J. Agric. Sci. Mansoura Univ., 28 (3): 2139 - 2159, 2003

EFFECTS OF TEMPERATURE AND WRAPPING ON MAINTENANING POSTHARVEST QUALITY OF SOME BROCCOLI CULTIVARS

El- Bassiouny, R. E. I. [1]; S.F. El-Sayed[2]; E.A. Abo El-Hassan[2] and A. S. Hasan[1]

[1] **Vegetable Handling Department, Horticulture Research Institute, Agriculture Research Center. Giza.**

[2] **Vegetable Crops Department, Faculty of Agriculture, Cairo University. Giza**

ABSTRACT

This work was done to study the effect of storage temperature and film-head wrapping on the postharvest appearance and compositional quality changes of $F_1$0175 and Landmark broccoli cultivars. Wrapped and unwrapped samples were stored at refrigerated storage (0°C or 5°C and 90-95 % RH) or at room temperature (about 20°C and 60 % RH). The latter samples were monitored daily while batches stored at 0°C and 5°C were sampled at 5 days intervals, including one day at retail conditions (15°C). Changes in weight loss, visual quality and chlorophyll, ascorbic acid and protein contents were used to access broccoli deterioration. The results show that higher temperatures accelerated the rate of deterioration of stored samples. Film wrapping was effective in retarding loss of quality throughout the storage period, and helped in retarding deterioration when temperature cannot be maintained near 0°C. Wrapped Landmark held at 0°C was the best treatment for long-term maintenance of quality, whereas unwrapped $F_1$0175 held at room temperature was the worst.

Key words: *Brassica oleracea*, temperature, wrapping, storage, quality, chlorophyll, ascorbic, protein.

INTRODUCTION

Broccoli (*Brassica oleracea* L., Italica group) is a floral organ containing immature tissue that is actively growing at harvest. When harvested, the floral apices are separated from nutrients, hormones and energy supplied by leaves and roots. Consequently, broccoli florets senesce rapidly as is typical of commodities harvested before physical growth has ceased (Huber, 1987; Tian *et al.*, 1994 and 1997; Fan and Mattheis, 2000).

Major physiological and biochemical changes occur in broccoli after harvest. Water loss result not only in appreciable weight loss but also in less attractive broccoli of poorer texture and soft tissues, and lowered quality (Hardenburg *et al.*, 1986; Brennan and Shewfelt, 1989; Toivonen, 1997). The most obvious characteristic of broccoli post harvest senescence is sepal degreening due to chlorophyll degradation (Shewfelt *et al.*, 1984; Rushing, 1990; King and Morris, 1994a; Tian *et al.*, 1994; Yamauchi and Watada, 1998). In addition, rapid decline in protein and vitamin C content occur as broccoli deteriorate (Toivonen, 1992; King and Morris, 1994b; Tian *et al.*, 1997; Lee and Kader, 2000)

Cooling to 0°C is the primary mean of maintaining good salable conditions, fresh green color and vitamin C content (Hardenburg *et al.*, 1986;

Brennan and Shewfelt, 1989;Forney *et al.*, 1989; Gillies and Toivonen, 1995; Forney, 1995; Pogson and Morris, 1997). When broccoli is stored at 0°C with 95% relative humidity, quality can be maintained for 2 to 4 weeks (Ryall and Lipton, 1979; Hardenburg *et al.*, 1986; Makhlouf *et al.*, 1989; Cantwell and Kasmir, 2002). On the other hand, storing broccoli at less favorable conditions will accelerate quality deterioration (Brennan and Shewfelt, 1989; Forney and Rij, 1991; Zhuang *et al.*, 1997). When held at ambient temperature, broccoli will yellow and become unmarketable in 1-3 days (Makhlouf *et al.*, 1989; King and Morris, 1994a; Forney, 1995; Pogson and Morris, 1997 ; Cantwell and Kasmir, 2002).

Utilization of permeable polymeric films to achieve modification of package atmospheric gases concentration offer ample potential to extend broccoli shelf life (El Kashif *et al.*, 1983; Forney *et al.*, 1989, Forney and Rij, 1991; Schlimme and Rooney, 1994). Atmospheric modification within a package develops as a result of the respiration rate of the plant tissue and gas diffusion characteristics of the film (Forney *et al.*, 1989; Forney and Rij, 1991; Kader *et al.*, 1989; Schlimme and Rooney, 1994 ; Kader, 2002).

Wrapping broccoli in polymeric films retards water loss, (Rij and Ross 1987; Forney *et al.*, 1989) enhances maintenance of visual quality, (Rij and Ross 1987; Forney *et al.*, 1989; Barth *et al.*, 1993 a) retention of green color and total chlorophyll content (Shewfelt *et al.*, 1983; Rij and Ross 1987; Barth *et al.*, 1993a, b and c) and minimizes the loss of protein and vitamin C content (Barth *et al.*, 1993 a, b and c; Lee and Kader, 2000).

Although, broccoli is of a high nutritional value and its production and consumption has increased sharply in many countries, it is not well known in Egypt, where it is newly introduced and information on the post harvest behavior of broccoli under Egyptian conditions is scarce.

This study has been conducted to evaluate the effects of cultivars, storage temperatures and wrapping on the maintenance of broccoli postharvest quality.

MATERIALS AND METHODS

Landmark and $F_1$0175 broccoli plants were grown at Kaha Experimental Station, Horticulture Research Institute, Agriculture Research Center, during the two seasons of 1997- 1998 and 1998- 1999. Culture practices recommendations were followed whenever needed, according to Hassan, (1989). At maturity, heads were harvested, stripped of remaining leaves and transported to the laboratory within two hours of harvest. The heads were immediately stored and kept overnight at 0°C with 90- 95 % relative humidity. The following morning one half of the heads of each cultivar was left unwrapped and the other half was wrapped individually in a polyvinyl chloride (PVC) stretch film (Pro-Pack, Italy), then edges were sealed with a hot-plate sealer machine. Each head either wrapped or unwrapped was weighted, labeled and placed in carton box, each box contained three heads. Samples were stored either at refrigerated storage (0°C or 5°C and 90-95 % RH) or at room temperature (about 20°C and 60 % RH). The latter samples

were monitored daily while the cold stored broccoli samples were examined every 5 days as follows: after 4, 9, 14, 19 and 24 days of cold storage, three randomly selected boxes of each treatment were transferred to retail storage temperature (15°C) for an additional 24 hours before evaluation. This represented a total storage of 5, 10, 15, 20 and 25 days, respectively.

