Middle East Journal of Agriculture Research
ISSN 2077-4605
Volume : 04 | Issue : 04 | Oct.-Dec. | 2015
Pages: 925-931

Effect of some Post-harvest Treatments on Sweet Corn (*Zea mays Var. Rugosa*) Quality during Storage

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ABSTRACT

This research was carried out to investigate the effect of some post-harvest treatments (wrapping [polyolefin stretch film, stretch film and unwrapping unwrapping], storage temperature (at 0°C and 5°C) and storage period on quality of ears of sweet corn during storage (samples were taken at 0, 7, 14, 21 and 28 days). The results could be summarized as follows:-

Wrapped with polyolefin stretch film reduced the weight loss percent, kernel denting and decay of ears compared to stretch film wrapping and unwrappingunwrapping, the lowest values were obtained by polyolefin stretch film, while, the highest values were obtained by unwrappingunwrapping. Wrapping ears with polyolefin maintained the visual quality, total sugars, sucrose percent (non-reducing sugar) and total soluble solids (TSS), higher than those of stretch or unwrapped. Unwrapped ears or those wrapped with stretch film contained higher starch percent and dry matter compared to ears wrapped with polyolefin stretch film.

Holding the ears at 5 ºC storage temperature increased the weight loss percent, denting, decay and reduced the visual quality values compared to holding at 0 ºC. Sweet corn ears held at 0 ºC had maintained the total sugars, sucrose percent (non-reducing sugar) and total soluble solids (TSS), higher than those held at 5 ºC. Starch percent and dry matter were higher when ears were stored at 5 ºC compared to 0 ºC.

Key words: Sweet corn, Post-harvest, Polyolefin, Quality, Wrapping, Storage temperature, Storage period, Visual quality, Denting, Decay.

Introduction

Sweet corn (*Zea mays* L. *var. rugosa*) is one of the most promising vegetable crops, grown in Egypt for local market and exportation.

Fresh sweet corn is a kind of perishable vegetables with high respiration rate and sweetness lost is considered one of the main quality degradation during storage. Storage condition i. e. wrapping film, storage temperature and storage period were the most effective on sweet corn kernels quality after picking. It was reported that about 60 and 6% of the sugar was lost in a single day at 30 and 0°C, respectively (Brecht, 2004). Postharvest techniques, such as shrink-wrapping (Aharoni *et al*. 1996), perforated package (Riad and Brecht, 2002) and combination of shrink-wrapping, refrigeration (Deak *et al*., 1987) were applied to maintain sweet corn kernels quality. The main objectives of sweet corn wrapping are shelf-life extension, maintenance of natural color, texture, flavor, and nutrients; reduction in moisture loss and subsequent wilting; limiting disease, infections and infestation; cushioning as a preventative measure against. Wrapping film decreased the moisture and weight loss from the ears. The highest weight loss may be attributed to the highest transpiration as well as respiration rates under the higher temperature in the unwrapped sweet corn ears at long storage period compared to those held at low temperature and wrapped sweet corn ears (Risse and McDonald , 1990).

Concerning the storage period, total and non-reducing sugars were decreased, gradually, by lengthening the storage period. This might be attributed to the consumption of sugars in respiration and/or the conversion of sugars to starch (El-Bassiouny *et al*., 2002).

Materials and Methods

The objective of this experiment was to study the effect of some treatments on maintaining the quality of ears during storage. Ears were harvested at the optimum harvest date. It was trimmed and wrapped with polyolefin stretch film, stretch film (0.09 micron) or unwrapped (check treatment). Wrapped and unwrapped ears were weighed, labeled and placed in carton boxes (two tray/box). Stored at either 0° C or 95-98% RH or at 5° C and 95-98% RH storage conditions. Samples were taken at 7, 14, 21 and 28 days from storage and subsequently transferred to 10° C (simulated retail display) for 24 hours to record the physical and chemical characters.

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The experimental design:

Completely randomized design was used with three factors (wrapping film, storage temperature and the storage period), in four replications.

