



**HDC CONTRACT FV137a
FACTORS AFFECTING THE SHELF-LIFE
OF THE CAULIFLOWER CROP**

FINAL REPORT FOR 1993 AND 1994 TRIALS

Final Report: December 1994

Project Number FV137a

Project Title: Factors affecting the shelf-life of the cauliflower crop

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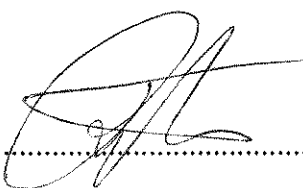
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AUTHENTICATION

I declare that this work was done under my supervision according to the procedures described herein and that this report represents a true and accurate record of the results obtained.

Signature 

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FACTORS AFFECTING THE SHELF-LIFE OF THE CAULIFLOWER CROP

Relevance to growers and practical application

The main point is that the condition of cauliflower at harvest is much more important than the time to the start of cooling, temperature cooled to, or time in holding store, in determining subsequent shelf-life.

Summary

On three occasions, once in the summer of 1993 and twice in 1994, cauliflower were harvested in the height of the day when their internal curd temperature rose above 20°C. The cauliflower were packed commercially in plastic crates, and then left in the packhouse in the afternoon heat for 2, 4 or 6 hours, before cooling with forced cold air to either 6 or 10°C. They were then held at these temperatures for 12 or 36 hours before putting in a shelf-life room at 20°C, 50% RH and a high light intensity. Subsequently daily measurements of weight loss and quality deterioration were made. The following conclusions were drawn:

1. Cauliflower harvested under high temperatures had a shelf-life of three to six days in the most part depending on the initial produce.
2. There was no detrimental effect of increasing the time from harvest to rapid cooling for at least six hours.
3. Little benefit was observed by using a 6°C holding temperature over 10°C.
4. A 36 hour period in the holding temperature did adversely affect subsequent shelf-life compared with holding for 12 hours, on two out of the three occasions.
5. The overriding conclusion that comes from this work, is that it is much more important to pack quality produce, than anything that can be done subsequently in terms of rapid cooling, lower holding temperatures or shorter holding periods.

EXPERIMENTAL SECTION

Introduction

During the 1992 growing season, HDC funded a project (FV137) entitled "Factors Affecting The Shelf-life of a Range of Vegetable Crops", which could be summarised as follows. The test crops were cauliflowers, calabrese and Brussels sprouts. Produce was either carefully harvested by technicians or harvested by farm staff on a commercial rig, and transported to the packhouse. The produce was weighed and then left at ambient conditions for two, four or six hours after harvesting before rapidly cooling to, and holding at, either 6 or 10°C. The following morning the produce was re-weighed, inspected and put into simulated supermarket shelf-life conditions. The produce was weighed and inspected daily for up to one week. When produce was downgraded from Class 1 to Class 2 it was discarded.

Carefully hand picked sprouts were cleaner of debris and had better shelf-life characteristics than machine stripped sprouts. Carefully harvested cauliflower were no better than those done commercially, and this was thought to be because a large proportion of produce downgraded, with both methods of harvest, was due to damage caused by subsequent handling of the produce. Carefully harvested calabrese crowns also showed little advantage over those commercially harvested.

The shelf-life of produce cooled and kept at a holding and dispatch temperature of 10°C was very similar to that at 6°C, which is the temperature currently used commercially. Varying the length of time between harvest to the start of cooling from two to six hours also had no effect upon subsequent shelf-life.

This last observation has management and energy saving implications if it could be substantiated. Observers expressed the concern that the produce used in the 1992 project was harvested in the early morning, and often during rather cool weather. Therefore, it was decided to repeat the cauliflower work but to harvest the crop only on hot days when the temperature of the centre of the curd exceeded 20°C. Unfortunately this occurred only once during 1993 after the contract had been agreed, but did occur more often in summer of 1994

when the practical work for this project was completed. The cauliflower used in the two 1994 trials matured under more stressful growing conditions than the crop used in 1993.

Materials and methods

Cooling units built in 1992 for FV137 were used to carry 2 x 5 tray loads (ie five supermarket trays per layer, stacked two high). Cooling was achieved by placing the stacked units in an ice bank store, drawing air through each pallet load with a lid-mounted fan. Air was directed by sealing each pallet load with bubble plastic (Pillosol) attached to the fan top lid. The air flow was regulated to achieve fast but even cooling.

i Treatments

- 1) Produce harvest method
 - (i) Carefully handled, cut and packed
- 2) Time delays between harvest and start of cooling:-
 - (i) 2 hours
 - (ii) 4 hours
 - (iii) 6 hours
- 3) Cooling rate - time to target temperature
 - (i) 2 hours
- 4) Target cooled temperatures (in ice bank store)
 - (i) 6°C
 - (ii) 10°C

- 5) Holding stage (direct expansion (DX) store) prior to shelf-life
- (i) 12 hours at 6°C to simulate rapid delivery onto supermarket shelf
 - (ii) 36 hours at 6°C to simulate produce being held before going onto supermarket shelf
 - (iii) 12 hours at 10°C
 - (iv) 36 hours at 10°C

ii Trial diaries

Trial 1 June/July 1993

29 June Internal temperature of curds of a crop of cauliflower cv Linmont at HRI-Kirton reached 20°C at 13.00 hrs, large gang cut 60 crates (480 heads) between 13.45 and 14.15 hrs.

