J. Agric. Sci. Mansoura Univ., 26 (11): 7237 - 7252, 2001.

PHYSIOLOGICAL STUDIES ON DEVELOPMENTAL STAGES, DIFFERENT WRAPPING FILMS AND COLD STORAGE OF EGGPLANT FRUITS.

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ABSTRACT

These experiments were carried out on eggplant fruits cultivar “Melida” to study the physical and chemical changes happened during fruits development and storage for determining the proper stage of harvesting, effect of different wrapping films and different degrees of cold storage were examined to improve the storability of fruits.

Results indicated that with age advance there was an increase in fruit length, diameter and weight while, the other fruit properties like firmness, dry matter, T.S.S and ascorbic acid content increased with aging till 15 days then followed by a decline up to 30 days. The tested determinations revealed that the eggplant fruits of Melida variety reached the proper stage of harvesting after 15 days from anthesis.

For the different wrapping films, the non-perforated polyethylene and stretch films were the most effective in reducing weight loss while the cellophane film was less effective. Weight loss was greater in the unwrapped fruits. Wrapping eggplant fruits with perforated and non-perforated cellophane film gave the lowest decay incidence and maintained the fruit firmness during storage. Fogging was severe by using polyethylene film but cellophane film did not show any fogging during storage. Extend of fogging within perforated stretch film was slightly less than non-perforated ones.

Examining of different cold storage degrees proved that the lower loss in weight occurred from storing eggplant fruits under 4^{o}C. The percentage of decay was lessened by the decrease in storage temperature degree. Eggplant fruits stored at 4 and 7^{o}C were more susceptible to chilling injury (surface pitting) than those stored at 10^{o}C which not show any pitting during storage. The highest values of firmness was obtained from fruit stored at 10^{o}C and the lowest ones came from 4^{o}C. Since, eggplant fruits can be stored at 10^{o}C to extend shelf life.

INTRODUCTION

Eggplant is an important market vegetable, especially in Asia and the Mediterranean countries (Nothmann, 1986). The fruits are very sensitive and rapidly deteriorate. The successful marketability of this crop depends on maintaining high quality of fruits after harvest. For this reason, this work has involved studies on the proper stage of harvesting, different wrapping films and various storage temperatures were used for improving the storability of fruits.

Several studies were done to determine the physical and chemical changes in fruits during different stages of development. Thus, on eggplant fruit, it was found that fruits increased in length, diameter and weight as it progresses towards maturity. While, ascorbic acid content increased gradually at the earlier stages of maturity and then decreased in the oldest ones. (Singh *et al*, 1990). However, on eggplant fruits it could be found that

fruit firmness increased gradually till the stage of physiological maturity (28 days. After fruit set) and then decreased with fruit ripening and over ripening (Esteban *et al.,* 1993).

Fruit weight loss and decay as a criterion happened during storage was affected by the stored fruit age. Thus, when storing red pepper fruits at 10^{o}C it showed greater weight loss and decay percentages than the fruits of green stage (Uncini *et al*., 1976 and Abd El- Rahman, 1990).

The use of selective film for prolonging the storability of fruits was studied by many investigators. Thus, wrapping eggplant fruits in sealed plastic films reduced weight loss, maintained firmness, but significantly increased decay compared with eggplant wrapped in perforated film. (Risse and Miller 1983) Moreover, eggplant fruits packaged in polyethylene bags delayed fruit senescence, reduced changes in color, weight loss and firmness compared with non-packaged fruits (Uncini *et al*., 1976, Mencarelli *et al*., 1989 and Fallik *et al.,* 1994). Moreover, over wrapped fruits with cellophane film had less decay incidence, gave good appearance, and would not cause moisture condensation compared with fruits wrapped in polyethylene or stretch film (Hassan *et al*., 1970 on tomato and Abd El- Rahman *et al*., 1995 on cucumber).

Storage temperature is the most important factor for regulating the rate of associated physical and chemical processes happened in the fruits. Evidence has been presented by Nothmann, (1989) on eggplant showing that fruits can be stored at 10^{o}C to extend shelf life without chilling injury symptoms. However Abe et al (1974) revealed that chilling injury in eggplant fruits (surface pitting of the peel and browning of seeds) occur after 4-5 days at 1^{o}C. These symptoms were associated with rapid decay development, mostly on the calyx. Moreover Mencarelli *et al* (1991) and Mohammed and Lougheed (1991) cleared that chilling injury in eggplant fruits became more severe as the storage temperature decreased. Later, Fallik et al, (1994) found that eggplant fruits stored at 6C progressively loss their firmness during storage.

MATERIALS AND METHODS

An experiment was carried out under plastic house conditions during two successive seasons 1996-1997 and 1997-1998 at Kaha Vegetable Experimental Farm. The soil in the farm was clay in texture with PH about 8.0. Eggplant (Solanum melongena L) Mileda cultivar was used in this study. Seeds were sown in trays on 20th and 23rd of August in the two seasons respectively, and transplanted in a plastic house after one month of sowing. Plastic house contained five rows. Each row was 100 cm wide and 60 m in length. Seedlings were transplanted alternatively on the two sides of each row with 100cm between plants and 50 cm between the two ridges on the row. The design of the experiment was complete randomized block with three replicates. Agricultural practices took place whenever it was necessary according to the recommendations of Ministry of Agriculture.

A-1- Developmental stage

At full bloom, flowers were labeled every 5 days. Harvesting take place on labeled fruits where it picked at the age of 5, 10, 15, 20, 25 and 30 days. After harvesting fruits were transferred to the laboratory at Giza where they sorted, sound and healthy fruits were chosen for the following properties:

Length – diameter, weight, firmness, T.S.S, dry matter and ascorbic acid content.