All broccoli of the two seasons were represented in three replicates (comprised of 3 heads each) and devoted to the following physical and chemical analysis before and after storage.

Weight loss percentage was estimated according to the following equation: Weight loss % = [{(initial weight of heads- weight of heads at sampling date) / initial weight of heads} x 100].

Visual quality was determined using the following rating score system: 9 = Excellent, 7 = Good, 5 = Fair, 3 = Poor, 1 = Unusable, (Kasmire *et al.*, 1974; Forney and Rij, 1991; Able *et al.*, 2002), which depends on whether there is any morphological defects such as shriveling, limpness, loss of compactness or color, floret opening and presence of physiological and pathological defects.

The term "storage life" refers to the time required for the sample to deteriorate from a rating of 9 (field fresh) to 3 (poor) (Watada and Morris, 1996).

Total chlorophyll was determined using fresh samples of the florets (Ranganna, 1979).

Ascorbic acid was determined using fresh samples of the florets (Ranganna, 1979).

Total protein was determined using dry samples (Koch Mcmeekin, 1924).

Statistical Analysis: The experiment was a factorial completely randomized design with three replicates. The data were tabulated and analyzed for statistical significant differences using the LSD test at 0.05 level of significance, according to Snedecor and Cochran (1989).

RESULTS

1. Effects of Cultivars and Wrapping on Broccoli Stored at Room Temperature.

Weight loss. The results in Table (1) indicate that weight loss at room temperature was significantly affected by cultivar, wrapping and storage time. During the three days of storage, the $F_1$0175 cultivar had higher weight loss percentage when compared with Landmark. Wrapping greatly affected weight loss. Regardless of cultivar, unwrapped heads lost 5.25% and 5.23% of their weight in 1997-1998 and 1998-1999, respectively after 2 days of storage.

Visual quality. The results in Table (2) show a continuous significant loss in visual quality with extending storage in both seasons. Cultivar Landmark surpassed $F_1$0175 in visual quality during storage. Wrapping was effective in minimizing loss of quality for both cultivars.

Total chlorophyll content. The results in Table (3) reveal that cultivar, wrapping and storage time had significant effects on chlorophyll content.

Table (1): Effect of cultivar and wrapping on broccoli weight loss percentage during storage at room temperature in 1997-1998 and 1998-1999 seasons.

Seasons		1997-1998				1998-1999				Grand average
cvs.	Treatments	1 day	2 days	3 days	Average	1 day	2 days	3 days	Average	
F1 0175	Wrapped	1.29	2.02	3.14	2.15	1.11	2.10	3.30	2.17	2.16
	Unwrapped	2.91	5.91	10.21	6.34	2.76	5.88	10.22	6.28	6.31
	Average	2.10	3.96	6.67	4.24	1.94	3.99	6.76	4.21	4.22
Land mark	Wrapped	0.66	1.84	1.87	1.45	0.81	1.39	2.00	1.40	1.42
	Unwrapped	1.68	4.59	8.27	4.84	1.68	4.57	8.51	4.92	4.88
	Average	1.17	3.22	5.07	3.15	1.24	2.98	5.25	3.16	3.15

Significance for weight loss% during 3 days of storage. LSD at 0.05%

Cultivar (CV)	**0.86**	**0.91**
Wrapped (W)	**1.85**	**1.11**
Days (D)	**0.38**	**0.44**
W X CV	**0.44**	**0.50**
D X CV	**0.54**	**0.62**
D X W	**0.54**	**0.62**
D X W X CV	**0.77**	**0.88**

Table (2): Effect of cultivar and wrapping on broccoli visual quality during storage at room temperature in 1997-1998 and 1998-1999 seasons.

Seasons		1997-1998				1998-1999				Grand average
Cvs.	Treatments	1 day	2 days	3 days	Average	1 day	2 days	3 days	Average	
F1 0175	Wrapped	7.00	5.00	3.00	5.00	7.00	5.00	3.00	5.00	5.00
	Unwrapped	4.33	2.33	1.00	2.55	5.00	2.30	1.00	2.76	2.65
	Average	5.66	3.66	2.00	3.77	6.00	3.65	2.00	3.88	3.82
Land mark	Wrapped	7.00	5.00	3.00	5.00	7.00	4.33	3.00	4.77	4.88
	Unwrapped	5.66	3.66	1.00	3.44	5.66	3.66	1.00	3.44	3.44
	Average	6.33	4.33	2.00	4.22	6.33	3.99	2.00	4.10	4.16

Significance for total chlorophyll content during 3 days of storage. LSD at 0.05%

Cultivar (CV)	0.40	n.s
Wrapped (W)	0.96	0.96
Days (D)	0.56	0.56
W X CV	0.64	0.64
D X CV	0.79	0.79
D X W	0.79	0.79
D X W X CV	1.12	1.12

V. Q was evaluated using a 1-9 scale. With 9= Excellent or having a freshly harvested appearance (i.e. dark green, compact head, no defects), and 1= unusable (i.e. showing yellowing, loose florets and major defects)

Table (3): Effect of cultivar and wrapping on broccoli total chlorophyll content (mg/100 g fresh weight) during storage at room temperature in 1997-1998 and 1998-1999 seasons.

Seasons		1997-1998					1998-1999					Grand
cvs.	Treatments	0 day	1 day	2 days	3 days	Average	0 day	1 day	2 days	3 days	Average	average
F1 0175	Wrapped	30.64	28.08	22.59	15.43	22.03	31.01	28.56	26.41	16.48	23.82	22.93
	Unwrapped	30.64	26.12	22.18	14.18	20.83	31.01	26.49	22.42	13.26	20.72	20.78
	Average	30.64	27.10	22.39	14.81	21.43	31.01	27.53	24.41	14.87	22.27	21.85
Land mark	Wrapped	25.56	22.50	19.16	15.15	18.94	25.65	22.83	20.71	14.89	19.47	19.21
	Unwrapped	25.56	20.00	17.71	13.18	16.96	25.65	21.55	17.55	12.06	17.05	17.01
	Average	25.56	21.25	18.44	14.17	17.95	25.65	22.19	19.13	13.47	18.26	18.11

Significance for visual quality during 3 days of storage. LSD at 0.05%

Cultivar (CV)	0.38	0.41
Wrapped (W)	0.38	0.41
Days (D)	0.47	0.50
W X CV	0.54	0.58
D X CV	0.66	0.71
D X W	0.66	0.71
D X W X CV	0.94	1.01

Chlorophyll content was (30.64 & 31.01) and (25.56 & 25.56) for $F_1$0175 and Landmark, respectively, in both seasons, and diminished gradually with the elapse of days. Chlorophyll degradation was higher in unwrapped heads than wrapped ones and this result holds true for both cultivars during storage.