Stacks of 10 plastic crates each containing eight curds were put into ice bank for rapid cooling at 16.00 hrs, 18.00 hrs and 20.00 hrs. Cooled to a mean stack temperature of 10°C and 6°C and then moved into the relevant holding temperature in DX store.

30 June 8.30 hrs 12 hr holding treatments moved into shelf-life room and recorded.

1 July 8.30 hr 36 hr holding treatment moved into shelf-life room and all produce recorded.

2-7 July Produce recorded daily.

Trial 2 July 1994

1 July Internal temperature of curds of a crop of cauliflower cv White Rock at HRI-Kirton reached 20°C at 14.00 hrs, large gang cut 60 crates (480 heads) between 14.00 and 14.30 hrs.

Stacks of 10 plastic crates each containing eight curds were put into ice bank for rapid cooling at 16.15 hrs, 18.15 hrs and 20.15 hrs. Cooled to a mean stack temperature of 10°C and 6°C and then moved into the relevant holding temperature in DX store.

2 July 8.30 hrs 12 hr holding treatments moved into shelf-life room and recorded.

3 July 8.30 hr 36 hr holding treatment moved into shelf-life room and all produce recorded.

4-8 July Produce recorded daily.

Trial 3 July 1994

22 July Internal temperature of curds of a crop of commercial cauliflower grown locally reached 20°C at 13.00 hrs, large gang cut 60 crates (480 heads) between 13.15 and 13.45 hrs.

Stacks of 10 plastic crates each containing eight curds were put into ice bank for rapid cooling at 15.30 hrs, 17.30 hrs and 19.30 hrs. Cooled to a mean stack temperature of 10°C and 6°C and then moved into the relevant holding temperature in DX store.

23 July 8.30 hr 12 hr holding treatments moved into shelf-life room and recorded.

24 July 8.30 hr 36 hr holding treatment moved into shelf-life room and all produce recorded.

25 July- Produce recorded daily.

1 August

iii Assessments and records

(i) Crop diary to maintain a record of crop collection, cooling, holding and shelf-life sequence.

(ii) Temperature records during pre-cooling delay, cooling, holding and shelf-life.

(iii) Percentage weight loss during shelf-life.

(iv) Number of heads in Class 1 with time.

NB Class 1 Good shape, curds must be firm, uniform white to ivory with no other colour present and free of pest, disease or other defects.

Class 2 The curds may be slightly misshapen, slightly loose, uneven in colour and or slight defects but not enough to detract from its overall appearance.

(v) Reason for downgrading produce.

These are in general ricey, bracted, looseness, coloured, rotted, frosted, damaged or diseased.

Results and discussion

1. Temperature records during trial

Table 1 and 2 show the temperatures during the first trial in full and demonstrate that the desired temperatures were achieved. Tables 3 & 4 show selected data from trials 2 & 3 to show that temperatures of produce coming from the field were high and that holding temperatures were achieved quite quickly and maintained until put into shelf-life. The temperature of the shelf-life was even and around 20°C. The cauliflower crops used in the two 1994 trials matured under more stressful conditions than that of 1993 and may well account for the more rapid deterioration of Trials 2 & 3 in shelf-life seen later.

Table 2 Trial 1. Produce temperature during trial for 36 hr holding of produce

Time		Treatment					
		2 hr/6°C	2 hr/10°C	4 hr/6°C	4 hr/10°C	6 hr/6°C	6 hr/10°C
29 June	14.00	20.3	20.4	20.6	20.0	20.6	20.5
	16.00	20.1	20.0	20.0	19.5	20.1	20.1
	18.00	6.6	10.1	19.5	19.1	19.2	19.4
	20.00	5.8	10.3	7.2	10.1	18.5	18.9
	22.00	5.9	10.1	6.1	10.1	6.1	10.0
30 June	9.00	6.0	9.9	6.0	10.0	6.0	9.9
	11.00	6.0	9.9	6.0	10.1	6.0	9.9
	13.00	5.9	10.0	5.9	9.9	6.0	10.0
1 July	9.00	6.0	9.9	6.0	9.9	6.1	10.0
	11.00	14.1	14.9	14.1	15.6	13.9	15.6
	13.00	18.9	19.8	18.5	19.2	17.4	18.6
2 July	9.00	20.1	20.3	20.1	20.1	20.1	20.1
3 July	9.00	20.2	20.1	20.0	20.1	20.1	20.1
4 July	9.00	20.3	19.9	20.2	20.2	20.0	20.1
5 July	9.00	20.1	20.0	20.1	20.3	20.1	20.1
6 July	9.00	20.0	20.0	20.3	20.1	20.2	20.2
7 July	9.00	20.2	20.4	20.1	20.0	20.2	20.2