A-2- Storage of developmental stages.

Fifteen replicates were prepared for each aforementioned age (each replicate weight approximately 600g) and placed in carton boxes (30x20x10cm). Fruits from all stages of development were stored under cold atmosphere at 10°c and 90% RH. Samples were taken at random from 3 replicates for each treatment and examined every 3 days intervals for the postharvest properties.

B- Different wrapping films

Eggplant fruits at 15 days age were divided into seven groups. Fruits packed in foam tray (20×10×2.5 cm) and tightly overwrapped with the following types of films:

1- Perforated cellophane film (15 µm thickness and 1% vent).
2- Non-perforated cellophane film (15 µm thickness).
3- Perforated stretch film (9 µm thickness and 1% vent).
4- Non-perforated stretch film (9 µm thickness).
5- Perforated polyethylene film (25 µm thickness and 1% vent).
6- Non-perforated polyethylene film (25 µm thickness).
7- Control (unwrapped fruits).

Fifteen replicates were prepared for each type of overwrapping film and control, each replicate weighted approximately 800g. All treatments were stored at the previous temperature and humidity. Complete randomized blocks design were adopted. Three replicates from each type were taken and examined every 3 days for the postharvest properties.

B- Cold storage

Eggplant fruits stored at various temperature degrees (4, 7 and 10°C). Fifteen replicates were prepared for each temperature degree (each replicate weighted approximately 800g) and placed in carton boxes (30x20x10cm). Complete randomized block design were adopted. Three replicates from each treatment were taken and examined every 3 days for the postharvest properties.

For all storage experiments the following properties were examined

a) Weight loss, decay, dry matter and T.S.S (in percent).

b) Fruit firmness was measured in Lb/ in^2 by magness and Ballouf pressure tester equipped with 3/16 inch plunger and adjusted in Newton (as recommended by ASHS Postharvest working Group).

c) Ascorbic acid was determined according (A.O.A.C., 1980) as mg/l00g fresh weight.

In the experiment of cold storage, chilling injury (dark round pits appeared on the calyx or peel) was expressed as a percentage of the total amount of fruit observed. Statistical analysis of data was done according to Snedecor and Cochran (1972).

RESULTS AND DISCUSSION

A-1- Developmental stages

Presented data in Table (1) show that fruit length and diameter of eggplant increased with aging. However the study exhibited a rapid increments in the initial periods up to 25 days which was followed by slow increases. The increase in fruit length and diameter may be attributed to considerable cell expansion after early cessation of cell division (Abo EL-Hamd, 1981 on tomato). These results agree with those obtained by Singh *et al*. (1990) on eggplant.

The same data reveal that fruit weight increase during the different developmental stages in both seasons. The obtained values of fruit weight increased rapidly in early stages of development up to the age of 25 days followed by a slow increase till the last examined age. These results coincided with the work of Esteban et al., (1993) on eggplant fruits. As previously mentioned, the increase in fruit weight may be attributed to cell enlargement. Physiological speaking, the rapid and slow increase in fruit weight during the cycle of tomato growth may be explained through the work of Abd El-Rahman *et al*. (1975) who related these periods to the change in the levels of IAA, GA_3 and cytokinins – indeed growth substances increased progressively in the first periods of fruit growth then tended to be very much less in the later stages of fruit development.

Data in Table (1) clear also that fruit firmness started with the least figures at 5 days age after which it gained higher values till a peak was reached at 20 days after which a decrease trend took place at the last periods of development. These results may be due to the increase of protopectin before physiological maturity and then decreases with fruit ripening and over ripening (Esteban *et al*., 1993 on eggplant). This was correlated with the increase and decrease in firmness. Also on pepper fruit showed that polyglacturonase activity increased during fruit ripening till it reached its maximum at the turning stage (Jen and Robinson, 1984) and this in turn decrease the fruit firmness during its ripening.

The same data reveal that dry matter content in eggplant fruits slowly increased with age till 20 days followed by gradually decrease till the last examined stage. Needless to say that the maximum peak was obtained at 20 days age.

Concerning T.S.S and ascorbic acid contents they increased gradually till 15 days then a gradual decline till the last periods of development. These results were in agreement with those obtained by Singh et al., (1990). Concerning discussing the results of T.S.S it may be clear to our knowledge that the changes in fruit T.S.S. during growth are the resultant of some aspects such as the movement of water and soluble solids to and

from the fruit, the inversion of insoluble compounds to simpler soluble forms and respiration. The prevalence of one or more of these factors during fruit development may accumulate or lessen these content (Abd EL-Rahman, 1990 on pepper).

Regarding ascorbic acid content, nutritionally speaking, the increases of the vitamin C during fruit development may be due to the high rate of hexose sugars synthesis and on the contrary the decrease may be attributed to its exhaustion during respiration and to its transference to the oxidized form (Abo EL-Hamd 1981).