Ascorbic acid content. The results in Table (4) reveal that cultivar, wrapping and storage time had significant effects on ascorbic acid content. Landmark contained higher ascorbic acid than $F_1$0175. Wrapped broccoli was higher in ascorbic acid content than unwrapped heads. Regardless of cultivar, the loss in ascorbic acid of wrapped broccoli was 32.7% and 33.9% for the two seasons, respectively, while that of unwrapped heads was 47.0% and 46.2%.

Protein content. The results in Table (5) show that there was a significant declining trend in protein content in all treatments during storage. The percentage of decrement in protein content for $F_1$0175 was higher than that for Landmark after 3 days of storage. Moreover, protein degradation was higher in unwrapped broccoli heads during the 3 days of storage.

2. Effects of Cultivars and Wrapping on Broccoli Stored at Refrigerated Temperatures.

Weight loss. The results in Table (6) demonstrate the effects of temperature and wrapping on the weight loss of the two broccoli cultivars. Stored broccoli heads showed significant weight loss as the storage period extended, the highest weight loss values were obtained at the end of storage. A varietal difference was detected between the two cultivars. The loss in weight was lower for Landmark than $F_1$0175. The loss in weight of wrapped $F_1$0175 reached 6.75 and 6.98 after 25 days of storage at 0°C, while that of Landmark was 3.16 and 4.53 at 0°C and reached 5.16 and 5.60 after the same period at 5°C. The results also reveal that temperature had a significant effect on weigh loss. Low temperature (0°C) proved to be effective in reducing the percentage of weight loss during the whole storage time. The rate of weight loss tended to be higher with high temperature. Wrapping had a more striking effect on reducing weight loss. During the first 10 days of storage, the loss in weight was significantly less for wrapped samples, which lasted longer than unwrapped heads.

Visual quality. The results in Table (7) indicate that visual quality decreased progressively as the storage period was prolonged. The results also show that the rate of decrement in visual quality was higher for $F_1$0175 than Landmark. After 25 days of storage at 0°C, wrapped $F_1$0175 broccoli became unusable while wrapped Landmark was fair and became unusable when stored at 5°C for the same period. Broccoli heads stored at 0°C were visually better than those stored at 5°C, especially when extending the storage period. Visual quality was significantly maintained by wrapping. During storage, wrapped broccoli had higher visual quality values as compared with unwrapped heads, this holds true for both cultivars at the two temperatures.

Total chlorophyll content. The results in Table (8) show that storing broccoli heads resulted in a significant decrease in head chlorophyll content, a general trend of decrease took place till the last storage period

Table (4): Effect of cultivar and wrapping on broccoli ascorbic acid content (mg/100 g fresh weight) during storage at room temperature in 1997-1998 and 1998-1999 seasons.

Seasons		1997-1998					1998-1999					Grand
cvs.	Treatments	0 Day	1 Day	2 Days	3 Days	Average	0 Day	1 Day	2 Days	3 Days	Average	average
F1 0175	Wrapped	110.7	97.14	91.03	79.51	89.23	112.1	97.31	87.72	75.38	86.80	88.02
	Unwrapped	110.7	97.81	72.18	55.37	75.12	112.1	91.50	82.20	56.37	76.69	75.91
	Average	110.7	97.48	81.61	67.44	82.18	112.1	94.41	84.96	65.88	81.75	81.97
Land mark	Wrapped	113.3	99.17	85.71	71.34	85.41	116.0	98.64	82.33	75.37	85.45	85.43
	Unwrapped	113.3	87.55	74.47	63.23	75.08	116.0	89.31	78.48	66.30	78.03	76.56
	Average	113.3	93.36	80.09	67.29	80.25	116.0	93.98	80.41	70.84	81.74	80.99

Significance for ascorbic acid content during 3 days of storage. LSD at 0.05%

Cultivar (CV)	0.48	0.40
Wrapped (W)	0.48	0.40
Days (D)	0.67	0.56
W X CV	0.78	0.65
D X CV	0.95	0.80
D X W	0.95	0.80
D X W X CV	1.35	1.13

Table (5): Effect of cultivar and wrapping on broccoli protein content (g/100 g fresh weight) during storage at room temperature in 1997-1998 and 1998-1999 seasons.

Seasons		1997-1998					1998-1999					Grand
cvs.	Treatments	0 Days	1 Days	2 Days	3 Days	Average	0 Days	1 Days	2 Days	3 Days	Average	average
F1 0175	Wrapped	32.62	30.29	29.28	28.32	29.29	32.23	29.96	29.07	27.97	29.00	29.14
	Unwrapped	32.62	28.38	27.26	26.02	27.22	32.23	28.42	26.42	25.81	26.88	27.05
	Average	32.62	29.33	28.27	27.17	28.25	32.23	29.19	27.75	26.89	27.94	28.09
Land mark	Wrapped	31.06	30.44	29.12	28.08	29.21	31.34	30.50	29.01	28.88	29.46	29.33
	Unwrapped	31.06	27.94	25.57	24.93	26.14	31.34	28.07	26.21	25.02	26.43	26.29
	Average	31.06	29.19	27.34	26.50	27.67	31.34	29.28	27.61	26.95	27.94	27.80

Significance for protein content during 3 days of storage. LSD at 0.05%

Cultivar (CV)	0.33	0.19
Wrapped (W)	0.40	0.38
Days (D)	0.19	0.15
W X CV	0.22	0.18
D X CV	0.27	0.22
D X W	0.27	0.22
D X W X CV	0.32	0.31

Table (6): Effect of cultivar and wrapping on broccoli weight loss percentage during storage at low temperatures + one day at 15°C in 1997-1998 and 1998-1999 seasons.