Four trays, each with two ears, were used at each sampling date (every seven days during storage) to record the following data:

Physical changes:

1. Weight loss percentage %: it was estimated according to the following equation: Weight loss% = [(Initial weight –weight of ears at sampling date)/Initial weight of ears] x 100.
2. Denting and decay were determined as score system of 1: none, 2: slight, 3: moderate, 4: moderately severe, 5: sever (Watada and Morris, 1996; Jimenez *et al.,* 1998).
3. Visual quality: it was determined according to the following score: 9: excellent, 7: good, 5: faire, 3: poor and 1: unusable. This scale depends on the morphological defects such as colour changes of kernels, denting and presence of physiological defects (Watada and Morris, 1996; Jimenez *et al.,* 1998).

Chemical changes

1. Total sugars and sucrose (non reducing sugars) were determined colormetrically using spectrophotometer, Model 6305 UV/visible range with 520 nm wave length according to Somogyi (1952) and Nelson (1974).
2. Total soluble solids (TSS) was measured with a hand rafractometer
3. Starch was determined by the method mentioned by A.O.A.C., (1990).
4. Dry matter percent was determined by weighing one hundred gram of fresh kernels and then dried at 70°C until a constant weight was obtained.

Statistical analysis: **-**

All data were subjected to statistical analysis according to the procedures reported by Snedecor and Cochran (1982) and means were compared by Duncan's multiple range tests at the 5 % level of probability Duncan (1955) in the two seasons of experimentation.

Results and Discussion

Effect of wrapping film

Data in Tables (1, 2 and 3) show that polyolefin stretch film gave the lowest value of weight loss percentage, denting, decay, starch percentage and dry matter percentage as compared with using stretch film. However, the highest values of weight loss percentage were recorded with the control (without wrapping). This result was true in both seasons. Similar results were reported by Shawalter (1967), Ben-Yehoshua (1985), Risse and McDonald (1990), Othieno *et al.* (1995) and Aharoni *et al.* (1996).

Results showed that, polyolefin stretch film gave the highest value of visual quality, total sugars percentage, non-reducing sugars (sucrose) percentage and total soluble solids (TSS) as compared with using stretch film, however, the lowest values of visual quality was recorded with the control (without wrapping). This result was true in both seasons. Similar results were reported by Showalter, (1967), Ben-Yehoshua (1985), Deak *et al.* (1987) and Rodov *et al.* (2000),

Using wrapping film keeping the quality of sweet corn ears and reduced ear weight losses as well as moisture loss and kernel denting. Change in ear quality depends on type of wrapping films.

The obtained data showed that using polyolefin film gave the highest quality characteristics of sweet corn ears as compared with using stretch film and control (unwrapping). These results are in agreement with those reported by Aharoni *et al*., 1996 as they mentioned that compared to polymeric film packaging, perforation-mediated modified atmosphere packaging of sweet corn can be more beneficial, while polyvinylchloride film can be replaced by polyolefin stretch films. Moreover, Attia (2006), reported that wrapping with polyethylene film decreased kernel denting but the decay value was higher with polyethylene compared to stretch film. Stretch film generally resulted in the best visual appearance during storage. Unwrapped ears had higher total sugar percent compared to ears wrapped with polyethylene or stretch film. Wrapping ears with polyethylene maintained the sucrose percent higher than those of stretch or check treatments. Wrapping ears with polyethylene or stretch films reduced the reducing sugars compared to check. Unwrapped ears or those wrapped with stretch film contained higher starch percent compared to ears wrapped with polyethylene film.

Effect of storage temperature

Storage temperature was significantly affected all physical characters and Chemical composition of sweet corn. Data in Tables (1, 2 and 3) show that increasing the storage temperature from 0 up to 5 ºC caused a significant increase on weight loss percentage, denting, decay, starch percentage and dry matter percentage of

sweet corn. Results also clear that visual quality values, total sugars percentage, non-reducing sugars (sucrose) percentage and total soluble solids (TSS) were decrease on with increasing the storage temperature as shown in both seasons.

Table 1: Effect of wrapping film, storage temperature and storage period on weight loss %, denting and decay of sweet corn in 2010 and 2011 seasons.