Table 3 Trial 2. Selected produce temperatures during trial for both holding regimes

Time		Treatment 12 hr holding		36 hr holding	
		4 hr/6°C	4 hr/10°C	4 hr/6°C	4 hr/10°C
1 July	14.00	20.7	21.8	21.7	20.9
	16.00	22.1	22.2	22.3	22.6
	18.00	16.8	14.2	15.4	16.2
	20.00	10.6	9.4	9.9	10.3
	22.00	7.9	10.2	7.7	10.1
2 July	9.00	5.5	*9.6	5.9	9.9
	11.00	10.5		6.1	9.8
	13.00	14.6		6.1	10.1
3 July	9.00	21.4		6.3	*10.0
	11.00	20.7		10.9	
	13.00	20.2		15.1	
4 July	9.00	21.8		20.3	
5 July	9.00	20.5		20.8	
6 July	9.00	20.4		20.5	
7 July	9.00	20.0		20.3	
8 July	9.00			20.4	

*Disconnected when taken into shelf-life

Table 4 Trial 3. Selected produce temperature during trial for both holding regimes

Time		Treatment 12 hr holding		36 hr holding	
		4 hr/6°C	4 hr/10°C	4 hr/6°C	4 hr/10°C
22 July	14.00	23.3	23.4	22.8	23.2
	16.00	22.9	23.3	22.1	22.2
	18.00	17.6	18.4	20.7	19.4
	20.00	11.9	12.7	11.4	12.2
	22.00	7.8	10.1	7.1	9.9
23 July	9.00	5.5	10.3	5.4	10.2
	11.00	6.9		5.5	10.1
	13.00	14.5		5.4	10.1
24 July	9.00	20.0		5.4	10.1
	11.00	20.2		12.1	
	13.00	20.2		16.7	
25 July	9.00	20.5		20.0	
26 July	9.00	20.0		20.0	
27 July	9.00	20.2		20.2	
28 July	9.00	20.2		20.0	
29 July	9.00			20.0	

2. Weight loss during cooling, holding and shelf-life assessment

The data are given for Trials 1 to 3 in Tables 5 to 7, respectively. The cauliflower in Trial 1 in 1993 lost weight at a slower rate than those in the two 1994 trials, the latter two weight losses were very similar. This was presumably a function of the cauliflower, either a varietal factor or related to the condition of the produce at harvest.

Taking all these trials together, there was very little weight loss during cooling and in cool storage. There was only a slightly greater weight loss in 36 hr holding than 12 hr and the extra day in holding had no effect on weight loss in shelf-life, at least for the first five days. Only in the second trial was there a slight indication that getting produce cooled fast, within 2 hr of harvest, had any effect on weight loss in shelf life. There was no beneficial effect of cooling lower than 10°C in terms of weight loss in shelf-life.

Table 5 Percentage weight loss under holding and shelf-life conditions. Trial 1
Means of three replicates of eight cauliflower in each

Treatment	Days in shelf-life					
	0*	1	2	3	4	5
12 hour holding						
2 hr/6°C	1.3	4.9	7.6	9.5	11.4	13.4
2 hr/10°C	1.5	5.6	8.4	10.1	12.2	14.3
4 hr holding						
4 hr/6°C	1.3	4.9	7.8	9.8	11.8	14.2
4 hr/10°C	1.5	5.6	9.4	11.1	13.1	15.3
6 hr holding						
6 hr/6°C	1.5	5.0	7.8	9.7	11.8	13.9
6 hr/10°C	1.6	5.3	8.6	10.5	12.8	15.1
36 hour holding						
2 hr/6°C	1.6	5.1	6.9	9.4	11.6	14.5
2 hr/10°C	2.1	5.1	6.6	8.7	10.6	13.3
4 hr holding						
4 hr/6°C	2.3	4.6	6.4	8.4	10.6	12.9
4 hr/10°C	2.1	4.3	6.3	8.1	10.4	12.4
6 hr holding						
6 hr/6°C	1.9	5.5	7.5	9.9	12.3	15.1
6 hr/10°C	2.9	5.3	7.0	8.9	10.8	13.4
<u>Marginal means for time from harvest to cooling</u>						
2 hr prior to cooling	1.6	5.2	7.4	9.4	11.5	13.9
4 hr prior to cooling	1.8	4.9	7.5	9.4	11.5	13.7
6 hr prior to cooling	2.0	5.4	7.7	9.8	11.9	14.4
<u>Marginal means for final cooled temp</u>						
cooled to 6°C	1.7	5.0	7.3	9.5	11.6	14.0
cooled to 10°C	2.0	5.2	7.7	9.6	11.6	14.0
<u>Marginal means for length of holding</u>						
12 hr holding	1.5	5.2	8.3	10.1	12.2	14.4
36 hr holding	2.2	5.0	6.8	8.9	11.0	13.6