CVs.	Seasons / Treatments	day	1997-1998 5	10	Aver.	15	20	25	1998-1999 5	10	Aver.	15	20	25	Grand average
F1 0175	0 °C	wrapped	0.61	1.18	0.89	1.70	3.14	6.75	0.72	1.44	1.08	1.77	3.47	6.98	0.98
		unwrapped	3.91	6.26	5.08	-	-	-	3.93	6.21	5.07	-	-	-	5.07
	Average		2.26	3.72	2.99				2.32	3.82	3.07				3.03
	5 °C	wrapped	1.19	1.92	1.55	3.18	5.18	-	1.08	2.29	1.68	3.73	5.90	-	1.61
		unwrapped	4.02	9.02	6.52	-	-	-	4.15	9.90	7.02	-	-	-	6.77
	Average		2.60	5.47	4.03				2.61	6.09	4.35				4.19
	Mean average		2.43	4.60	3.51				2.46	4.95	3.72				3.61
Landmark	0 °C	wrapped	0.75	0.83	0.79	1.15	2.03	3.16	0.78	0.91	0.84	1.29	2.84	4.53	0.81
		unwrapped	2.94	4.13	3.53	5.75	-	-	2.92	4.39	3.65	6.00	-	-	3.59
	Average		1.84	2.48	2.16	3.45			1.85	2.65	2.24	3.64			2.20
	5 °C	wrapped	0.82	1.43	1.12	2.17	3.76	5.16	0.84	1.60	1.22	2.36	3.51	5.60	1.17
		unwrapped	3.97	7.91	5.94	-	-	-	3.76	7.30	5.53	-	-	-	5.73
	Average		2.39	4.67	3.53				2.30	4.45	3.37				3.45
	Mean average		2.11	3.57	2.84				2.07	3.55	2.81				2.83
Grand average			2.27	4.08	3.17				2.26	4.25	3.26				3.22

Significance for weight loss% during 1st ten days of storage. LSD at 0.05%

	1997-1998	1998-1999
Temperature (T)	0.35	0.43
Wrapping (W)	0.43	0.56
Cultivar (CV)	n.s	n.s
Days (D)	0.38	0.45
T X W	0.29	0.33
T X CV	0.29	0.33
W X CV	0.29	0.33
D x CV	0.29	0.33

Table (7): Effect of cultivar and wrapping on broccoli visual quality during storage at low temperatures + one day at 15°C in 1997-1998 and 1998-1999 seasons.

CVs.	seasons		1997-1998						1998-1999						Grand average
	Treatments	day	5	10	Aver.	15	20	25	5	10	Aver.	15	20	25	
F1 0175	0 °C	wrapped	9.00	9.00	9.00	9.00	5.00	1.00	9.00	9.00	9.00	8.33	4.33	1.00	9.00
		unwrapped	5.00	1.00	3.00	-	-	-	5.00	3.00	4.00	-	-	-	3.50
	Average		7.00	5.00	6.00				7.00	6.00	6.50				6.25
	5 °C	wrapped	9.00	9.00	9.00	5.00	1.00	-	9.00	8.33	8.66	4.33	1.00	-	8.83
		unwrapped	4.33	1.00	2.66	-	-	-	4.33	1.66	2.99	-	-	-	2.82
	Average		6.66	5.00	5.83				6.66	4.99	5.82				5.82
	Mean average		6.83	5.00	5.91				6.83	5.49	6.16				6.03
Landmark	0 °C	wrapped	9.00	9.00	9.00	9.00	7.00	5.00	9.00	9.00	9.00	9.00	6.33	4.33	9.00
		unwrapped	6.33	4.33	5.33	1.00	-	-	6.33	3.66	4.99	1.00	-	-	5.16
	Average		7.66	6.66	7.16	5.00			7.66	6.33	6.99	5.00			7.07
	5 °C	wrapped	9.00	9.00	9.00	7.00	3.00	1.00	9.00	9.00	9.00	6.33	4.33	1.00	9.00
		unwrapped	5.00	3.00	4.00	-	-	-	5.66	3.66	4.66	-	-	-	4.33
	Average		7.00	6.00	6.50				7.33	6.33	6.83				6.66
	Mean average		7.33	6.33	6.83				7.49	6.33	6.91				6.87
Grand average			7.08	5.66	6.37				7.16	5.91	6.53				6.45

Significance for visual quality during 1st ten days of storage. LSD at 0.05%

	1997-1998	1998-1999
Temperature (T)	0.65	n.s.
Wrapping (W)	0.53	1.08
Cultivar (CV)	0.41	n.s.
Days (D)	0.62	0.98
T X W	0.41	0.89
T X CV	0.41	0.89
W X CV	0.41	0.89
D x CV	0.41	0.89

V. Q was evaluated using a 1-9 scale. With 9= Excellent or having a freshly harvested appearance (i.e. dark green, compact head, no defects), and 1= unusable (i.e. showing yellowing, loose florets and major defects)

Table (8): Effect of cultivar and wrapping on broccoli total chlorophyll content (mg/100 g fresh weight) during storage at low temperatures + one day at 15°C in 1997-1998 and 1998-1999 seasons.

CVs.	Treatments (seasons)	day	1997-1998 0	5	10	Aver.	15	20	25	1998-1999 0	5	10	Aver.	15	20	25	Grand average
F1 0175	0 °C	wrapped	30.64	28.95	27.05	28.00	17.19	14.32	11.98	31.01	28.64	27.35	27.99	17.04	13.27	11.87	28.00
		unwrapped	30.64	26.27	20.72	23.50	-	-	-	31.01	26.06	20.40	23.23	-	-	-	23.37
	Average		30.64	27.61	23.89	25.75				31.01	27.35	23.87	25.61				25.68
	5 °C	wrapped	30.64	24.43	21.30	22.86	12.29	10.67	-	31.01	24.66	21.15	22.91	12.14	10.78	-	22.89
		unwrapped	30.64	19.43	10.29	14.86	-	-	-	31.01	18.74	10.60	14.67	-	-	-	14.77
	Average		30.64	21.93	15.80	18.86				31.01	21.70	15.88	18.79				18.83
	Mean average		30.64	24.77	19.84	22.30				31.01	24.52	19.88	22.20				22.25
Landmark	0 °C	wrapped	25.56	25.07	19.47	22.27	15.94	12.88	10.51	25.65	25.46	20.40	22.93	17.74	14.59	11.86	22.60
		unwrapped	25.56	23.63	17.70	20.67	13.57	-	-	25.65	22.27	18.72	20.49	15.75	-	-	20.58
	Average		25.56	24.35	18.58	21.47				25.65	23.86	19.56	21.71				21.59
	5 °C	wrapped	25.56	24.02	19.13	21.58	14.18	11.64	9.78	25.65	22.35	18.43	20.39	15.64	14.24	11.94	20.99
		unwrapped	25.56	22.64	16.15	19.40	-	-	-	25.65	19.58	18.29	18.94	-	-	-	19.17
	Average		25.56	23.33	17.64	20.49				25.65	20.97	18.36	19.66				20.07
	Mean average		25.56	23.84	18.11	20.98				25.65	22.41	18.96	20.68				20.83
Grand average			25.56	24.31	18.98	21.64				25.65	23.47	19.42	21.45				21.54

