SHELF LIFE TESTING

AND

STORAGE OF ASPARAGUS

HDC FV21/C/87/0355/4a

HDC CONTRACT R & D - EXPERIMENT REPORT Date: 21-11-89

HDC FV21/C/87/0355/4a

SHELF LIFE TESTING - STORAGE OF ASPARAGUS

Experiment Leader: Mrs Helen Airdrie, Luddington Experimental Horticulture Station, Stratford-on-Avon, Warwickshire CV37 9SJ. Tel: 0789 750601

Fax: 0789 750957

HDC Project Leader: Dr M R Shipway, Luddington Experimental Horticulture Station, Stratford-on-Avon, Warwickshire CV37 9SJ. Tel: 0789 750601

Fax: 0789 750957

Status of work: completed

Year of experiment: 3

Report Number: 3

Period covered: financial year 1989/90

Abstract

Asparagus from a commercial site in the Vale of Evesham was used for a series of trials at Luddington EHS to investigate the effects of harvest date throughout the season, and pre-cooling techniques on storage potential.

Bacterial soft rotting was a problem in virtually all the storage work in 1989, although it had not been observed in previous years. Acceptable storage periods in 1989 ranged from 7 to 14 days depending on the date of harvest.

Pre-cooling spears in a hydrocooling system improved spear turgidity and reduced toughness in the early stages of shelf life but this system requires further evaluation if used on spears stored for more than 7 days. Chlorination of the cooling water was also investigated. Hydrocooling without chlorination led to poorer shelf life.

Objective

To evaluate the potential for the short term storage of asparagus.

Introduction

The ability to store UK asparagus for short periods, both during the main season and at the end of the season, is attractive since it increases flexibility in the marketing operation and may also briefly extend the supply of produce later into June.

Work in previous years highlighted the increase in fibrousness and desiccation of spears in store as being the main factors limiting storage life. Work in 1987 and 1988 indicated that spears stored well for 7-14 days, depending on the season.

Trials in 1989 were designed to evaluate the potential for storing asparagus in a third season and also to briefly assess the effect of pre-cooling techniques on the subsequent storage quality.

Materials and Methods

Trial one

To evaluate the storage potential of asparagus throughout the 1989 season.

Asparagus was harvested from a commercial site on 17, 24 and 31 May and transported to Luddington EHS for use in the storage trials. Spears <10 mm were discarded as were damaged and crooked ones.

The asparagus was hydrocooled to 5^{o}C and then packaged in bundles and stood upright in ventilated crates. The crates were then held in an ice bank cold store at 2^{o}C, 95% RH for the following periods.

Harvest	Storage
1. 17/5/89	0, 7, 14, 19 and 21 days
2. 24/5/89	0, 7 and 14 days
3. 31/5/89	0, 7 and 14 days.

After the appropriate period in store, three replicate bundles were removed and spears trimmed, packed in 250g trays and overwrapped with perforated PVC. The pre-packed asparagus was placed into shelf life conditions of 20^{o}C, 50% RH and monitored over a 48 hour period.

Assessments

Weight loss during storage was recorded on untrimmed bundles as was weight loss on shelf life samples (daily intervals). Spear turgidity, tip condition and rotting were scored in shelf life after 0, 24 and 48 hours using a 9-0 scale, where 9 = excellent and 6 = just unmarketable.

The fibrousness of spears was also measured using a 30^{o} Warner Bratzler shear plate under a 50N load cell at a crosshead speed of 500 mm/min. Spear diameter and peak load were recorded 5 and 10 cm behind the tip. The peak load which is expressed in Newtons has been adjusted to the mean sample diameter at each assessment for comparative purposes.

Statistical analysis

This has been carried out by Mr A Mead, IHR Wellesbourne.

Analysis of shelf life data was carried out separately for each run.

Weights after 24 and 48 hours in shelf life were subjected to analysis of covariance with weight into shelf life as the covariate. Peak loads at both 5 cm and 10 cm from the tip after 0, 24 and 48 hours were subjected to analysis of covariance with the appropriate cross section area as the covariate. These analyses adjusted the peak loads for differences between the cross section areas of the different samples. Peak load testing of crops is still at a development stage and therefore results should be treated with caution.

