to Control Scald

Table 3. Fruit Quality of d'Anjou pears treated with ethoxyquin or DPA after time delay in RA before CA Storage.

TRTMT	WEEKS RA UNTIL TRTMT	WEEKS IN CA	FIRM. LB	SHRVL %	ROT %	SCALD %	α-FARN OD x 100	CTs OD x 100	CTs X AO OD x 100
UNTRTD	24	0	8.70	0	5	80	20.8	63.7	36.9
UNTRTD	0	24	12.05	0	0	0	25.5	70.0	39.1
UNTRTD	2	22	12.96	0	0	10	23.8	60.7	30.0
UNTRTD	4	20	11.70	5	0	0	26.3	54.1	29.5
UNTRTD	6	18	10.35	0	0	5	25.3	51.8	27.8
UNTRTD	8	16	9.12	0	0	28	24.4	58.9	31.6
UNTRTD	12	16	10.23	0	0	95	29.7	73.0	38.2
ETX 1350 PPM	0	24	10.32	0	0	0	25.7	38.3	18.7
ETX 1350 PPM	2	22	9.56	5	0	2	34.8	44.7	25.3
ETX 1350 PPM	4	20	7.82	65	0	8	25.1	42.0	22.8
ETX 1350 PPM	6	18	4.45	30	0	2	23.4	39.7	19.0
ETX 1350 PPM	8	16	5.12	25	0	0	25.9	45.8	25.6
ETX 1350 PPM	12	16	9.84	0	0	15	35.5	39.8	20.5
ETX 2700 PPM	0	24	10.10	5	0	0	22.9	36.0	21.5
ETX 2700 PPM	2	22	11.02	0	0	0	22.4	35.3	20.6
ETX 2700 PPM	4	20	10.44	0	0	0	24.3	32.4	19.1
ETX 2700 PPM	6	18	5.82	20	20	0	27.9	35.9	20.6
ETX 2700 PPM	8	16	3.86	20	20	0	22.3	42.6	27.2
ETX 2700 PPM	12	16	9.42	0	20	10	35.4	43.2	24.6
DPA 800 PPM	0	24	9.25	5	0	0	20.9	43.2	25.2
DPA 800 PPM	2	22	9.82	0	0	2	22.9	45.3	29.2
DPA 800 PPM	4	20	9.26	15	0	8	19.8	40.7	22.6
DPA 800 PPM	6	18	9.17	0	5	0	24.1	46.7	30.7
DPA 800 PPM	8	16	9.70	0	0	15	23.8	47.3	32.2
DPA 800 PPM	12	16	9.35	0	0	65	27.0	66.0	37.2
DPA 1600 PPM	0	24	13.51	5	0	0	16.5	44.5	23.8
DPA 1600 PPM	2	22	12.72	0	0	3	18.2	41.0	24.3
DPA 1600 PPM	4	20	10.72	0	0	0	23.5	46.5	27.7
DPA 1600 PPM	6	18	9.55	0	0	0	27.8	48.4	32.0
DPA 1600 PPM	8	16	11.28	0	0	2	24.3	51.1	32.7
DPA 1600 PPM	12	16	9.10	0	10	40	24.0	70.2	39.9

These data suggest that untreated fruit may be held in RA for 6-8 weeks before imposing CA and still maintain good scald control. When using ethoxyquin at 2700 ppm or DPA at 1600 ppm, a delay of 8 weeks is possible before treating and imposing

CA and still maintains good scald control. Shrivel seems more of a potential problem with the use of ethoxyquin. DPA also appears to keep the fruit greener and firmer than ethoxyquin.

Effect of Drying Time on DPA induced Skin Injury

One of the problems associated with the use of DPA on d'Anjou pears has been the problem of skin marking. Experiments were conducted to look at rate effects and contact time effects. In the first experiment below fruit were dipped in varying rates of DPA, allowed to air dry, and then placed in storage.

Table 4. Disorders of d'Anjou pears treated with ethoxyquin or DPA (6 MO RA).

TRTMT	RATE (PPM)	% DARK LENTICELS	SCALD SEVERITY*	% FRUIT W / SCALD
UNTRTD	--	16	1.7	68
WATER DIP	--	10	2.0	79
ETHOX.	2700	8	0	3
DPA	1000	16	0.6	40
DPA	2000	10	0.1	9
DPA	4000	10	0	3
DPA	8000	55	0	0

*Scald Severity: 0=None; 1=Slight but marketable; 2=Brown, no pitting; 3=Brown + pitting.

Curiously, the type of damage seen by others was not seen here. Perhaps this was due to location or treatment temperature or some other unobvious condition during treatment. The main difference between this trial and others in which damage was seen was this was done in the lab and allowed for drying whereas others were done in bulk. This suggested damage at the points of contact. The next experiment was to examine how drying time affected peel injury at the contact points.

Table 5. Effect of treatment on drying time of d'Anjou pears dipped in water or 2000 ppm DPA.

AREA ON FRUIT	CHAMBER	DRYING TIME (hrs) WATER	DRYING TIME (hrs) DPA
EXPOSED SURFACE	OPEN	0.5	1.0
EXPOSED SURFACE	CLOSED	1.5	1.0
CONTACT POINTS	OPEN	140	28
CONTACT POINTS	CLOSED	24	2.5

Table 6. Effect of drying time on peel damage of d'Anjou pears dipped in water, Mertect or 2000 ppm DPA.

TREATMENT	STORAGE	% DAMAGED CONTACTS	% DAMAGED LENTICELS	% FRUIT W/ SHRIVEL	% FRUIT W/ SCALD
UNTREATED	REGULAR	0.5	0	0	92
WATER+MERTECT	REGULAR	8.7	7.5	27	92
2000 PPM DPA	REGULAR	16	28	73	20
4000 PPM DPA	REGULAR	23	13	68	20
UNTREATED	CA	0.6	0	0	0
WATER+MERTECT	CA	0	0	0	0
2000 PPM DPA	CA	2.1	0	0	0
4000 PPM DPA	CA	0	7.5	2.5	0

Most peel damage occurred in RA, which would be similar to the 'open' chambers in table 5.

PROCEDURE:

Follow cuticle and wax development of d'Anjou pears from fruitlet to maturity stage under different environmental conditions.
Repeat ethoxyquin/DPA drying time vs. damage trial with different orchards.
Determine if quantity or quality of wax is related to antioxidant efficacy.

ANTICIPATED BENEFITS AND INFORMATION TRANSFER:

The new technology to be derived from this work will be an ability to identify ripening behavior and scald potential, and the potential efficacy of antioxidants through the assistance of microclimate/environmental data from which the fruit was harvested. Information will be disseminated through peer reviewed journal articles, presentations, and technical publications.

BUDGET:

1. Amount allocated by commission for FY 1999-00: $38,000

2. Request for FY 2000-2001:

Salary (GS 7, 35hr/wk)	$27,000
Goods and Services[1]	6,500
Travel[2]	1,500
Benefits	8,000
TOTAL	$42,000

SEM & Wax

[1]Chemical supplies, equipment consumables (vials, columns, gases; gases for CA storage and calibration, SEM Time at PNNL, Richland, WA); presentation materials.
[2]General work travel; travel and presentation at WPCC, WTFRC and related regional meetings.

OTHER SUPPORT OF PROJECT:

The WPCC is the sole sources of funding for this work on pears.