Table (1): Some properties changes in the various developmental stages of eggplant in 1996-1997 and 1997-1998 seasons

Developmental stages	Fruit length cm	Fruit Diameter cm	Fruit Weight gm	Firmness (N)	Dry matter %	T.S.S %	Ascorbic acid mg/100g (F.W)
	1996 – 1997						
5	6.3	1.72	23.1	25.6	3.82	4.33	12.3
10	13.5	2.93	56.3	46.8	4.25	4.75	15.7
15	16.5	3.41	86.4	58.4	4.74	5.14	22.3
20	18.7	3.62	94.8	64.2	4.81	5.00	21.5
25	20.2	3.84	109.5	53.5	4.62	4.82	16.5
30	20.6	3.87	111.2	41.8	4.31	4.50	13.6
L.S.D at 5%	1.84	0.20	5.7	5.6	0.29	0.26	2.62
	1997 – 1998						
5	5.4	1.58	18.7	21.7	3.97	4.13	11.8
10	14.3	3.08	62.8	49.5	4.43	4.52	16.2
15	17.1	3.32	94.2	61.3	4.90	5.26	25.8
20	20.3	3.52	108.4	67.8	4.97	4.92	20.6
25	21.4	3.61	115.6	55.3	4.32	4.73	14.1
30	21.6	3.71	117.3	39.5	4.11	4.41	11.7
L.S.D at 5%	1.72	0.18	6.2	5.3	0.26	0.28	2.46

A-2- Storage of developmental stage

The presented data in Table (2) show that the loss in weight was increased in all the stage of maturation of eggplant fruits as the storage period elapsed in the two seasons. The decrease in fresh weight might be attributed to the loss in moisture through transpiration and loss in dry matter content through respiration. When the results of the various ages were put in comparison during storage, the first demonstration observed in that fruit of 15 days age exhibited the least loss during the various storage period.

Table (2): Effect of storage on loss in weight percentage of the various development stages in 1996-1997 and 1997-1998 seasons

Age in days	Storage period in days							
	3	6	9	12	3	6	9	12
	1996 – 1997				1997 – 1998			
5	5.72	--	--	--	6.12	--	--	--
10	3.62	8.46	--	--	3.72	7.92	--	--
15	2.13	4.68	6.96	9.72	2.06	4.25	7.12	9.35
20	2.62	5.74	8.14	--	2.75	6.08	8.45	--
25	2.82	6.21	--	--	3.06	6.43	--	--
30	3.10	--	--	--	3.25	--	--	--

Data in Table (3) clear that decay percentage of eggplant fruits increased with the prolongation of storage period. This finding may be due to the biological activity in fruit became low at the later period of storage and this in turn led to fungal and bacterial infection. These results are in harmony with those obtained by Agamia (1972) and Abd EL-Rahman and Hosny (2001) on eggplant. From the obtained date, it was reasonable to say that the decayed fruits started to be shown in the age of 15 days at 9 days of storage. In general, eggplant fruits at the age of 15 days was the most effective ones in minimizing the decay percentage during storage.

Table (3): Effect of storage on decay percentage of the various development stages in 1996-1997 and 1997-1998 seasons

Age in days	Storage period in days							
	3	6	9	12	3	6	9	12
	1996 – 1997				1997 – 1998			
5	74.8	--	--	--	85.2	--	--	--
10	22.6	58.6	--	--	30.4	65.8	--	--
15	00.0	00.0	10.6	16.5	00.0	00.0	8.9	17.5
20	00.0	11.2	39.4	--	00.0	19.5	36.2	--
25	15.4	46.6	--	--	18.2	53.9	--	--
30	52.8	--	--	--	62.4	--	--	--

Data presented in table (4) reveal that eggplant fruits before storage were firmer than fruits at the end of storage period. There was a significant reduction in fruit firmness by the prolongation of storage period in both seasons. These results are in agreement with those obtained by Abd EL-Rahman and Hosny (2001) on eggplant. The decrease in fruit firmness may be due to the gradual breakdown of protopectin to lower molecular weight fractions which are more soluble in water and this was directly correlated with the rate of softening of the fruits (Wills et al, 1981). However, it was obvious that the fruits at 15 days were the firmest ones during the whole storage periods in the two seasons.

Table (4): Effect of storage on firmness (N) of the various development stages

Age in days	Storage period in days									
	0	3	6	9	12	0	3	6	9	12
	1996 - 1997					1997 – 1998				
5	25.6	18.2	--	--	--	21.7	16.7	--	--	--
10	46.8	38.3	30.7	--	--	49.5	43.6	35.8	--	--
15	58.4	56.3	55.2	52.4	50.3	61.3	58.1	56.7	53.4	50.2
20	60.2	55.5	54.7	47.8	--	64.8	57.1	54.5	50.1	--
25	58.5	50.1	42.3	--	--	55.3	48.3	42.5	--	--
30	41.8	30.6	--	--	--	39.5	31.4	--	--	--

Data in Table (5,6 and 7) demonstrate that T.S.S., dry matter and ascorbic acid content of eggplant fruits were increased gradually till 6 days of storage and then decreased with the Prolongation of the storage period. The increase in T.S.S and dry matter content in the first period might owe much to the higher rate of moisture loss through transpiration than the rate of dry

matter loss through respiration. The reduction in these characters during the last period of storage might be due to the higher rate of sugar loss through respiration. These results are true in the two seasons. However, when put different stages of development in comparison, it was obvious that higher contents of T.S.S dry matter and ascorbic acid were obtained from the age of 15 days in the first season and the age of 15 and 20 days in the second season.

From the previous results it could be concluded that the age of 15 days from anthesis in eggplant fruits was the proper stage of harvesting which contained high fruit quality and storability (had low percentage of weight loss and decay) and high content of dry matter, T.S.S and ascorbic acid beside maintaining fruit firmness during storage.