Turgidity scores, tip condition scores and disease scores after 0, 24 and 48 hours, plus spear diameter at 5 cm and 10 cm from the tip after 0, 24 and 48 hours were subjected to analysis of variance.

Results

Weight loss during storage from the first and last harvest (17/5 and 31/5) followed a fairly predictable pattern where weight loss increased with the period in store (Table 1).

Table 1 Percentage weight loss during storage

Storage period (days)	Harvest 1 17/5	Harvest 2 24/5	Harvest 3 31/5
7	N/A	6.69	1.58
14	4.63	5.03	3.03
19	5.02	3.52	3.72
21	5.26	4.18	6.23

No statistical analysis available.

Shelf life quality

Harvest I (17/5/89) - At the end of shelf life, weight loss from the asparagus packs was greatest for those stored for 21 days and least for those not stored at all (Table 2).

Turgidity scores reflected the weight loss pattern with a gradual loss of turgidity associated with increasing periods in store. Deterioration was most rapid beyond 19 days storage (Table 2).

The condition of the spear tips followed a similar pattern of deterioration, with the sharpest decrease in quality between 19 and 21 days (Table 2). 0 days storage results are out of line with the others.

Very little rotting (disease) developed on the spears from this early harvest, although a small amount had developed at the end of shelf life after 21 days storage.

As mentioned earlier, peak load results need to be treated with caution because of their unpredictability. Results from this first harvest do however suggest that spears may be getting tougher in store, although no differences between treatments were evident near the spear tips (Table 2).

Table 2 Shelf life characteristics of asparagus after 48 hours shelf life. Harvest I 17/5/89

Time in store (days)	Turgidity	Tip condition	Disease	Peak load (N) 5 cm from tip 24 hrs	Peak load (N) 10 cm from tip 24 hrs	% wt loss
		scored 9-0, where 9 =		excellent		
0	7.33	6.40	9.00	11.60	14.58	1.37
7	7.07	7.33	9.00	14.76	16.85	2.15
14	7.00	7.07	9.00	16.69	18.17	2.68
19	6.73	7.00	9.00	16.72	21.05	2.22
21	6.02	6.33	8.60	12.49	20.16	3.47
SED	0.204 *	0.290 *	0.037 ***	0.694 ***	0.791 ***	0.301

Harvest II (24/5/89) - No consistent pattern emerged from records of weight loss during shelf life. Turgidity scores for unstored asparagus (0 days) were higher after one day of shelf life than for spears stored for 7 or 14 days, but no differences were apparent at the end of shelf life (Table 3).

There were no differences in tip condition between storage periods but disease levels were much higher on spears stored for 14 days at the end of shelf life than on unstored spears (0 days), or spears stored for 7 days (Table 3). Soft rotting in spear tips was again the major factor involved.

Peak load records made upon entry into the shelf life room seem to indicate that unstored spears are less tough both at 5 and 10 cm back from the tip than those stored for 7 or 14 days. Records made later in shelf life do not follow any consistent trend.

Table 3 Shelf life characteristics of asparagus after 48 hours storage. Harvest II 24/5/89

Time in store (days)	Turgidity	Tip condition	Disease	Peak load (N) 5 cm from tip 0 hrs	Peak load (N) 10 cm from tip 0 hrs	% wt loss
		scored 9-0, where 9 = excellent				
0 (Control)	6.87	6.87	9.00	11.50	11.73	2.43
7	6.83	6.77	8.43	13.86	16.21	2.47
14	6.78	6.78	5.80	15.88	20.12	2.97
SED (between control and other periods in store)	0.191 ns	0.239 ns	0.354 ***	1.411 * 7 df	2.291 * 7 df	0.438 ns 7 df
SED (between time in store) (excluding control) 8 df	0.156 ns	0.195 ns	0.289 ***	1.152 ns 7 df	1.871 ns 7 df	0.358 ns 7 df

Harvest III (31/5/89) - Results from the third harvest did not show the same trends shown earlier for weight loss.