* = into shelf-life from DX store

Table 6 Percentage weight loss under holding and shelf-life conditions. Trial 2
Means of three replicates of eight cauliflowers in each

Treatment	Days in shelf-life					
	0	1	2	3	4	5
<u>12 hour holding</u>						
2 hr/6°C	1.2 isl	5.1	8.4	11.6	14.8	18.4
2 hr/10°C	0.9 isl	5.1	9.9	12.2	15.5	18.6
4 hr/6°C	1.7 isl	5.6	9.3	13.1	15.8	20.0
4 hr/10°C	1.6 isl	5.9	10.0	13.8	17.2	20.6
6 hr/6°C	2.0 isl	6.4	10.9	14.2	17.8	21.1
6 hr/10°C	2.1 isl	6.3	10.4	14.1	17.0	20.3
<u>36 hour holding</u>						
2 hr/6°C	2.4 isl	5.0	8.9	11.5	15.2	17.5
2 hr/10°C	2.1 isl	5.5	9.1	12.4	16.1	20.6
4 hr/6°C	2.3 isl	5.7	9.4	13.5	17.0	20.6
4 hr/10°C	2.4 isl	5.8	9.2	12.9	16.6	20.2
6 hr/6°C	2.5 isl	4.8	9.2	12.4	16.4	20.1
6 hr/10°C	2.6 isl	5.0	8.6	12.2	15.3	19.4
<u>Marginal means for time from harvest to cooling</u>						
2 hr prior to cooling	1.7 isl	5.2	8.9	11.9	15.4	18.8
4 hr prior to cooling	2.0 isl	5.8	9.5	13.3	17.1	20.4
6 hr prior to cooling	2.3 isl	5.6	9.8	13.2	16.6	20.2
<u>Marginal means for final cooled temp</u>						
cooled to 6°C	2.0 isl	5.4	9.4	12.7	16.2	19.6
cooled to 10°C	2.0 isl	5.6	9.5	12.9	16.3	20.0
<u>Marginal means for length of holding</u>						
12 hr holding	1.6 isl	5.7	9.7	13.2	16.4	19.8
36 hr holding	2.4 isl	5.3	9.1	12.5	16.1	19.7

isl = into shelf-life from DX store

Table 7 Percentage weight loss under holding and shelf-life conditions. Trial 3
Means of three replicates of eight cauliflowers in each

Treatment	Days in shelf-life					
	0	1	2	3	4	5
<u>12 hour holding</u>						
2 hr/6°C	1.2 isl	7.0	11.1	14.5	18.4	21.3
2 hr/10°C	1.4 isl	6.9	11.4	15.1	19.3	21.6
4 hr/6°C	1.4 isl	5.5	10.1	13.6	17.9	21.2
4 hr/10°C	1.7 isl	6.1	10.5	14.9	15.9	22.5
6 hr/6°C	1.8 isl	7.1	10.8	14.6	18.6	22.2
6 hr/10°C	1.5 isl	5.7	9.9	12.9	16.6	20.3
<u>36 hour holding</u>						
2 hr/6°C	1.7 isl	5.7	9.2	13.2	16.4	19.2
2 hr/10°C	1.8 isl	6.1	10.1	14.0	18.5	21.9
4 hr/6°C	2.1 isl	6.4	11.4	15.3	19.4	20.9
4 hr/10°C	2.2 isl	6.5	10.9	14.2	18.7	22.6
6 hr/6°C	2.2 isl	6.1	10.6	13.9	18.8	22.6
6 hr/10°C	2.2 isl	6.6	11.1	13.1	16.2	18.9
<u>Marginal means for time from harvest to cooling</u>						
2 hr prior to cooling	1.5 isl	6.4	10.4	14.2	18.1	21.0
4 hr prior to cooling	1.4 isl	6.1	10.7	14.5	18.7	21.0
6 hr prior to cooling	1.9 isl	6.4	10.6	13.7	17.5	21.0
<u>Marginal means for final cooled temp</u>						
cooled to 6°C	1.7 isl	6.3	10.5	14.2	18.3	21.2
cooled to 10°C	1.8 isl	6.3	10.7	14.5	18.0	21.3
<u>Marginal means for length of holding</u>						
12 hr holding	1.5 isl	6.4	10.6	14.3	18.2	21.5
36 hr holding	2.0 isl	6.2	10.5	14.0	18.0	21.0