Treatments			First season						Second season					
Wrapping film	Storage temperature	Storage period	Weight loss %		Denting		Decay		Weight loss %		Denting		Decay	
Control	0	0			1.00	h	1.00	f			1.00	i	1.00	h
		7	5.11	ef	1.33	gh	1.00	f	5.38	k	1.33	hi	1.00	h
		14	9.21	c	2.00	efg	2.00	e	9.36	f	2.33	efg	2.33	e
		21	14.60	b	3.67	bc	3.33	c	14.88	d	3.67	bc	3.67	c
		24	20.44	a	5.00	a	4.00	b	21.50	b	5.00	a	4.33	b
	5	0			1.00	h	1.00	f			1.00	i	1.00	h
		7	6.30	de	1.67	fgh	1.00	f	6.83	h	2.00	fgh	1.00	h
		14	10.56	c	2.33	def	1.67	ef	10.89	e	2.67	def	2.33	e
		21	15.93	b	4.33	b	4.33	b	16.24	c	4.00	b	4.67	ab
		24	22.08	a	5.00	a	5.00	a	22.43	a	5.00	a	5.00	a
Polyolefin stretch film	0	0			1.00	h	1.00	f			1.00	i	1.00	h
		7	0.37	l	1.00	h	1.00	f	6.10	e	1.00	i	1.00	h
		14	0.74	jkl	1.33	gh	1.00	f	10.12	c	1.67	ghi	1.00	h
		21	4.48	efg	2.00	efg	1.00	f	15.56	b	2.67	def	1.33	gh
		24	2.08	hijkl	2.33	def	1.67	ef	21.97	a	3.33	bcd	2.00	ef
	5	0			1.00	h	1.00	f			1.00	i	1.00	h
		7	0.49	kl	1.00	h	1.00	f	0.53	x	1.00	i	1.00	h
		14	1.05	ijkl	2.00	efg	1.33	ef	0.90	v	2.67	def	1.67	fg
		21	2.61	ghij	3.00	cd	1.67	ef	1.84	s	3.67	bc	2.33	e
		24	3.41	fgh	3.67	bc	2.67	d	2.45	q	4.00	b	3.00	d
Stretch film	0	0			1.00	h	1.00	f			1.00	i	1.00	h
		7	1.41	hijkl	1.00	h	1.00	f	0.69	w	1.00	i	1.00	h
		14	2.49	hijk	2.00	efg	1.00	f	1.33	u	2.33	efg	1.00	h
		21	4.73	ef	2.67	de	1.67	ef	2.91	o	3.00	cde	2.33	e
		24	5.85	de	4.00	b	2.67	d	3.75	m	3.67	bc	3.00	d
	5	0			1.00	h	1.00	f			1.00	i	1.00	h
		7	1.77	hijkl	1.33	gh	1.00	f	0.61	l	1.33	hi	1.00	h
		14	2.82	ghi	2.67	de	1.67	ef	1.12	k	2.67	def	2.00	ef
		21	5.60	de	3.67	bc	2.67	d	2.38	i	4.00	b	3.33	cd
		24	7.07	d	4.33	b	3.33	c	3.10	g	4.67	a	3.67	c
Control			13.03	A	2.73	A	2.43	A	13.44	A	2.80	A	2.63	A
Polyolefin stretch film			1.90	C	1.83	C	1.33	C	1.80	C	2.20	C	1.53	C
Stretch film			3.97	B	2.37	B	1.70	B	4.31	B	2.47	B	1.93	B
	0		5.96	B	2.09	B	1.62	B	6.05	B	2.27	B	1.80	B
	5		6.64	A	2.53	A	2.02	A	6.98	A	2.71	A	2.27	A
		0			1.00	D	1.00	D			1.00	E	1.00	D
		7	2.57	D	1.22	D	1.00	D	2.85	D	1.28	D	1.00	D
		14	4.48	C	2.06	C	1.44	C	4.73	C	2.39	C	1.72	C
		21	7.99	B	3.22	B	2.44	B	7.80	B	3.50	B	2.94	B
		28	10.15	A	4.06	A	3.22	A	10.69	A	4.28	A	3.50	A

Values followed by the same letter (s) are not significantly different at 5 %

Storage temperature is a very important factor which influences post-harvest sweet corn quality and it has been suggested that the optimum maintenance of quality is achieved when cobs are held as close as possible to 0°C (Shiina *et al*., 1997 and Brecht, 2002). Moreover, Shiina *et al*. (1997) reported that its respiration rate increases approximately 5-8-fold after an increase in temperature of 20°C, which implies the significance of storage temperature in sweet corn quality preservation. The biological explanation of the importance of storage temperature on the shelf life of fruits and vegetables relies on the general observation that an increase in temperature of approximately 10°C, results in double or even treble the number of biological reactions occurring in the plant (Riad and Brecht 2003). The effect of a temperature change of 10°C on the biological reactions is described as temperature quotient Q_{10}.