No differences between storage treatments were noted for turgidity scores or for the condition of spear tips or disease levels (Table 4). This suggests spear quality showed little deterioration during the 14 days in store.

Peak load assessments do not follow a consistent trend either.

Table 4 Shelf life characteristics of asparagus after 48 hours shelf life. Harvest III 31/5/89

Time in store (days)	Turgidity	Tip condition	Disease	Peak load (N) 5 cm from tip	Peak load (N) 10 cm from tip	% wt loss
0 (Control)	7.25	7.37	9.00	16.93	18.80	2.26
7	7.60	7.40	8.80	8.10	15.14	3.18
14	7.44	7.62	8.66	12.77	17.17	2.46
SED (between control and storage) 8 df	0.139 ns	0.187 ns	0.214 ns	1.154 *** 7 df	0.994 ** 7 df	0.195 ** 7 df
SED (between length of storage) (excluding control) 8 df	0.113 ns	0.152 ns	0.175 ns	0.942 ** 7 df	0.812 * 7 df	0.159 ** 7 df

Discussion

Work in previous years has suggested that the storage potential for asparagus will vary between season and throughout the season. Results have confirmed these findings. Asparagus harvested on 24 May stored well for 14 days but deteriorated rapidly beyond this point. Similarly the crop harvested on 31 May showed few signs of deterioration up to 14 days in store. In contrast, the spears harvested on 24 May had deteriorated considerably even after 7 days in store. This difference is likely to be due in part to the weather conditions during growth. Heavy rain on 23 May meant the following days harvest was both wet and muddy, and due to poor harvesting conditions, probably suffered more physical damage, skin abrasions etc.

Storage quality was not enhanced in all three harvests by the overwrapping bundles in a perforated film after hydrocooling. Poor ventilation of the wet spears probably encouraged bacterial soft rotting in an otherwise tender crop.

Trial two. To evaluate the effect of pre-cooling technique on the storage quality of asparagus.

Following the development of rotting during storage in May 1989, asparagus from an early June harvest was used to evaluate the effect the pre-cooling technique might have on subsequent storage quality.

Materials and Methods

Treatments

Pre-cooling

1. Forced air (ice bank)
2. Hydrocooling without chlorine
3. Hydrocooling with 150 ppm chlorine.

The asparagus was held in store for:

1. 0 days
2. 7 days
3. 14 days.

Upon removal from store the asparagus was graded (marketable and unmarketable), trimmed and packed in 250g overwrapped trays (perforated PVC film). The packaged asparagus was placed into shelf life conditions of 20^{o}C, 50% RH and was monitored for 48 hours.

Assessments

Assessments were carried out as described in the previous trial, except the % of marketable spears out of store was also recorded and peak load measurements were made at 10 cm from the tip only.

Statistical analysis

Weights out of store were subjected to analysis of covariance with weight into store as the covariate. Weight into store and percentage marketable (by weight) out of store were subjected to analysis of variance.

Weights after 24 and 48 hours in shelf life were subjected to analysis of covariance with weight into shelf life as the covariate. Peak loads at 0, 24 and 48 hours were subjected to analysis of covariance with cross section areas at 0, 24 and 48 hours respectively, as the covariates. This corrects the peak load measurements for differences in cross section area, the adjusted means being the peak loads for spears with a cross section area equal to the mean cross section area.

Turgidity scores, tip condition and disease scores at 0, 24 and 48 hours were subjected to analysis of variance.

Results and Discussion

As might be expected, weight loss from the asparagus increased with the longer period in store (Table 5). In addition, there was also a reduction in the marketable yield after 14 days in store. Losses were due to soft rotting in the spear tips and although figures are not significant, levels did appear to be higher on the hydrocooled spears (Table 6).

Assessments on the shelf life quality of the pre-cooled asparagus indicated

lower weight loss from the 14 day stored asparagus and from the forced air cooled asparagus after 24 hours (Table 7). These differences were not significant after 48 hours but the trends were still apparent. Lower weight loss in these treatments during shelf life is probably due to the higher weight loss previous experienced in store and the fact that hydrocooled spears had been made wet after harvest.