isl = into shelf-life from DX store

3. Mean class deterioration in shelf-life

In previous trials the eight cauliflowers per replicate were weighed into shelf-life, inspected for produce downgraded to class 2, which was then discarded, and the remaining produce reweighed to be able to determine percentage weight loss over the period under inspection. The procedure was changed this year to try to improve the objectivity of records.

Each of the eight heads per crate were individually numbered so that their deterioration could be followed. Crates were inspected daily and heads classed into 1 & 2 or 3 when outclassed, and no heads were discarded until the end of the trial thus making percentage weight loss measurements more meaningful.

The mean rate of deterioration of cauliflower from Class 1 to outclassed are given in Tables 8 to 10 for Trials 1 to 3. As with the percentage weight loss results presented above, there is a distinct difference between Trial 1 which, up to day 6, still had marketable produce, and Trials 2 & 3 where a high proportion of produce was outclassed by day 4.

The length of time the produce was kept in the packhouse prior to cooling had no effect on product deterioration as recorded by class. In Trial 1 there was a slight suggestion that produce cooled to and held at 10°C deteriorated slightly faster than that cooled to 6°C, but this was not substantiated by Trials 2 & 3 where there was no difference between the two holding temperatures. However, as stated earlier, the produce in Trial 1 seems to have been of a superior material to the other two and so it cannot be absolutely discounted on this evidence that such produce may benefit from the lower holding temperature.

In Trial 1 holding for 36 hrs prior to shelf-life as opposed to 12 hrs had no detrimental effect until day 6 of shelf-life, when the former deteriorated rapidly. In Trial 2 this rapid deterioration took place on day 3, but in Trial 3 there was no difference in deterioration rate of produce held in cool store for 12 or 36 hrs.

However, on balance, the results suggest that holding an extra 24 hrs in cool store may affect shelf-life but in most cases this would be outside of the normal commercial shelf-life of the crop.

These observations were confirmed by the number of curds remaining in Class 1 with time and those outclassed (Tables 11 to 13). Not surprisingly the patterns are the same as Tables 8 to 10.

Reasons for downgrading each curd were recorded but are not presented in detail. It was mostly because of the expression of harvest damage or the development of disease, with looseness and curd discolouration also being important during the later part of the trials.

Table 8 Mean class of produce* under shelf-life conditions. Trial 1

Treatment	Days in shelf-life						
	0	1	2	3	4	5	6
<u>12 hour holding</u>							
2 hr/6°C	1.13	1.29	1.54	1.71	1.75	1.96	1.96
2 hr/10°C	1.04	1.21	1.50	1.54	1.67	1.96	2.04
4 hr/6°C	1.04	1.13	1.25	1.33	1.42	1.67	2.04
4 hr/10°C	1.17	1.33	1.38	1.67	1.75	1.79	2.00
6 hr/6°C	1.17	1.25	1.41	1.51	1.58	1.67	1.83
6 hr/10°C	1.04	1.33	1.71	1.83	2.04	2.25	2.50
<u>36 hour holding</u>							
2 hr/6°C	1.13	1.17	1.28	1.42	1.54	1.75	2.38
2 hr/10°C	1.38	1.42	1.63	1.83	1.92	2.29	2.63
4 hr/6°C	1.04	1.21	1.29	1.38	1.58	1.83	2.50
4 hr/10°C	1.08	1.08	1.17	1.25	1.38	1.50	2.58
6 hr/6°C	1.13	1.17	1.33	1.42	1.58	1.79	2.42
6 hr/10°C	1.08	1.21	1.29	1.29	1.67	2.13	2.67
<u>Marginal means for time from harvest to cooling</u>							
2 hr prior to cooling	1.17	1.27	1.49	1.63	1.72	1.99	2.25
4 hr prior to cooling	1.08	1.19	1.27	1.41	1.53	1.70	2.28
6 hr prior to cooling	1.10	1.24	1.44	1.51	1.72	1.96	2.35
<u>Marginal means for final cooled temp</u>							
cooled to 6°C	1.10	1.20	1.35	1.46	1.58	1.78	2.19
cooled to 10°C	1.13	1.26	1.45	1.57	1.74	1.99	2.40
<u>Marginal means for length of holding</u>							
12 hr holding	1.10	1.26	1.47	1.60	1.70	1.88	2.06
36 hr holding	1.14	1.21	1.32	1.44	1.61	1.88	2.53