Table (5): Effect of storage on Total soluble solids percentage of the various development stages in 1996-1997 and 1997-1998 seasons

Age in days	Storage period in days									
	0	3	6	9	12	0	3	6	9	12
	1996 – 1997					1997 – 1998				
5	4.33	4.47	--	--	--	4.13	4.23	--	--	--
10	4.75	4.89	4.53	--	--	4.52	4.75	4.32	--	--
15	5.14	5.28	5.35	5.21	5.04	5.26	5.38	5.52	5.36	5.24
20	5.00	5.32	5.16	4.82	--	4.92	5.13	5.02	4.61	--
25	4.82	5.06	4.72	--	--	4.73	4.93	4.63	--	--
30	4.60	4.34	--	--	--	4.41	4.06	--	--	--

Table (6): Effect of storage on dry matter content of the various development stages in 1996-1997 and 1997-1998 seasons

Age in days	Storage period in days									
	0	3	6	9	12	0	3	6	9	12
	1996 – 1997					1997 – 1998				
5	3.82	3.61	--	--	--	4.97	4.56	--	--	--
10	4.25	4.36	4.15	--	--	4.43	4.56	4.32	--	--
15	4.74	4.83	4.96	4.80	4.70	4.90	5.12	5.19	5.06	4.93
20	4.81	4.92	4.83	4.71	--	4.97	5.13	5.02	4.81	--
25	4.62	4.75	4.52	--	--	4.32	4.35	4.02	--	--
30	4.31	4.10	--	--	--	4.11	3.90	--	--	--

Table (7): Effect of storage on ascorbic acid (mg/100g. Fresh weight) of the various development stages in 1996-1997 and 1997-1998 seasons

Age in days	Storage period in days									
	0	3	6	9	12	0	3	6	9	12
	1996 – 1997					1997 – 1998				
5	12.3	9.2	--	--	--	11.8	9.7	--	--	--
10	15.7	17.9	13.5	--	--	16.2	18.3	14.6	--	--
15	22.3	24.6	25.8	23.4	20.8	25.8	28.2	30.1	27.4	25.5
20	21.5	23.7	26.2	21.5	--	20.6	22.8	25.3	21.8	--
25	16.5	18.3	15.7	--	--	14.1	16.9	11.4	--	--
30	13.6	10.8	--	--	--	11.7	9.3	--	--	--

B- Different wrapping film

Data in Table (8) reveal that weight loss percentage of eggplant fruits increased by the prolongation of the storage periods. This results was indeed expected as mentioned before. However, it was seen that different wrapping material showed significant differences in their fruit weight loss percentage. In this respect, wrapping eggplant fruits in the different films slowed the rate of weight loss comparatively to the highest ones obtained from unwrapped fruits. Non-perforated film of various types of wrapping materials surpasses the perforated ones in minimizing fruit weight loss percentage during storage. However, when the used non-perforated different wrapping films were put in comparison, it was clear that polyethylene and stretch films were the most effective in reducing weight loss; the cellophane film was less effective. These results were in agreement with those reported by Risse and miller(1983); Fallik et al(1994) and Kaynas et al(1995) on eggplant fruits. It is noteworthy to detect from the previous results that the use of various types of films provide an excellent hinder against moisture loss.

The interaction between different wrapping film and storage periods in weight loss was significant in both seasons.

Table (8): Effect of different wrapping films on Weight loss percentage of eggplant during storage in 1996-1997 and 1997-1998 seasons

Treatment	Storage period in days									
	3	6	9	12	Mean	3	6	9	12	Mean
	1996 – 1997					1997 – 1998				
Per. cellophane	0.75	1.25	2.21	3.20	1.85	0.94	1.38	2.43	3.38	2.03
Nonper. cellophane	0.31	0.92	1.52	1.93	1.17	1.26	1.42	1.75	2.06	1.62
Per. Stretch	0.23	0.35	0.48	0.66	0.43	0.19	0.26	0.44	0.58	0.37
Nonper. Stretch	0.13	0.26	0.36	0.39	0.29	0.11	0.18	0.28	0.37	0.24
Per. Polyethylene	0.19	0.32	0.45	0.52	0.37	0.14	0.28	0.39	0.48	0.32
Nonper. Polyethylene	0.08	0.19	0.26	0.29	0.21	0.06	0.12	0.20	0.24	0.16
Unwrapped fruit	2.23	4.75	6.87	9.63	5.87	2.17	4.35	7.00	9.26	5.7
Mean	0.56	1.15	1.74	2.37		0.7	1.14	1.78	2.34	
L.S.D at 5%	Storage period				0.16			0.14		
	Treatment				0.20			0.18		
	Storage p. X Treat.				0.22			0.28		

Data in Table (9) clear that decay percentage of eggplant fruits increased with the prolongation of storage period. It is clear from the data that perforated and non-perforated cellophane film were the most effective ones in minimizing the decay percentage during whole periods of storage. On the contrary, the highest percentage of decay were obtained when using non-perforated polyethylene film. These higher percentage of decay may be due to the high humidity which in turn favor the infection of fungi and bacterial diseases. In general, wrapping fruits in different perforated films reduced the decay percentage as compared to non-perforated or unwrapped ones. Comparing the perforated wrapping films, it was clear that those of perforated cellophane film appeared to be the best one in reducing decay. The low decay incidence in perforated film could be attributed to the continuous

ventilation, less moisture condensation, suppression of off-flavor development(Abd El-Rahman, 1990) on pepper. These results were in agreement with those reported by Fallik et al. (1994) and Kaynas et al.,(1995) on eggplant.