Significance for total chlorophyll content during 1st ten days of storage. LSD at 0.05%

	1997-1998	1998-1999
Temperature (T)	0.22	0.28
Wrapping (W)	0.22	0.28
Cultivar (CV)	0.22	0.28
Days (D)	0.22	0.28
T X W	0.35	0.48
T X CV	0.35	0.48
W X CV	0.35	0.48
D x CV	0.35	0.48

The results also reveal the presence of a significant difference in chlorophyll content in favor of $F_1$0175 over Landmark. Irrespective of cultivars or wrapping, the data indicate that storing broccoli at 0°C was significantly effective in decreasing the loss in chlorophyll content as compared with 5°C. Wrapped heads contained significantly higher chlorophyll content than unwrapped heads. Wrapping was effective in arresting the loss in chlorophyll and became more prominent as temperature and storage time increased. At the end of storage, chlorophyll content of wrapped broccoli held at 0°C were almost comparable for both cultivars, though $F_1$0175 contained higher chlorophyll content at the beginning.

Ascorbic acid content. The results in Table (9) show that ascorbic acid content has significantly declined as the storage period extended. $F_1$0175 contained lower ascorbic acid content when compared with Landmark. Both temperature and wrapping had significant effects on ascorbic acid content. The highest ascorbic acid content was detected in wrapped broccoli stored at 0°C for both cultivars.

Protein content. The results in Table (10) reveal that protein content decreased gradually towards the end of storage period. Landmark retained higher protein content after 10 days of storage when compared with $F_1$0175, though the latter was higher in its content at the beginning of the storage. This indicates that protein degradation was much greater in $F_1$0175. Storing broccoli at 0°C and wrapping decreased the loss in protein content for both cultivars during the storage.

3. Correlation among various physical and chemical characters

Table (11) gives Pearson's pairwise correlation coefficients between the various physical and chemical traits of broccoli heads. The correlation coefficients are all highly significant at the 0.001 level, and are fairly high in absolute values indicating fairly strong relationships among the various characters. In fact, while visual quality, chlorophyll, ascorbic acid and protein content are inversely (negatively) related to weight loss, they are positively related to each other, and this holds true at both room and refrigerated temperatures. The correlation coefficients were similar in magnitude for the two cultivars, except that the relationship between chlorophyll content and each of the other traits seems to be a bit stronger for $F_1$0175 compared with Landmark at cold temperature.

Table (9): Effect of cultivar and wrapping on broccoli ascorbic acid content (mg/100 g fresh weight) during storage at low temperatures + one day at 15°C in 1997-1998 and 1998-1999 seasons.

CVs.	Treatments	day	1997-1998 0	5	10	Aver.	15	20	25	1998-1999 0	5	10	Aver.	15	20	25	Grand average
F1 0175	0 °C	wrapped	110.7	99.18	92.70	95.94	80.37	73.33	-	112.1	101.3	93.79	97.56	82.40	77.30	-	96.75
		unwrapped	110.7	83.50	75.56	79.53	62.90	-	-	112.1	85.22	77.17	81.19	-	-	-	80 36
	Average		110.7	91.34	84.13	87.74				112.1	93.28	85.48	89.38				88.56
	5 °C	wrapped	110.7	86.65	80.39	83.52	68.62	60.31	-	112.1	89.31	82.13	85.72	69.62	60.33	-	84.62
		unwrapped	110.7	70.80	57.70	64.25	-	-	-	112.1	72.12	59.83	65.98	-	-	-	65.12
	Average		110.7	78.72	69.05	73.88				112.1	80.72	70.98	75.85				74.87
	Mean average		110.7	85.03	76.59	80.81				112.1	87.00	78.22	82.61				81.71
Landmark	0 °C	wrapped	113.3	101 6	95 56	98.57	81.28	75.38	63.04	116.0	103.7	98.72	101.2	83 53	78.24	68.27	99.88
		unwrapped	113.3	88.14	82.23	85.19	69 62	-	-	116.0	91.46	85 21	88.34	72.84			86.75
	Average		113.3	94.86	88.90	91.88				116.0	97.56	91.97	94.76				93.32
	5 °C	wrapped	113.3	95.70	84.93	90.32	78.42	69.35	57.45	116.0	94.41	87.04	90.73	81.85	75 18	61 21	90.53
		unwrapped	113.3	76.19	70.48	73.33	-	-	-	116.0	76.42	73.85	75.13	-	-	-	74.23
	Average		113.3	85.95	77.71	81 84				116.0	85.41	80.44	82 93				82.39
	Mean average		113.3	90.40	83.30	86.85				116.0	91.49	86.21	88.85				87.85
Grand average			113.3	87.72	79.94	83.83				116.0	89.24	82.22	85.73				84.78

Significance for ascorbic acid content during 1st ten days of storage. LSD at 0.05%

Temperature (T)	0.09	0.34
Wrapping (W)	0.09	0.34
Cultivar (CV)	0.09	0.34
Days (D)	0.09	0.34
T X W	0.11	0.42
T X CV	0.11	0.42
W X CV	0.11	0.42
D x CV	0.11	0.42

Table (10): Effect of cultivar and wrapping on broccoli protein content (g/100 g fresh weight) during storage at low temperatures + one day at 15°C in 1997-1998 and 1998-1999 seasons.

CVs.	seasons		1997-1998							1998-1999							Grand average
	Treatments	day	0	5	10	Aver.	15	20	25	0	5	10	Aver.	15	20	25	
F1 0175	0 °C	wrapped	32.62	29.39	25.89	27.64	22.28	20.70	19.30	32.23	29.83	25.41	27.62	22.39	20.12	19.10	27.63
		unwrapped	32.62	24.41	20.26	22.33	-	-	-	32.23	24.13	20.90	22.51	-	-	-	22.42
	Average		32.62	26.90	23.07	24.98				32.23	26.98	23.15	25.06				25.02
	5 °C	wrapped	32.62	27.85	23.23	25.54	20.13	19.15	-	32.23	27.12	23.40	25.26	21.10	19.00	-	25.40
		unwrapped	32.62	23.06	19.27	21.16	-	-	-	32.23	23.28	19.69	21.48	-	-	-	21.32
	Average		32.62	25.45	21.25	23.35				32.23	25.20	21.54	23.37				23.36
	Mean average		32.62	26.17	22.16	24.16				32.23	26.09	22.34	24.21				24.18
Land mark	0 °C	wrapped	31.06	30.36	28.67	29.51	24.54	22.50	19.45	31.34	30.40	28.48	29.44	25.10	23.43	20.34	29.49
		unwrapped	31.06	27.73	25.09	26.41	22.14	-	-	31.34	27.71	25.04	26.37	22.20	-	-	26.39
	Average		31.06	29.04	26.88	27.96				31.34	29.05	26.76	27.90				27.94
	5 °C	wrapped	31.06	29.19	25.59	27.39	21.07	20.50	18.30	31.34	29.26	26.78	28.02	23.34	21.43	20.00	27.70
		unwrapped	31.06	25.89	23.52	24.70	-	-	-	31.34	25.58	22.38	23.98	-	-	-	24.34
	Average		31.06	27.54	24.55	26.04				31.34	27.42	24.58	26.00				26.02
	Mean average		31.06	28.29	25.71	27.01				31.34	28.23	25.67	26.95				26.98
Grand average			31.06	27.23	23.93	25.59				31.34	27.16	24.00	25.58				25.59