Keeping temperature low is crucial as increasing storage temperature results in increased CO_2 and therefore increased sugar utilization/conversion and water loss (Riad, 2004). Indeed, among the sweet corn examined, ears stored at 0°C had higher sugar content than ears stored at 5°C. In addition to storage temperature, controlled atmosphere is also used for better retention of sweet corn quality. Generally, at lower temperatures the quality of sweet corn is better retained and the changes in the biochemical and textural profile

of sweet corn are minimized. At higher temperatures enzymatic and oxidative reactions occur faster (Rodov *et al*., 2000; Riad and Brecht, 2001; Riad, 2004).

Table 2: Effect of wrapping film, storage temperature and storage period on visual quality, total sugars % (g/100 g FW) and non-reducing sugars (sucrose) (g/100 g FW) of sweet corn in 2010 and 2011 seasons.

Treatments			First season						Second season					
Wrapping film	Storage temperature	Storage period	Visual quality		Total sugars % (g/100 g FW)		Non-reducing sugars (sucrose) (g/100 g FW)		Visual quality		Total sugars % (g/100 g FW)		Non-reducing sugars (sucrose) (g/100 g FW)	
Control	0	0	9	a	6.17	defg	5.22	a	9	a	6.16	e	5.08	a
		7	7.67	abc	6.19	cdef	4.82	h	8.33	ab	6.10	i	4.69	h
		14	6.33	cde	6.22	cde	4.69	jk	7.00	bcd	6.06	j	4.39	m
		21	3.67	gh	6.09	i	4.42	n	4.33	fgh	5.97	n	4.19	r
		24	2.33	hi	6.16	defg	4.32	q	1.67	jk	6.01	l	4.04	t
	5	0	9	a	6.17	defg	5.22	a	9.00	a	6.16	e	5.08	a
		7	7.00	bcd	6.21	cdef	4.70	j	6.33	cde	6.14	fg	4.52	k
		14	5.67	def	6.31	a	4.65	l	5.00	efg	6.04	k	4.25	q
		21	3.67	gh	6.10	hi	4.32	q	2.33	ijk	5.94	o	4.02	u
		24	1.00	i	6.07	i	4.18	r	1.00	k	5.99	m	3.87	v
Polyolefin stretch film	0	0	9	a	6.17	defg	5.22	a	9	a	6.16	e	5.08	a
		7	9.00	a	6.15	fgh	5.17	b	9.00	a	6.16	ef	5.01	b
		14	9.00	a	6.24	bc	5.08	c	8.33	ab	6.21	c	4.91	c
		21	8.33	ab	6.31	a	4.91	f	7.00	bcd	6.31	a	4.79	e
		24	6.33	cde	6.32	a	4.77	i	5.00	efg	6.29	b	4.61	i
	5	0	9	a	6.17	defg	5.22	a	9	a	6.16	e	5.08	a
		7	9.00	a	6.16	efg	5.06	d	8.33	ab	6.15	efg	4.92	c
		14	8.33	ab	6.12	ghi	4.88	g	7.00	bcd	6.14	g	4.76	f
		21	5.67	def	6.19	cdef	4.68	k	4.33	fgh	6.16	e	4.53	j
		24	3.67	gh	6.20	cdef	4.52	m	3.00	hij	6.18	d	4.36	n
Stretch film	0	0	9	a	6.17	defg	5.22	a	9	a	6.16	e	5.08	a
		7	9.00	a	6.25	bc	5.00	e	9.00	a	6.28	b	4.87	d
		14	8.33	ab	6.22	bcd	4.78	i	7.67	abc	6.20	cd	4.61	i
		21	6.33	cde	6.08	i	4.53	m	5.67	def	6.09	i	4.41	lm
		24	4.33	fg	6.10	hi	4.39	o	3.67	ghi	6.10	i	4.27	p
	5	0	9	a	6.17	defg	5.22	a	9	a	6.16	e	5.08	a
		7	9.00	a	6.28	ab	4.87	g	9.00	a	6.27	b	4.73	g
		14	7.67	abc	6.23	bc	4.70	j	5.67	def	6.10	i	4.42	l
		21	5.00	efg	6.21	cde	4.53	m	3.67	ghi	6.12	h	4.28	o
		24	3.67	gh	6.21	cdef	4.38	p	2.33	ijk	6.10	i	4.12	s
Control			5.53	C	6.17	B	4.65	C	5.40	C	6.06	C	4.41	C
Polyolefin stretch film			7.73	A	6.20	A	4.95	A	7.00	A	6.19	A	4.81	A
Stretch film			7.13	B	6.19	A	4.76	B	6.47	B	6.16	B	4.59	B
	0		7.18	A	6.19	A	4.84	A	6.91	A	6.15	A	4.67	A
	5		6.42	B	6.19	A	4.74	B	5.67	B	6.12	B	4.53	B
		0	9	A	6.17	B	5.22	A	9	A	6.16	B	5.08	A
		7	8.44	A	6.21	A	4.94	B	8.33	B	6.18	A	4.79	B
		14	7.56	B	6.22	A	4.80	C	6.78	C	6.13	C	4.56	C
		21	5.44	C	6.16	B	4.57	D	4.56	D	6.10	E	4.37	D
		28	3.56	D	6.18	B	4.43	E	2.78	E	6.11	D	4.21	E