*means of 8 heads classed as 1, 2 or 3; for example,
 1.04 = slightly poorer than Class I
 2.67 = approaching outclassed

Table 9 Mean class deterioration under shelf-life conditions. Trial 2

Treatment	Days in shelf-life						
	0	1	2	3	4	5	6
<u>12 hour holding</u>							
2 hr/6°C	1.11	1.15	1.15	1.59	2.48	2.96	3.00
2 hr/10°C	1.15	1.18	1.29	1.59	2.48	2.96	3.00
4 hr/6°C	1.04	1.07	1.11	1.41	2.18	2.67	2.95
4 hr/10°C	1.07	1.11	1.11	1.48	2.37	2.96	3.00
6 hr/6°C	1.11	1.07	1.11	1.70	2.52	2.89	3.00
6 hr/10°C	1.11	1.18	1.29	1.71	2.12	2.96	3.00
<u>36 hour holding</u>							
2 hr/6°C	1.22	1.37	1.78	2.26	2.93	2.95	3.00
2 hr/10°C	1.07	1.15	1.48	2.37	2.85	3.00	3.00
4 hr/6°C	1.00	1.07	1.48	2.29	2.82	3.00	3.00
4 hr/10°C	1.00	1.04	1.26	2.26	2.87	2.95	3.00
6 hr/6°C	1.18	1.18	1.52	2.18	2.78	3.00	3.00
6 hr/10°C	1.04	1.07	1.18	2.33	2.96	3.00	3.00
<u>Marginal means for time from harvest to cooling</u>							
2 hr prior to cooling	1.14	1.50	1.43	1.95	2.69	2.96	3.00
4 hr prior to cooling	1.03	1.07	1.24	1.86	2.56	2.90	2.99
6 hr prior to cooling	1.11	1.13	1.28	1.98	2.71	2.96	3.00
<u>Marginal means for final cooled temp</u>							
cooled to 6°C	1.11	1.15	1.36	1.91	2.62	2.91	2.99
cooled to 10°C	1.07	1.12	1.27	1.96	2.68	2.97	3.00
<u>Marginal means for length of holding</u>							
12 hr holding	1.10	1.13	1.18	1.58	2.10	2.90	2.99
36 hr holding	1.09	1.15	1.45	2.28	2.87	2.98	3.00

Table 10 Mean class deterioration under shelf-life conditions. Trial 3

Treatment	Days in shelf-life						
	0	1	2	3	4	5	6
<u>12 hour holding</u>							
2 hr/6°C	1.30	1.34	2.09	2.42	2.54	2.82	2.88
2 hr/10°C	1.17	1.25	2.09	2.50	2.75	2.88	3.00
4 hr/6°C	1.17	1.29	1.88	2.13	2.42	2.85	3.00
4 hr/10°C	1.33	1.50	2.29	2.67	2.92	3.00	-
6 hr/6°C	1.17	1.25	2.00	2.13	2.50	2.79	3.00
6 hr/10°C	1.00	1.00	1.38	1.92	2.21	2.67	2.96
<u>36 hour holding</u>							
2 hr/6°C	1.00	1.42	2.08	2.38	2.71	2.88	3.00
2 hr/10°C	1.00	1.29	1.88	2.13	2.71	2.82	3.00
4 hr/6°C	1.04	1.71	2.21	2.55	2.88	3.00	-
4 hr/10°C	1.00	1.00	1.63	2.13	2.63	3.00	-
6 hr/6°C	1.00	1.34	1.84	2.30	2.75	3.00	-
6 hr/10°C	1.04	1.92	2.29	2.32	2.57	3.00	-
<u>Marginal means for the time from harvest to cooling</u>							
2 hr prior to cooling	1.12	1.33	2.04	2.36	2.68	2.82	2.97
4 hr prior to cooling	1.14	1.38	2.00	2.37	2.71	2.96	3.00
6 hr prior to cooling	1.05	1.38	1.88	2.17	2.51	2.87	2.99
<u>Marginal means for final cooled tray</u>							
cooled to 6°C	1.11	1.39	2.02	2.72	2.63	2.89	2.98
cooled to 10°C	1.09	1.32	1.93	2.28	2.63	2.90	2.99
<u>Marginal means for length of holding</u>							
12 hr holding	1.19	1.27	1.96	2.30	2.56	2.84	2.97
36 hr holding	1.01	1.45	1.99	2.31	2.71	2.95	3.00

Table 11 Number of heads, out of 24, remaining in Class 1, with number outgraded in parenthesis. Trial 1