Table 5 Percentage weight loss during storage

Pre-cooling treatment	Days in store 7	14	Mean
Forced air	1.96	2.98	2.47
Hydrocooling -chlorine	2.49	4.71	3.59
Hydrocooling +chlorine	2.99	3.87	3.43
Mean	2.48	3.86	
SED (between pre-cooling means)		0.412 ns (9 df)	
SED (between storage means)		0.262 ***	
SED (other comparisons)		0.517 ns	

Table 6 Percentage of marketable spears out of store (by weight)

Pre-cooling treatment	Days in store 7	14	Mean
Forced air	100.0	94.6	97.3
Hydrocooling -chlorine	100.0	80.1	90.0
Hydrocooling +chlorine	100.0	84.3	92.1
Mean	100.0	86.3	
SED (between pre-cooling means)		3.93 ns (10 df)	
SED (between storage means)		3.21 **	
SED (other comparisons)		5.56 ns	

Table 7 Percentage weight loss after 24 hours shelf life

Pre-cooling treatment	Days in store 0	7	14	Mean
Forced air	1.59	1.75	1.29	1.54
Hydrocooling -chlorine	1.97	1.88	1.53	1.80
Hydrocooling +chlorine	2.23	2.18	1.43	1.95
Mean	1.93	1.94	1.42	
SED (between pre-cooling means)		0.169 *	(15 df)	
SED (between storage means)		0.193 *		
SED (other comparisons)		0.305 ns		

Peak load assessments gave an indication of the toughness of the spears. Results tend to be variable and indicate a number of interactions. There is good evidence, from the hydrocooled asparagus, that spears stored for 14 days were tougher than those not stored or held for only 7 days (Tables 8 and 9).

Initial peak load assessments made upon entry into shelf life indicated that hydrocooled asparagus, both with and without the inclusion of chlorine in the water, was less tough than forced air cooled spears after 0 and 7 days storage. This difference was apparent later in shelf life and was only evident on spears hydrocooled with chlorinated water after 14 days shelf life (Tables 8 and 9).

After two days shelf life no differences between treatments were evident in terms of spear toughness.

Table 8 Peak load assessments (N) after 0 hours shelf life

Pre-cooling treatment	Days in store 0	7	14	Mean
Forced air	17.50	19.94	17.87	18.44
Hydrocooling -chlorine	13.77	13.64	17.10	14.84
Hydrocooling +chlorine	12.80	14.27	14.71	13.93
Mean	14.69	15.95	16.56	
SED (between pre-cooling means)		0.498 *** (15 df)		
SED (between storage means)		0.640 *		
SED (other comparisons)		0.914 **		

Table 9 Peak load assessments (N) after 24 hours shelf life

Pre-cooling treatment	Days in store 0	7	14	Mean
Forced air	12.59	9.47	14.54	12.20
Hydrocooling -chlorine	11.17	8.35	14.12	11.30
Hydrocooling +chlorine	13.24	11.43	14.12	12.93
Mean	12.34	9.75	14.35	
SED (between pre-cooling means)		0.603 * (15 df)		
SED (between storage means)		0.696 ***		
SED (other comparisons)		1.082 ns		

Initially upon entry into shelf life, assessments of spear turgidity indicated hydrocooled asparagus from store to be more turgid than that pre-cooled by forced air cooling in an ice bank store (Table 10). This effect did not carry through to the end of shelf life (Table 11).

Overall assessments of the effect of storage on spear turgidity show spears stored for 14 days generally had the lowest turgidity scores, indicating spear turgidity was decreasing with time in store.