Values followed by the same letter (s) are not significantly different at 5 %

Effect of storage period

Results in Tables (1, 2 and 3) showed that, with prolonging the storage period, weight loss, decay and denting were increased and visual quality decreased. With extending the storage period total soluble solids (TSS), total and non-reducing sugars were decreased but reducing sugars, starch and dry matter were increased.

The obtained result showed that increasing storage period resulted in a decrease in sweet corn quality due to the increase in respiration rate which decreases the quality of sweet corn i.e. firmness sugar content, aroma, and flavor. Such results are attributed to that most sweet corn varieties when stored for more than a few days, a serious deterioration and loss of tenderness and sweetness will be obtained. The loss of sugar is about four times more at 10ºC (50ºF) than at 0ºC (32ºF). Pericarp toughening can be minimized by prompt cooling and by maintaining sweet corn at 0ºC (32ºF). Under optimum storage conditions, the potential post harvest life of common sweet corn varieties is under 2 weeks (Brecht, 2004).

Under high respiration, a major part of post harvest interventions is dedicated to reducing respiration and other metabolic reactions associated with quality retention by manipulating the external environment. In general, the storage life of vegetables varies inversely with the rate of respiration; this is because respiration supplies compounds that determine the rate of metabolic processes directly related to quality parameters, e.g., firmness, sugar content, aroma, and flavor (Saltveit, 2004). Given all these factors, the firs quality-improvement step that can be taken is cooling of sweet corn and handling in a safe and sanitary manner (to avoid damage and bruising) and subsequent storage at low temperatures. this opinion is agreement with those reported by Chang *et al*. (1979), Carey *et al.* (1982), Evenson and Boyer (1986), Lee *et al.* (1987), Risse and McDonald (1990), Brash *et al.* (1992), Marcos *et al*. (1999), Turk *et al*. (2001), El-Bassiouny *et al*. (2003), Attia (2006), Wanikanukul *et al*. (2007).

Table 3: Effect of wrapping film, storage temperature and storage period on total soluble solids (TSS), starch % (g/100 g FW) and dry matter % of sweet corn in 2010 and 2011 seasons.