Treatment	Days in shelf-life						
	0	1	2	3	4	5	6
12 hour holding							
2 hr/6°C	21(0)	18(1)	14(3)	11(4)	10(4)	6 (5)	6 (5)
2 hr/10°C	23(0)	15(0)	13(1)	12(1)	9(1)	7 (6)	7 (8)
4 hr/6°C	23(0)	22(1)	20(1)	17(1)	15(1)	12 (4)	8 (9)
4 hr/10°C	20(0)	17(1)	16(2)	14(6)	13(7)	12 (7)	8 (9)
6 hr/6°C	20(0)	20(2)	16(2)	14(3)	13(3)	12 (4)	10 (6)
6 hr/10°C	23(0)	17(1)	12(5)	11(7)	6(7)	5(10)	3(15)
36 hour holding							
2 hr/6°C	21(0)	20(0)	17(0)	14(0)	12(1)	10 (4)	3(11)
2 hr/10°C	15(0)	14(1)	11(2)	9(5)	8(6)	6(13)	3(18)
4 hr/6°C	23(0)	16(1)	15(2)	14(2)	11(9)	6 (5)	2(13)
4 hr/10°C	22(0)	22(0)	21(1)	20(2)	18(3)	17 (5)	0(14)
6 hr/6°C	21(0)	20(0)	18(2)	16(2)	14(3)	10 (6)	2(12)
6 hr/10°C	22(0)	19(0)	17(0)	17(0)	10(2)	6 (8)	1(17)
<u>Marginal means for the time from harvest to cooling</u>							
2 hr prior to cooling	20.0(0)	16(0.5)	13.8(1.5)	11.5(2.5)	9.8(3.0)	7.3 (7.0)	4.8(10.5)
4 hr prior to cooling	22.0(0)	19(0.8)	18.0(1.5)	16.3(2.3)	14.3(3.8)	11.8 (5.3)	4.5(11.3)
6 hr prior to cooling	21.5(0)	19(0.8)	15.8(2.3)	14.5(3.0)	10.8(7.8)	8.3 (7.0)	4.0(12.5)
<u>Marginal means for final cooled temp</u>							
cooled to 6°C	21.5(0)	19.3(2.3)	16.7(1.7)	14.3(2.0)	12.5(2.7)	9.3 (4.7)	5.2 (9.3)
cooled to 10°C	20.8(0)	17.2(0.8)	15.0(1.8)	13.5(3.5)	10.7(4.3)	8.8 (8.2)	3.7(13.5)
<u>Marginal means for length of holding</u>							
12 hr holding	21.7(0)	18.2(1.0)	15.2(2.3)	13.2(3.7)	11.0(3.8)	9.0 (6.0)	7.0 (8.7)
36 hr holding	20.7(0)	18.5(0.5)	16.5(1.2)	15.0(1.8)	12.2(3.2)	9.2 (6.8)	1.8(14.2)

Table 12 Number of heads, out of 24, remaining in Class 1, with number outgraded in parenthesis. Trial 2

Treatment	Days in shelf-life						
	0	1	2	3	4	5	6
12 hour holding							
2 hr/6°C	21(0)	21(1)	13(1)	6 (1)	1(18)	0(23)	0(24)
2 hr/10°C	22(0)	21(0)	18(1)	15 (3)	0(11)	0(23)	0(24)
4 hr/6°C	23(0)	22(1)	22(1)	18 (3)	4 (8)	0(21)	0(23)
4 hr/10°C	22(0)	21(0)	21(0)	13 (2)	0(10)	0(23)	0(24)
6 hr/6°C	21(0)	21(0)	18(1)	6 (8)	1(16)	0(23)	0(24)
6 hr/10°C	22(1)	20(1)	19(3)	11 (5)	0(14)	0(23)	0(24)
36 hour holding							
2 hr/6°C	21(1)	19(3)	11(6)	3 (9)	0(22)	0(22)	0(24)
2 hr/10°C	22(0)	22(1)	17(3)	0(10)	0(19)	0(24)	-
4 hr/6°C	24(0)	22(0)	14(2)	1 (8)	0(21)	0(24)	-
4 hr/10°C	24(0)	23(0)	19(2)	2 (8)	0(21)	0(23)	0(24)
6 hr/6°C	19(0)	19(0)	16(4)	2 (7)	0(19)	0(24)	-
6 hr/10°C	23(0)	23(1)	20(1)	0 (9)	0(23)	0(24)	-
<u>Marginal means for the time from harvest to cooling</u>							
2 hr prior to cooling	21.5(0.3)	20.8(1.3)	14.8(3.8)	6.0 (5.8)	0.3(16.3)	0(23.0)	0(24.0)
4 hr prior to cooling	23.3(0)	22.0(0.3)	19.0(1.3)	8.5 (5.3)	1.0(15.0)	0(22.8)	0(23.8)
6 hr prior to cooling	21.3(0.3)	20.8(0.5)	15.3(2.3)	4.8 (7.3)	0.3(18.0)	0(23.5)	0(24.0)
<u>Marginal means for final cooled temp</u>							
cooled to 6°C	21.5(0.2)	20.7(0.8)	15.7(2.5)	6.0 (6.0)	1.0(16.5)	0(22.8)	0(23.8)
cooled to 10°C	22.5(0.2)	21.7(0.5)	19.0(1.7)	6.8 (6.2)	0(16.3)	0(23.3)	0(24.0)
<u>Marginal means for length of holding</u>							
12 hr holding	21.8(0.2)	21.0(0.5)	18.5(1.2)	11.5 (3.7)	1.0(12.0)	0(22.7)	0(23.8)
36 hr holding	22.2(0.2)	21.3(0.8)	16.2(3.0)	1.3 (8.5)	0(20.8)	0(23.8)	0(24.0)