Significance for protein content during 1st ten days of storage. LSD at 0.05%

Temperature (T)	0.36	0.36
Wrapping (W)	0.45	0.40
Cultivar (CV)	0.43	0.41
Days (D)	0.70	0.78
T X W	0.16	0.16
T X CV	0.16	0.16
W X CV	0.16	0.16
D x CV	0.16	0.16

Table (11): Pairwise correlations among various physical and chemical Characters of broccoli heads.

	Weight Loss	Visual Quality	Chlorophyll Content	Ascorbic Acid	Protein Content
Weight Loss		-0.942	-0.739	-0.886	-0.852
Visual Quality	-0.865		0.638	0.826	0.810
Chlorophyll Content	-0.617	0.779		0.778	0.648
Ascorbic Acid	-0.850	0.924	0.848		0.903
Protein Content	-0.867	0.853	0.676	0.817	

(1) The correlations below diagonal are for heads stored at room temperature, while those above diagonal are for heads at cold storage.
(2) All correlations are highly significant at the 0.001 level.

DISCUSSION

The results show that there was an increase trend in the loss in weight with advancement of storage time (Tables 1&6). This continuous loss in weight during storage results from the loss of water by transpiration and dry matter due to respiration. Water accounted for 86 % to 90 % of the total weight loss in the broccoli (Forney *et al.*, 1989). The data also show that the weight loss of two broccoli cultivars, stored at room temperature for 3 days, was higher than those held at refrigerated stores for 10 days. Zero temperature was effective in minimizing weight loss than 5°C. The great weight loss in room temperature samples may be due to the fact that the drier the storage air, the more rapid the loss of water from stored products. Whereas, the reason for the difference in weight loss between 0°C and 5°C may be that the water loss is faster at a high temperature than at a low one, when the relative humidity is the same, as well as the effect of low temperatures in reducing metabolic activity (Ryall and Lipton, 1972 and Hardenburg *et al.*, 1986).

Furthermore, a gradual significant reduction in chlorophyll, ascorbic acid and protein contents was noticed with the progress of storage time. The rate of deterioration was higher in broccoli held at room temperature than in those stored at refrigerated temperatures. That is because holding commodity above the recommended temperature accelerates respiration and ethylene production and subsequently enhance deterioration. According to Kadder (2002), the rate of deterioration increases by two to three folds for each increase of 10°C above optimum temperature. The longer the period during which the temperature is above the optimum, the grater the loss of quality. Similar results are reported by others (Pogson and Morris, 1997 and Zhuang, *et al.*, 1997).

Wrapping provides excellent protection against weight loss (Tables 1&6), as it minimizes air movement around broccoli and would also help to maintain a microclimate with a very high humidity around the heads. Moreover, modification of the atmosphere around the broccoli, as a result of respiration, may relatively reduce water loss due to its inhibiting effect on senescence. These results are in agreement with Forney *et al*, 1989; Barth.

1993 a, b and c, and Zhuang, *et al*, 1997. Forney et *al*, (1989) suggested that it may also affect stomatal aperture, cuticle composition and structure.

Wrapped broccoli heads retained significantly greater total chlorophyll content during storage (Tables 3&8). Loss of chlorophyll was reported to be slowed in elevated CO_2 environments (Shewfelt *et al*., 1983). Ethylene as little as <1ppm have been shown to elicit responses in plant tissue such as chlorophyll degradation and acceleration of senescence (Watada, 1986). The modified atmosphere inside the wrapped samples may have prevented the accumulation of higher levels of ethylene and may have reduced its biological activity of enhancing senescence and chlorophyll degradation. These results are in accordance with reports by others (Barth, 1993 a, b and c and Makhlouf *et al.*, 1989).

Wrapping significantly reduced the degradation of ascorbic acid (Tables 4&9). Peroxidase plays an important role in enzymatic degradation of ascorbic acid (Barth *et al.*, 1993c). Reduction in O_2 within the wrapped sample can prevent ascorbic losses, presumably through prevention of oxidation. Moreover, increased ascorbic acid destruction in unwrapped broccoli held at 20°C could have occurred due to increased deterioration of cellular integrity resulting in greater interaction between ascorbic acid and enzyme (peroxidase) and as a result of a greater dehydration at 20°C storage. According to Lee and Kader (2000), conditions favorable to water loss after harvest result in a rapid loss of vitamin C content. Hence, modified atmosphere conditions and greater humidity inside the packages possibly served to better preserve vitamin C content. These results are in agreement with those of (Wang, 1979; Barth, 1993a, b and c and Chachin *et al.*, 1999), in which post harvest storage of broccoli under modified conditions was shown to slow down the rate of ascorbic acid distraction as compared with broccoli stored in air.

Wrapping broccoli diminished the loss in protein content during storage period (Tables 5&10). This effect in minimizing the loss in protein content may be attributed to a suppression of metabolic activity as a result of modified atmosphere in wrapped samples. Previous studies came to the same conclusion (Zhuang *et al.*, 1997).

Broccoli is a perishable vegetable that deteriorates rapidly after harvest, with senescence primarily expressed as softening and yellowing. (Hardenburg *et al.*, 1986).