Treatments			First season						Second season					
Wrapping film	Storage temperature	Storage period	Total soluble solids (TSS)		Starch % (g/100 g FW)		Dry matter %		Total soluble solids (TSS)		Starch % (g/100 g FW)		Dry matter %	
Control	0	0	15	a	2.22	w	21.84	r	15	a	2.25	r	22.63	v
		7	14.33	abc	3.70	r	24.12	m	14.00	bcd	3.91	o	24.93	o
		14	13.33	def	4.24	k	26.45	g	13.33	def	4.42	k	27.34	h
		21	13.00	efg	4.92	g	29.14	c	12.67	fg	5.14	g	30.06	d
		24	11.67	ij	5.71	b	30.35	b	11.33	ij	5.92	b	31.22	b
	5	0	15	a	2.22	w	21.84	r	15.00	a	2.25	r	22.63	v
		7	13.67	cde	4.01	n	24.82	k	13.33	def	4.24	lm	25.53	m
		14	13.00	efg	4.72	h	26.05	h	12.33	gh	4.95	h	26.74	i
		21	12.00	hij	5.34	d	30.24	b	11.67	hi	5.57	d	31.14	c
		24	10.67	k	6.14	a	32.03	a	11.00	ij	6.37	a	32.96	a
Polyolefin stretch film	0	0	15	a	2.22	w	21.84	r	15	a	2.25	r	22.63	v
		7	15.00	a	3.02	v	22.54	q	15.00	a	3.29	q	23.11	u
		14	14.67	ab	3.52	s	23.05	p	14.33	abc	3.79	p	23.84	t
		21	14.00	bcd	3.92	p	24.53	l	13.67	cde	4.16	mn	25.34	n
		24	13.67	cde	4.49	j	25.73	i	13.00	efg	4.78	i	26.55	j
	5	0	15	a	2.22	w	21.84	r	15	a	2.25	r	22.63	v
		7	14.67	ab	3.42	t	23.15	p	14.33	abc	3.69	p	23.90	s
		14	14.00	bcd	3.94	o	23.83	n	13.67	cde	4.22	lm	24.55	q
		21	13.67	cde	4.52	i	25.44	j	13.33	def	4.57	j	26.24	k
		24	12.67	fgh	5.09	f	26.93	e	12.33	gh	5.38	e	27.52	g
Stretch film	0	0	15	a	2.22	w	21.84	r	15	a	2.25	r	22.63	v
		7	14.67	ab	3.40	u	23.32	o	14.67	ab	3.71	p	24.05	r
		14	14.00	bcd	4.06	m	24.17	m	13.67	cde	4.30	l	24.84	p
		21	13.33	def	4.72	h	25.95	h	13.00	efg	5.04	gh	26.25	k
		24	12.33	ghi	5.21	e	26.95	e	11.67	hi	5.50	d	27.63	f
	5	0	15	a	2.22	w	21.84	r	15	a	2.25	r	22.63	v
		7	14.00	bcd	3.79	q	24.08	m	13.67	cde	4.10	n	24.82	p
		14	12.67	fgh	4.22	l	24.83	k	12.33	gh	4.51	jk	25.74	l
		21	11.67	ij	4.91	g	26.71	f	11.00	ij	5.28	f	27.54	g
		24	11.33	jk	5.51	c	28.14	d	10.67	j	5.82	c	28.94	e
Control			13.17	B	4.32	A	26.69	A	12.97	B	4.50	A	27.52	A
Polyolefin stretch film			14.23	A	3.64	C	23.89	C	13.97	A	3.84	C	24.63	C
Stretch film			13.40	B	4.03	B	24.78	B	13.07	B	4.28	B	25.51	B
	0		13.93	A	3.84	B	24.79	B	13.69	A	4.05	B	25.54	B
	5		13.27	B	4.15	A	25.45	A	12.98	B	4.36	A	26.23	A
		0	15	A	2.22	E	21.84	E	15	A	2.25	E	22.63	E
		7	14.39	B	3.56	D	23.67	D	14.17	B	3.82	D	24.39	D
		14	13.61	C	4.12	C	24.73	C	13.28	C	4.37	C	25.51	C
		21	12.94	D	4.72	B	27.00	B	12.56	D	4.96	B	27.76	B
		28	12.06	E	5.36	A	28.35	A	11.67	E	5.63	A	29.14	A

Values followed by the same letter (s) are not significantly different at 5 %

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