Table 10 Turgidity of spears scored after 0 hours shelf life

Pre-cooling treatment	Days in store 0	7	14	Mean
Forced air	8.07	6.73	7.07	7.29
Hydrocooling -chlorine	7.33	8.73	8.00	8.02
Hydrocooling +chlorine	7.87	8.60	7.80	8.09
Mean	7.76	8.02	7.62	
SED (between pre-cooling means)		0.086 *** (16 df)		
SED (between storage means)		0.086 ***		
SED (other comparisons)		0.149 ***		

Table 11 Turgidity of spears scored after 48 hours shelf life

Pre-cooling treatment	Days in store 0	7	14	Mean
Forced air	6.80	6.73	6.13	6.56
Hydrocooling -chlorine	6.20	7.73	5.73	6.56
Hydrocooling +chlorine	6.80	7.33	6.07	6.73
Mean	6.60	7.27	5.98	
SED (between pre-cooling means)		0.163 ns (16 df)		
SED (between storage means)		0.163 ***		
SED (other comparisons)		0.283 **		

There were few significant treatment effects on tip condition scores, except that after 48 hours shelf life, asparagus stored for 14 days had poorer tips than those stored for 0 or 7 days. Bracts were going very soft and showing signs of soft rots (Table 12).

Table 12 Tip condition, scored 9-0, where 9 = excellent, after 48 hours shelf life

Pre-cooling treatment	Days in store 0	7	14	Mean
Forced air	7.33	7.40	6.53	7.09
Hydrocooling -chlorine	7.13	7.40	6.60	7.04
Hydrocooling +chlorine	6.87	7.53	6.67	7.02
Mean	7.11	7.44	6.60	
SED (between pre-cooling means)		0.156 ns	(16 df)	
SED (between storage means)		0.156 ***		
SED (other comparisons)		0.271 ns		

Levels of rotting on the spears was generally fairly low but disease scores at the end of shelf life show non-chlorinated hydrocooled plots to be worse affected. In addition, rotting became more of a problem the longer the period in store (Table 13).

Table 13 Disease, scored 9-0, where 9 = excellent, after 48 hours shelf life

Pre-cooling treatment	Days in store 0	7	14	Mean
Forced air	9.00	8.93	8.60	8.84
Hydrocooling -chlorine	9.00	8.40	8.20	8.53
Hydrocooling +chlorine	9.00	8.60	8.53	8.71
Mean	9.00	8.64	8.44	
SED (between pre-cooling means)		0.091 *	(16 df)	
SED (between storage means)		0.091 ***		
SED (other comparisons)		0.157 ns		

Discussion

As in previous trials, the quality of asparagus was beginning to deteriorate during storage with significant decreases in this trial beyond 7 days storage. Soft rotting in trials reported here had been largely attributable to storing wet (hydrocooled) and wrapped bundles of spears. Results from this trial indicate that although soft rotting was worse on hydrocooled spears, it was also present on the dry (forced air cooled) asparagus. Soft rotting was obviously a problem in 1989 although had not been observed in previous years.

Despite the soft rotting problems in stored treatments, hydrocooling did result in better spear turgidity and reduced toughness. Chlorination of hydrocooling water is widely practised and recommended as a technique for reducing bacterial infection from contaminated water. It is already recommended in other countries for use with asparagus and although does not appear to be of outstanding benefit from these results, it is likely to prove useful in a commercial situation where disease pressures are higher because of the volume of produce processed.

Conclusions - All trials

1. The maximum storage potential for asparagus varies both between seasons and within a season. Weather conditions during growth and harvest appear to play a major role but other factors are probably involved as well. Even in good conditions a maximum storage period of only 14 days was feasible in 1989.

2. Hydrocooling spears increased their turgidity and reduced toughness in the early stages of shelf life, compared to forced air cooling, but where chlorination was not practised, there was an increased risk of soft rotting later in store and in subsequent shelf life.

3. Chlorination of the hydrocooling water reduced the subsequent disease level on spears during shelf life. This effect is likely to be more marked in a commercial situation where disease pressures may be higher.

Recommendations for future action

Asparagus is a high value crop with a limited shelf life. Techniques to reduce post harvest deterioration are essential. Further work should include the use of controlled atmospheres to improve storage and detailed assessments of varietal performance in store. Work elsewhere suggests that varietal choice plays a very important role in storage potential, in addition to season and weather conditions at harvests.