Table (9): Effect of different wrapping films on decay percentage of eggplant during storage in 1996-1997 and 1997-1998 seasons

Treatment	Storage period in days									
	3	6	9	12	Mean	3	6	9	12	Mean
	1996 - 1997					1997 – 1998				
Per. Cellophane	0.00	0.00	0.00	9.4	2.35	0.00	0.00	0.00	6.12	1.53
Nonper. Cellophane	0.00	0.00	4.82	11.16	4	0.00	0.00	7.41	12.18	4.9
Per. Stretch	0.00	0.00	6.46	18.26	6.18	0.00	0.00	8.35	14.23	5.65
Nonper. Stretch	0.00	0.00	8.14	10.91	4.76	0.00	0.00	10.41	18.74	7.29
Per. Polyethylene	0.00	0.00	7.26	19.53	6.7	0.00	0.00	12.87	22.18	8.76
Nonper. Polyethylene	0.00	0.00	12.28	26.38	9.67	0.00	0.00	15.23	29.11	11.09
Unwrapped fruit	0.00	0.00	19.58	21.3	10.22	0.00	0.00	12.9	26.6	9.88
Mean	0.00	0.00	8.36	16.71		0.00	0.00	9.6	18.45	

Data in Table (10) reveal that significant reduction in fruit firmness had occurred by prolongation of investigation. However, wrapping eggplant fruits with perforated and non-perforated cellophane film led to significant reduction in the rate of fruit softening followed by perforated stretch and polyethylene films. Other wise wrapping fruits in non-perforated polyethylene and stretch films and unwrapped ones had highest softening rate.

Table (10): Effect of different wrapping films on Firmness (N) of eggplant during storage in 1996-1997 and 1997-1998 seasons

Treatment	Storage period in days											
	0	3	6	9	12	Mean	0	3	6	9	12	Mean
	1996 – 1997						1997 – 1998					
Per. Cellophane	60.3	58.7	56.2	54.1	53.5	56.6	57.4	56.2	54.1	53.7	50.3	54.3
Nonper. Cellophane	60.3	58.5	57.3	55.4	53.7	57.0	57.4	55.7	54.2	53.6	51.8	54.5
Per. Stretch	60.3	58.2	55.2	53.1	51.8	55.7	57.4	55.3	53.1	51.7	46.5	52.8
Nonper. Stretch	60.3	59.5	58.1	49.2	45.3	54.5	57.4	56.4	55.4	47.1	42.7	51.8
Per. Polyethylene	60.3	58.1	55.4	52.7	50.7	55.4	57.4	54.2	52.6	50.4	48.2	52.6
Nonper. Polyethylene	60.3	59.2	58.2	49.4	46.5	54.7	57.4	56.9	55.2	46.2	43.5	51.8
Unwrapped fruit	60.3	57.1	54.4	51.7	49.2	54.5	57.4	53.3	51.5	49.2	46.7	51.6
Mean	60.3	58.5	56.4	52.2	50.1		57.4	55.4	53.7	50.3	47.1	
L.S.D at 5%	Storage period				1.61		1.25					
	Treatment				1.82		1.47					
	Storage p. X Treat.				2.05		1.78					

The interaction between different wrapping films and storage periods concerning fruit firmness was significant in the two seasons. However, eggplant fruits wrapping in non-perforated polyethylene or stretch films reduced the rate of softening during the first 6 days of storage and then a sharp decrease drop in this character take place up to the end of storage periods. This reduction of the rate of softening during the first period of storage may be attributed to the water-saturated atmosphere in the sealed enclosure around the fruit. Softening of fruit was highly correlated with

declining water potential of fruit. Sealing drastically inhibited softening as well as changes in cell wall pectines. Sealing also delayed disintegration of membrance as shown by the inhibited leakage of amino acid, in particular and electrolytes in general. (Risse and Millar., 1983 on eggplant).

Data in Table (11, 12 and 13) show that the results of T.S.S, dry matter and ascorbic acid changes during storage as affected by the different overwrapping films during the two seasons. There were clear evidences from the data that the percentages of these materials in all stored fruits increased initially during the first periods of storage up to 6 days then a decrease trend took place till the last storage period. However, eggplant fruits wrapping in different perforated films hold more T.S.S., dry matter and ascorbic acid contents during storage than non-perforated or the unwrapped fruits, whereas the highest T.S.S, dry matter and ascorbic acid were obtained from wrapped eggplant fruits in perforated cellophane film. The aforementioned results were in accordance with those obtained by Menearelli et al (1989) and Kaynas et al (1995) on eggplant, who reported that wrapping fruits in different perforated films kept more T.S.S., dry matter and ascorbic acid than non-perforated and unwrapped ones during storage.

Table (11): Effect of different wrapping films on T.S.S percentage of eggplant during storage in 1996-1997 and 1997-1998 seasons

Treatment	Storage period in days											
	0	3	6	9	12	Mean	0	3	6	9	12	Mean
	1996 – 1997						1997 – 1998					
Per. Cellophane	5.20	5.33	5.43	5.32	5.25	5.31	5.10	5.30	5.42	5.35	5.27	5.29
Nonper. Cellophane	5.20	5.28	5.40	5.20	5.10	5.24	5.10	5.28	5.32	5.28	5.10	5.22
Per. Stretch	5.20	5.30	5.40	5.30	5.18	5.28	5.10	5.20	5.35	5.25	5.15	5.21
Nonper. Stretch	5.20	5.25	5.35	5.15	5.10	5.21	5.10	5.20	5.30	5.10	5.00	5.14
Per. Polyethylene	5.20	5.30	5.38	5.28	5.21	5.27	5.10	5.25	5.40	5.20	5.10	5.21
Nonper. Polyethylene	5.20	5.25	5.32	5.10	5.00	5.17	5.10	5.20	5.31	5.10	5.00	5.14
Unwrapped fruit	5.20	5.30	5.40	5.23	5.00	5.23	5.10	5.18	5.30	5.16	4.92	5.13
Mean	5.20	5.29	5.38	5.23	5.12		5.1	5.23	5.34	5.21	5.08	
L.S.D at 5%	Storage period				0.10		0.12					
	Treatment				0.16		0.17					
	Storage p. X Treat.				0.22		0.26					