The quality retention in broccoli is a consequence of two factors. The first is weight loss which is strongly associated with losses in firmness, turgidity and compactness. The second is color retention, which appears to be correlated with changes in respiration and ethylene. The data exhibited a subjective score of visual quality corresponding with changes in fresh weight and chlorophyll content (Tables 1,2,3,6,7 and 8). These results are in agreement with those reported by (Toivonen, 1997). Toivonen and DeEll (2001) found that the appearance rating scores paralleled the firmness scores, suggesting that the two scores are linked. Thus, the overall appearance (Tables 2&7) of unwrapped broccoli held at high temperature severely deteriorated at the end of storage due to excessive weight loss of more than 5% (Hardenburg *et al.*, 1986) or by chlorophyll degradation (Barth

et al, 1993c). This is in agreement with Ryall and Lipton (1972) who reported that the symptoms of water loss become objectionable when vegetables have lost between 5% and 10 % of their weight due to transpiration. Hence, low temperature and wrapping significantly affected the visual quality of stored broccoli either by reducing weight loss subsequently shriveling and softening or by better maintenance of color and appearance due to their effect on inhibiting respiration and ethylene biosynthesis (Forney *et al.*, 1989; Forney and Rij, 1991; Gillies *et al.*, 1997 and Zhuang *et al.*, 1997).

Although the chlorophyll and protein conte.nts were higher for $F_1$0175 at the binging of the experiment, Landmark had higher or comparable values, for all traits studied, at the end of storage. This indicates that the rate of deterioration of landmark was slower than that of $F_1$0175, suggesting that Landmark may have a slower rate of respiration. The differences between the two cultivars might be explained on the basis of different rates of respiration, the variation in color, structure, thickness and nature of the outer layers (waxy coating) and the amount of pectic substance, chlorophyll, ascorbic acid and protein content. All these characteristics affect the broccoli post harvest quality to a great extent, as they are governed by genetic components (Makhlouf *et al*, 1989; King and Morris, 1994; Forney, 1995 and Pogson and Morris, 1997). Cantwell and Kasmir (2002) stated that broccoli cultivars can vary by more than 50% in their potential shelf life.

The findings indicate that cooling broccoli to 0°C and wrapping resulted in less weight loss, so conserving turgidity and firmness, greater ascorbic acid and protein retention, thus providing better vitamin C content and nutrients for the consumer, and greater chlorophyll retention, thereby contributing to greener appearance. Furthermore, film wrapping can also extend the storage life of broccoli at non-optimal temperatures. Also, Landmark outlasted $F_1$0175 in its keeping quality.

REFERENCES

Able, A. J.; L. S. Wong; A. Prasad and T. J. O'Hare (2002). 1- MCP is more effective on a floral brassica (*Brassica oleracea* var. *italica* L.) than a leafy brassica (*Brassica rapa* var. *chinensis*). Postharvest Biol. Technol., 26:147-155.

Barth, M. M.; E. L. Kerbel; A. K. Perry; S. J. Schmidt (1993 a). Modified atmosphere packaging affects ascorbic acid, enzyme activity and market quality of Broccoli. J. Food Sci., 58:140-143.

Barth, M. M.; E. L. Kerbel; S. Broussard and S. J. Schmidt (1993 b). Modified atmosphere packaging protects market quality in broccoli spears under ambient temperature storage. J. Food Sci., 58:1070-1072.

Barth, M. M.; E. L. Kerbel; S. Broussard and S. J. Schmidt (1993 c). Modified atmosphere packaging (high Co_2 / low O_2) effects on market quality and microbial growth in broccii spears under temperature abuse conditions. Acta Hort., 343:187-189.

Brennan, P. S. and R. L. Shewfelt (1989). Effect of cooling delay at harvest on broccoli quality during post-harvest storage. J. Food Quality, 12: 13-22.

Cantwell, M. I. and R. F. Kasmir (2002). Postharvest handling systems: flower, leafy, and stem vegetables. In A. A. Kadder (Ed) Postharvest Technology of Horticultural Crops. Univ. Calif. Agricultural and Natural Resources, Publication, 3311:423-433.

Chachin, K.; Y. Imahori and Y. Ueda (1999). Factors affecting the postharvest quality of MA packaged broccoli. Acta Hort., 483:255-264.

Elkashif, M. E.; D. J. Huber and M. Sherman (1983). Delaying deterioration of broccoli and cucumber using polymeric films. Proc. Fla. State Hort. Soc., 96:332-335.

Fan, X. and J. P. Mattheis (2000). Yellowing of broccoli in storage is reduced by 1-Methylcyclopropene. Hort.Science, 35:885-887

Forney, C. F.; R. E. Rij and S. R. Ross (1989). Measurement of broccoli respiration rate in film-wrapped packages. Hort.Science, 24:111- 113.

Forney, C. F. and R. E. Rij (1991). Temperature of broccoli florets at time of packaging influences package atmosphere and quality. Hort.Science, 26:1301-1303.

Forney, C. F. (1995). Hot water depth extend the shelf life of fresh broccoli. Hort.Science, 30:1054-1057.

Gillies, S. L. and P. M. A. Tiovenen (1995). Cooling method influences the postharvest quality of broccoli. Hort.Science, 30:313-315.

Gillies, S. L.; M. A. Cliff; P. M. A. Tiovenen and M. C. King (1997). Effects of atmosphere on broccoli sensory attributes in commercial MAP and microperforated packages. J. Food Quality, 20:105-115.

Hardenburg, R.E.; A. E. Watada and C. Y. Wang (1986). The Commercial Storage of Fruits, Vegetables and Florets and Nursery Stocks. Agriculture Handbook No. 66. US Dept. of Agriculture, Washington DC.

Hassan, A. A. (1989). The secondary vegetables. El-Dar El-Arabia of Publishing and Distribution, Cairo, Egypt, (in arabic) 113 – 122.

Huber, D. J. (1987). Post harvest senescence: An introduction to the symposium. Hort.Science., 22: 853 - 854.

Kader, A. A.; D. Zagory and E. L. Kerbel (1989). Modified atmosphere packaging of fruits and vegetables. Crit. Rev. Food Sci. Nutr., 28:1-30.

Kadar, A. A. (2002). Postharvest biology and technology: An overview. In A. A. Kadder (Ed) Postharvest Technology of Horticultural Crops Univ. Calif. Agricultural and Natural Resources, Publication, 3311:39-47.

Kasmire, R. F.; A. A. Kader and J. A. Klaustermeyer (1974). Influence of aeration rate and atmospheric composition during simulated transit on visual quality and of odor production by broccoli. Hort.Science, 9:228-229.

King, G. A. and S. C. Morris (1994 a). Physiological changes of broccoli during early postharvest senescence and through the preharvest – posharvest continuum. J. Amer. Soc. Hort. Sci., 119:270-275.

King, G. A. and S. C. Morris (1994 b). Early compositional changes during postharvest senescence of broccoli. J. Amer. Soc. Hort. Sci., 119:1000-1005.