Table 13 Number of heads, out of 24, remaining in Class 1, with number outgraded in parenthesis. Trial 3.

Treatment	Days in shelf-life						
	0	1	2	3	4	5	6
12 hour holding							
2 hr/6°C	16(2.0)	16(2)	7(10)	2(13)	1(14)	0(21)	0(23)
2 hr/10°C	20(4.0)	19(4)	7 (9)	1(13)	0(18)	0(22)	0(24)
4 hr/6°C	20(3.0)	19(3)	10 (7)	5 (8)	1(11)	0(20)	0(24)
4 hr/10°C	16(1.0)	13(2)	4(11)	0(16)	0(22)	0(24)	-
6 hr/6°C	18(2.0)	16(2)	7 (8)	4 (9)	1(16)	0(19)	0(24)
6 hr/10°C	24(0.0)	23(0)	15 (1)	6 (5)	3 (9)	0(16)	0(23)
36 hour holding							
2 hr/6°C	24(0.0)	14(2)	7 (9)	2(11)	1(18)	0(22)	0(24)
2 hr/10°C	24(0.0)	15(0)	3 (1)	2 (5)	0(17)	0(21)	0(24)
4 hr/6°C	21(0.0)	9(3)	1 (6)	0(13)	0(21)	0(24)	-
4 hr/10°C	23(0.0)	20(1)	11 (5)	3 (8)	0(15)	0(24)	-
6 hr/6°C	22(0.0)	14(2)	7 (4)	2 (9)	0(18)	0(24)	-
6 hr/10°C	20(1.0)	6(5)	4(12)	3(16)	1(18)	0(24)	-
<u>Marginal means for the time from harvest to cooling</u>							
2 hr prior to cooling	21.0(1.5)	16.0(2.0)	6.0 (7.3)	1.5(10.5)	0.5(16.8)	0(21.3)	0(23.8)
4 hr prior to cooling	20.0(1.0)	15.3(2.3)	6.5 (7.3)	2.0(11.3)	0.3(17.3)	0(23.0)	0(24.0)
6 hr prior to cooling	21.0(0.8)	14.8(2.3)	8.3 (6.5)	3.8 (9.8)	1.3(15.3)	0(20.8)	0(23.8)
<u>Marginal means for final cooled temp</u>							
cooled to 6°C	20.2(1.2)	14.7(2.3)	6.5 (7.3)	2.5(10.5)	0.7(16.3)	0(21.7)	0(23.8)
cooled to 10°C	21.2(1.0)	16.0(2.0)	7.3 (6.5)	2.5(10.5)	0.7(16.5)	0(21.8)	0(23.8)
<u>Marginal means for length of holding</u>							
12 hr holding	19.0(2.0)	16.7(2.2)	8.3 (7.7)	3.0(10.7)	1.0(15.0)	0(20.3)	0(23.7)
36 hr holding	22.3(0.2)	14.6(2.2)	5.5 (6.2)	2.0(10.3)	0.3(17.8)	0(25.2)	0(24.0)

Conclusions

1. Cauliflowers marketed under high temperatures had a shelf-life of three to six days, in the most part depending on the initial produce.
2. There was no detrimental effect of increasing the time from harvest to cooling, to at least six hours.
3. Little benefit was observed by using a 6°C holding temperature instead of 10°C.
4. The extended period in the holding temperature did adversely affect subsequent shelf-life on two out of the three occasions.
5. The overriding conclusion that comes from this work, is that it is much more important to pack quality produce, than anything that can be done subsequently in terms of rapid cooling or lower holding temperatures.

RECOMMENDATIONS FOR FURTHER WORK

None at present but it would be interesting to repeat this with an ambient (ie. non cooled) control.

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