Table (12): Effect of different wrapping films on dry matter content of eggplant during storage in 1996-1997 and 1997-1998 seasons

Treatment	Storage period in days											
	0	3	6	9	12	Mean	0	3	6	9	12	Mean
	1996 – 1997						1997 – 1998					
Per. Cellophane	4.85	4.98	5.20	5.10	4.91	5.01	4.67	4.83	4.96	4.87	4.80	4.83
Nonper. Cellophane	4.85	4.95	5.05	4.90	4.70	4.89	4.67	4.80	4.85	4.65	4.53	4.70
Per. Stretch	4.85	4.95	5.10	5.00	4.80	4.94	4.67	4.80	4.87	4.70	4.60	4.73
Nonper. Stretch	4.85	4.90	5.05	4.90	4.70	4.88	4.67	4.75	4.80	4.58	4.45	4.65
Per. Polyethylene	4.85	4.90	5.14	5.07	4.83	4.96	4.67	4.79	4.85	4.63	4.55	4.70
Nonper. Polyethylene	4.85	4.90	5.00	4.85	4.61	4.84	4.67	4.70	4.80	4.56	4.40	4.63
Unwrapped fruit	4.85	4.92	5.05	4.80	4.40	4.8	4.67	4.76	4.83	4.55	4.31	4.62
Mean	4.85	4.93	5.08	4.95	4.71		4.67	4.78	4.85	4.65	4.52	
L.S.D at 5%	Storage period				0.09		0.11					
	Treatment				0.12		0.14					
	Storage p. X Treat.				0.20		0.22					

Table (13): Effect of different wrapping films on ascorbic acid content of eggplant during storage in 1996-1997 and 1997-1998 seasons

Treatment	Storage period in days											
	0	3	6	9	12	Mean	0	3	6	9	12	Mean
	1996 – 1997						1997 – 1998					
Per. Cellophane	23.5	26.6	28.8	27.1	25.5	26.3	27.8	30.9	32.2	29.4	27.8	29.6
Nonper. Cellophane	23.5	25.2	25.9	23.2	21.2	23.8	27.8	27.4	28.8	26.4	24.8	27.0
Per. Stretch	23.5	25.4	27.2	25.1	24.2	25.1	27.8	28.3	29.1	27.2	26.1	27.7
Nonper. Stretch	23.5	26.5	27.7	21.3	18.7	23.5	27.8	27.2	28.7	25.2	23.1	26.4
Per. Polyethylene	23.5	27.2	28.3	25.3	24.5	25.8	27.8	28.4	29.3	26.6	24.2	27.3
Nonper. Polyethylene	23.5	25.5	26.3	21.8	20.4	23.5	27.8	28.3	29.6	24.2	20.2	26.0
Unwrapped fruit	23.5	25.8	26.3	21.5	19.2	23.3	27.8	29.3	30.2	25.4	18.2	26.2
Mean	23.5	26.0	27.2	23.6	22.0		27.8	28.5	29.7	26.3	23.5	
L.S.D at 5%	Storage period				0.12		0.13					
	Treatment				0.18		0.16					
	Storage p. X Treat.				0.20		0.19					

The extent of fogging of different overwrapping films on eggplant fruits during storage were shown in Table (14). Fogging was severe by using polyethylene either perforated or non-perforated but cellophane film did not show any fogging during storage. However, the extent of fogging within perforated stretch film was slightly less than non-perforated one (Abd El-Rahman et al., 1995 on cucumber).

Table (14): Extent of fogging within different wrapping films on eggplant fruits during storage in 1996-1997 and 1997-1998 seasons

Treatment	Storage period in days							
	3	6	9	12	3	6	9	12
	1996 - 1997				1997 – 1998			
Per. Cellophane	None	None	None	None	None	None	None	None
Nonper. cellophane	None	None	None	None	None	None	None	None
Per. Stretch	Slight	Slight	moderate	Moderate	Slight	Slight	Moderate	Moderate
Nonper. Stretch	Slight	Moderate	Severe	Severe	Slight	Moderate	Severe	Severe
Per. Polyethylene	Slight	Severe	Severe	Severe	Slight	Severe	Severe	Severe
Nonper. Polyethylene	Severe	Severe	Severe	Severe	Severe	Severe	Severe	Severe

From the previous results, it can be concluded that wrapping eggplant fruits with perforated or non-perforated cellophane film produced an important improvement in market quality, it would reduce decay percentage and hold more T.S.S, dry matter and ascorbic acid contents during storage and also maintained fruit firmness without fogging.

C- cold storage

Data in Table (15) reveal that stored eggplant fruits showed gradual losses in fruit weight percentage during storage. The period of storage had a pronounced effect, since the increment in weight loss percentage increased as the storage period prolonged. However, various temperature degrees showed significant differences in fruits weight loss, while fruit stored at 4^{o}C exhibited the least loss. As known, the continuous loss in weight during storage as due to evaporation and respiration (Wills *et al*., 1981) lower temperature reduced the rate of these two physiological processes and

hence decreased the speed of this character (Fallik *et al*., 1994). Similar results were obtained by Peinis *et al*. (1994) on eggplant.

The interaction between various temperature degrees and storage periods on weight loss showed significant effect on both seasons.