Koch, F. C. and T. L. McMeekin (1924). The chemical analysis of food and food products. J. Amer. Chem. Soc., 46: 2066.

Lee, S. K. and A. A. Kader (2000). Preharvest and post harvest factors influencing vitamin C content of horticultural crops. Postharvest Biol. Technol., 20:207-220.

Makhlouf, J. C.; F. Castaigne; J. Arul; C. Willemot and A. Gosselin (1989). Long term storage of broccoli under controlled atmosphere. Hort.Science, 24: 637 – 639.

Pogson, B. J. and S. C. Morris (1997). Consequences of cool storage of broccoli on physiological and biochemical changes and subsequent senescence at 20°C. J. Amer. Soc. Hort. Sci., 122 : 553 – 558.

Ranganna, S. (1979). Manual of analysis of fruit and vegetable products. Central Food Technological Research Institute. Ph. D. Published by Tata Mc Graw-Hil Publishing Company limited, 12 / 4 Asaf Ali Road, New Delhi 110002, and printed at Raj Bandhu Industrial Company, C – 61, May a puri, phase 11, New Delhi 1100064.

Rij, R. E. and S. R. Ross (1987). Quality retention of fresh broccoli packaged in plastic films of defined CO_2 transmission rates. Packaging Technol., 17:22-23.

Rushing, J. W. (1990). Cytokinins affect respiration, Ethylene production and chlorophyll retention of packaged broccoli florets. Hort.Science, 25:88-90

Ryall, A. L. and W. J. Lipton (1979). Handling, Transportation and Storage of Fruits and Vegetable. Vol.1 Vegetables and melons 2nd Ed. AVI, Westport, Conn.

Schlimme, D. V. and M. L. Rooney (1994). Packaging of minimally processed fruits and vegetables. In R. C. Wiley (Ed) Minimally Processed Refrigerated fruits & Vegetables. Chapman & Hall, New York, N Y, 135-182.

Shewfelt, R. L.; K. M. Batal and E. K. Heaton (1983). Broccoli storage: effect of N^6 – benzyladenine, packaging and icing on color of fresh broccoli. J. Food Sci., 48:1594-1597.

Shewfelt, R. L.; E. K. Heaton and K. M. Batal (1984). Non destructive color measurement of fresh broccoli. J. Food Sci., 49: 1612 – 1613.

Snedecor, G.W. and W.G. Cochran (1989). Statistical methods, 8th Ed. Iowa State Univ. Press, Ames, Iowa, USA.

Tian, M. S.; C. G. Downs; R. E. Lill and G. A. King (1994). A role for ethylene in the yellowing of broccoli after harvest. J. Amer. Soc. Hort. Sci., 119:276 – 281.

Tian, M. S.; T. Islam; D. G. Stevenson and D.E. Irving (1997). Color, Ethylene production respiration and compositional changes in broccoli dipped in hot water. J. Amer. Soc. Hort. Sci., 122:112-116.

Toivonen, P.M.A. (1992). Chlorophyll fluorescence as a non destructive indicator of freshness in harvested broccoli. Hort. Science, 27:1014-1015

Toivonen, P.M.A. (1997). The effect of storage temperature storage duration, hydro - cooling, and micro-perforated wrapped on shelf life of broccoli (*Brassica oleracea* L., Italica group). Postharvest Biol. Technol., 10:59-65.

Toivonen, P.M.A. and J. R. DeEll (2001). Chlorophyll fluorescence, fermentation product accumulation, and quality of stored broccoli in modified atmosphere packages and subsequent air storage. Postharvest Biol. Technol., 23:61-69.

Watada, A. E. and L. L. Morris (1966). Effect of chilling and non-chilling temperatures on snap beans fruits. Proc. Amer. Soc. Hort. Sci., 89:368-374.

Wang, C. Y. (1979). Effect of short-term high CO_2 treatment on the market quality of stored broccoli. J. Food Sci., 44: 1478-1482.

Yamauchi, N. and A. E. Watada (1998). Chlorophyll and Xanthophyll changes in broccoli florets stored under elevated CO_2 or Ethylene-containing atmosphere. Hort,Science, 33:114-117

Zhuang, H.; D. F. Hildebrand and M. M. Barth (1997). Temperature influenced lipid peroxidation and deterioration in broccoli buds during post-harvest storage. Postharvest Biol. Technol., 10:49-58.

تأثيرات درجة الحرارة والتغليف فى المحافظة على جودة ما بعد الحصاد لبعض اصناف البروكلى

راوية البسيونى ابراهيم البسيونى[1] - سيد فتحى السيد[2] - الشربينى ابو الحسن[2] - امل سيد حسن[1]

[1] قسم تداول الخضر – معهد بحوث البساتين - مركز البحوث الزراعية – الجيزة

[2] قسم البساتين – كلية الزراعة – جامعة القاهرة – الجيزة

أجرى هذا البحث لدراسة تأثير درجات الحرارة والتغليف على مظهر الرؤوس والتغير فى مكونات الجودة لصنفي البروكلي Landmark، F_1 0175 أثناء التخزين ، وقد تم تخزين عينات البروكلي المغلفة والغير مغلفة على درجات حرارة مبردة (صفر أو ٥م ، ٩٠ – ٩٥% رطوبة نسبية) أو على درجة حرارة الغرفة (حوالي ٢٠م ، ٦٠% رطوبة نسبية) ، ثم تم فحص العينات المخزنة على درجة حرارة الغرفة يوميا أما العينات المخزنة تحت التبريد فكانت تفحص كل ٥ أيام (بما في ذلك نقل العينات المراد فحصها لمدة يوم واحد على درجة حرارة ١٥م قبل إجراء الفحص). وتم قياس بيانات التغير في الوزن والمظهر والمحتوى من الكلوروفيل وحمض الأسكوربيك والبروتين أثناء التخزين وقد أظهرت النتائج ما يلي:

- زيادة معدل تدهور الصفات بارتفاع درجات حرارة التخزين.
- التغليف بالبولى فينايل كلوريد كان فعالاً فى تأخير فقد الجودة أثناء التخزين ، وساعد على تقليل التدهور فى الجودة عند تخزين البروكلي على درجات حرارة أعلى من درجة الصفر المئوي.
- كانت رؤوس صنف Landmark المغلفة والمخزنة على درجة الصفر المئوي هي الأفضل في المحافظة على الجودة أثناء التخزين لفترة طويلة بينما كانت رؤوس صنف F_1 0175 الغير مغلفة والمخزنة على درجة حرارة الغرفة هي الأسوأ.