Table (15): Effect of different temperature degrees on weight loss percentage of eggplant during storage in 1996-1997 and 1997-1998 seasons

Treatment	Storage period in days									
	3	6	9	12	Mean	3	6	9	12	Mean
	1996 – 1997					1997 – 1998				
4°C	1.12	2.26	3.75	5.08	3.05	1.25	2.52	4.12	6.03	3.48
7°C	1.78	3.25	4.93	6.68	4.16	1.83	3.43	5.32	7.94	4.63
10°C	2.38	4.68	6.94	9.75	5.94	2.28	4.48	7.14	10.13	6.01
Mean	1.76	3.4	5.21	7.17		1.79	3.48	5.53	8.03	
L.S.D at 5%	Storage period			0.18				0.16		
	Treatment			0.28				0.24		
	Storage p. X Treat.			0.31				0.33		

Data in Table (16) reveal that decay percentage started slowly and successively increased till the end of storage period during the two seasons. From the same data, it was clear that the less the temperature of storage, the less the percentage of decay fruits. However, the decayed fruits started to show at 12 days in 4°C and at 9 days at 7°C and 10°C. However, this may be explained before by Fallik et al., 1995 on eggplant fruits, when they pointed that decay percentage was minimized in stored fruits under low temperature conditions than the higher ones.

Table (16): Effect of different temperature degrees on decay percentage of eggplant during storage in 1996-1997 and 1997-1998 seasons

Treatment	**Storage period in days**									
	3	**6**	**9**	**12**	**Mean**	**3**	**6**	**9**	**12**	**Mean**
	1996 – 1997					**1997 – 1998**				
4°C	0.00	0.00	0.00	14.12	3.53	0.00	0.00	0.00	11.64	2.91
7°C	0.00	0.00	6.23	18.52	6.19	0.00	0.00	6.24	14.38	5.16
10°C	0.00	0.00	12.94	28.75	10.42	0.00	0.00	13.8	21.15	8.74
Mean	0.00	0.00	6.39	20.46		0.00	0.00	6.68	15.72	

The effect of different storage temperatures on the pitting percentage of eggplant fruits in Table (17) show clearly that this disteration occurred only in eggplant fruits stored at 4°C and 7°C after 6 and 9 days of storage, respectively and increased with the elapse of storage periods. On the other side of view, fruits stored at 10°C did not show any pitting during storage. This criterion seem to be connected with the storage of fruits in low temperatures as 4 and 7°C in this experiment, due to chilling injury(Mencarelli *et al*., 1991 and Fallik *et al*., 1994 on eggplant). Chilling injury(surface pitting) may be due to the increase of ethylene evolution and level of aminocyclopropane carboxylic acid (ACC), putrescine (put) and abscisic acid(ABA). The high concentration of these chemicals in the preicari tissue induced chilled fruits with pitting appearance. While in fruits stored at 10°C

the values were low and changes were observed (Serrano *et al.,* 1997 on pepper).

Table (17): Effect of different temperature degrees on pitting percentage of eggplant during storage in 1996-1997 and 1997-1998 seasons

Treatment	Storage period in days									
	3	6	9	12	Mean	3	6	9	12	Mean
	1996 – 1997					1997 – 1998				
4°C	0.00	18.62	37.18	62.14	29.49	0.00	11.25	29.60	64.00	26.21
7°C	0.00	0.00	15.38	27.24	10.66	0.00	0.00	15.15	26.00	10.29
10°C	0.00	0.00	0.00	0.00	0.0	0.00	0.00	0.00	0.00	0.00
Mean	0.00	6.21	17.52	29.79		0.00	3.75	14.92	30	
L.S.D at 5%	Storage period			4.18		3.84				
	Treatment			6.21		5.42				
	Storage p. X Treat.			7.11		6.13				

Data in Table (18) present that eggplant fruits before storage were firmer than at the end of storage period. Also, there was a significant reduction in fruit firmness by the prolongation of storage period in both seasons (Abd El-Rahman and Hosny., 2001 on eggplant). From the same data it is obvious that fruit firmness was significantly affected by different storage temperature. The highest values of firmness comparatively resulted from fruits stored at 10°C and the lowest ones came from 4°C. This may be due to symptoms of chilling injury on fruit stored at 4°C (Fallik *et al*., 1994 on eggplant).

The effect on interaction between different storage temperature and periods on fruit firmness was significant in both seasons.

Table (18): Effect of different temperature degrees on Firmness (N) of eggplant during storage in 1996-1997 and 1997-1998 seasons

Treatment	Storage period in days											
	0	3	6	9	12	Mean	0	3	6	9	12	Mean
	1996 – 1997						1997 – 1998					
4°C	60.3	53.2	50.5	46.2	42.4	50.5	57.4	53.2	50.2	46.7	40.1	49.5
7°C	60.3	55.2	53.6	51.1	47.3	53.5	57.4	54.2	51.3	47.2	45.7	51.2
10°C	60.3	58.2	55.3	51.5	49.2	54.9	57.4	54.6	52.1	50.3	47.5	52.4
Mean	60.3	55.5	53.1	49.6	46.3		57.4	54.0	51.2	48.1	44.4	
L.S.D at 5%	Storage period				2.06		2.13					
	Treatment				2.41		2.54					
	Storage p. X Treat.				2.95		3.18					

Data in Table (19, 20 and 21) showing that T.S.S, dry matter and ascorbic acid content increase with prolongation of storage period until 6 days at 10°C and 9 days for the temperature degrees 7 and 4°C, then it began to decrease gradually. However, when we have a look to the different storage temperatures it can be possible to detect that fruits stored in the lower temperature hold these materials content more than those kept in higher temperature. These results might be attributed to that lower temperature led to a depression in the vital physiological and biochemical reactions in the fruits which in turn minimize the exhaust of these materials.

Table (19): Effect of different temperature degrees on T.S.S. percentage of eggplant during storage in 1996-1997 and 1997-1998 seasons

Treatment	Storage period in days											
	0	3	6	9	12	Mean	0	3	6	9	12	Mean
	1996 - 1997						1997 – 1998					
4ºC	5.20	5.26	5.37	5.46	5.32	5.32	5.10	5.18	5.28	5.37	5.35	5.26
7ºC	5.20	5.30	5.40	5.48	5.35	5.35	5.10	5.20	5.32	5.40	5.32	5.27
10ºC	5.20	5.32	5.41	5.28	5.13	5.27	5.10	5.22	5.36	5.30	5.17	5.23
Mean	5.20	5.29	5.39	5.41	5.27		5.10	5.2	5.32	5.36	5.28	
L.S.D at 5%	Storage period			0.10			0.09					
	Treatment			0.14			0.15					
	Storage p. X Treat.			0.19			0.21					

Table (20): Effect of different temperature degrees on dry matter content of eggplant during storage in 1996-1997 and 1997-1998 seasons

Treatment	Storage period in days											
	0	3	6	9	12	Mean	0	3	6	9	12	Mean
	1996 - 1997						1997 – 1998					
4ºC	4.85	4.90	4.97	5.10	4.92	4.95	4.67	4.75	4.90	5.05	4.83	4.84
7ºC	4.85	4.87	4.92	5.17	5.00	4.96	4.67	4.78	4.80	4.90	4.80	4.79
10ºC	4.85	4.90	4.96	4.82	4.62	4.83	4.67	4.78	4.84	4.61	4.44	4.67
Mean	4.85	4.89	4.95	5.03	4.85		4.67	4.77	4.85	4.85	4.69	
L.S.D at 5%	Storage period			0.11			0.13					
	Treatment			0.17			0.16					
	Storage p. X Treat.			0.22			0.20					

Table (21): Effect of different temperature degrees on ascorbic acid (mg/100g F.W) of eggplant during storage in 1996-1997 and 1997-1998 seasons

Treatment	Storage period in days											
	0	3	6	9	12	Mean	0	3	6	9	12	Mean
	1996 - 1997						1997 – 1998					
4ºC	23.5	25.2	26.9	28.3	24.9	25.2	27.8	28.1	30.5	32.0	28.1	29.3
7ºC	23.5	24.9	25.3	26.4	20.1	24.4	27.8	28.4	29.1	30.5	24.7	28.1
10ºC	23.5	25.3	26.3	23.3	18.5	23.8	27.8	28.5	30.2	26.1	19.2	26.4
Mean	23.5	25.1	26.2	25	22.2		27.8	28.3	29.9	29.5	24	
L.S.D at 5%	Storage period			0.06			0.07					
	Treatment			0.09			0.10					
	Storage p. X Treat.			0.12			0.14					

From the previous results, it could be suggested that eggplant fruits can be stored at 10ºC to extend shelf life (low decay percentage without chilling injury, beside maintaining fruit firmness).

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دراسات فسيولوجية على مراحل النضج و بعض المغلفات و التخزين المبرد على ثمار الباذنجان

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أجريت التجربة على الباذنجان صنف ميلدا خلال موسمى ١٩٩٦-١٩٩٧ و ١٩٩٧-١٩٩٨ لدراسة التغيرات الطبيعية و الكيماوية التى تحدث فى بعض الصفات خلال مراحل النضج المختلفة و التخزين و ذلك لتحديد أنسب مرحلة لقطف الثمار , كما درس تأثير استخدام بعض المغلفات و درجات تبريد مختلفة علي القدرة التخزينية لثمار الباذنجان.

أوضحت النتائج أن هناك زياده فى طول و قطر و وزن الثمره مع تطور عمر الثمره بينما لوحظ أن الصلابه و الماده الجافه و المواد الصلبه الذائبه و حمض ألاسكوربيك قد زادت مع تطور عمر الثمره حتى ١٥ يوم من تفتح الزهرة, ثم حدث نقص تدريجي حتي ٣٠ يوم. أوضحت النتائج أن عمر ١٥ يوم من تفتح الزهرة لثمار الباذنجان صنف ميلدا هو انسب ميعاد للقطف حيث حققت الثمار اعلي جودة وأفضل قدرة تخزينية.

كما أوضحت النتائج أن المغلفات من البولي أيثيلين و الأسترتش الغير مثقب قد ادت الى الحصول علي اقل نسبة فقد وزن, بينما كان السلوفان اقل تاثير و اعطت الثمار الغير مغلفة اكبر نسبة فقد وزن. اعطت الثمار المغلفة بالسلفان المثقب و الغير المثقب اقل نسبة تالف كما احتفظت الثمار بصلابتها اثناء التخزين. كان تكثيف بخار الماء كثير في العبوات المغلفة بالبولي ايثيلين. بينما لم يظهر تكثيف لبخار الماء في العبوات المغلفة بالسلوفان.

بالنسبة لتاثير درجات الحرارة المختلفة لوحظ أن تخزين الثمار على درجة ٤م قد اعطى اقل نسبة فقد وزن. كما كانت نسبة التالف قليلة فى الثمار المخزنة على درجات حرارة منخفضة.كما أوضحت النتائج ان تخزين الثمار على درجة ٤و٧م قد ادت الى اصابة الثمار بأضرار البرودة (ظهور نقر على سطح الثمرة) بينما لم يلاحظ اى اضرار للثمار التى خزنت على درجة ١٠م. اعطى تخزين الثمار على درجة ١٠م اعلى قيمة من صلابة الثمار بينما اعطت ٤م اقل قيمة. لذلك يمكن تخزين ثمار الباذنجان على درجة ١٠م لاطالة فترة حياتها بعد الحصاد لمدة ١٢ يوم بحالة جيدة.