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EVALUATION OF POST-HARVEST QUALITY OF MARIGOLD FLOWERS AFTER PACKAGING AND STORAGE IN DIFFERENT SEASONS

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Abstract

In the present study, the keeping quality of differently packed and stored marigold flowers was evaluated under ambient conditions during summer and rainy seasons. The shelf life of marigold was 1 day in summer and 4 days in rainy season which was supported by high membrane stability index, relative water content, total soluble proteins, total soluble sugars, lesser loss in physiological weight, minimum spoilage and maximum freshness index of flowers in rainy season. The ice box, CFB box and polythene packages showed better results in comparison to gunny bag and onion mesh bag. One day storage was better in comparison to two and three days in all the seasons. Thus, marigold flowers can be packed in ice box, CFB box and polythene for 2 to 3 days without any adverse effect on keeping quality during rainy season.

Introduction

Marigold (*Tagetes erecta* L.), belonging to Asteraceae is one of the important commercial flower crops paving its way to be the leading flower crop. It has brightly colored flowers in different shades ranging from yellow to orange. As loose flower, it is used in interior decoration, car decoration, festive procession, marriages, religious ceremonies and social functions. Inappropriate storage ruins the flower so it is very essential to know what type of material should be used for packaging (Figueroa *et al*. 2005). Normally flowers of marigold last for 3-4 days and in summer, the shelf life declines to 1 day due to which flowers could not reach the market in good quality. During rainy season when humidity increases and temperature decreases comparative to summer season, the shelf life increases to 3-4 days but still losses occur during storage (at the time of glut) and transportation. This leads to major setback to farmers so they have to sell the flowers at very less prices. Short term storage methods in locally available materials can result higher profits by cutting postharvest losses (Devi *et al*. 2017). Keeping in view, the year-round demand for marigold, influence of temperature and humidity and post-harvest losses during transportation, the present study was conducted to correlate the shelf life of marigold with temperature and humidity during different seasons after storage and packaging of flowers for different durations in different packaging materials.

Materials and Methods

The experiment was conducted on fully opened harvested fresh flowers of marigold var. (Punjab Gainda No-1) during summer and rainy season. The seeds of Punjab Gainda No-1 were sown in the last week of January and June, transplanting was done in the first week of March and August , respectively and correspondingly the harvesting of flowers began in May and October. The harvested flowers were placed in different packaging materials (Polythene bags, Corrugated fiber board box, Ice box, Bamboo basket, Gunny bags, Onion mesh bags, Control) under different storage durations (0,1, 2 and 3 days). After different treatments, the keeping quality of the flowers

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was evaluated under ambient conditions. The post-harvest quality parameters *viz.* shelf life, moisture content (%), physiological loss in weight (%), change in colour (by Royal Horticultural Chart), spoilage (%) and freshness index (scoring on visual basis) were recorded after storage.

The physiological and biochemical parameters *viz.* membrane stability index (Weatherly 1950), relative water content (Dubois *et al.* 1956), total soluble sugar (Lowry *et al.*1951), total soluble proteins (Hiscox and Israelstam 1979) and total carotenoid content (Madiah and Reddy 1992) were recorded from tepals of marigold flowers.

Results and Discussion

The flowers of Punjab Gainda No-1 were packed in different packages for 0, 1, 2 and 3 days during first week of June. Due to high temperature and low humidity, the fresh flowers lost their acceptability next day. The flowers packed in different packages for one day were found to be acceptable whereas flowers stored for 2 and 3 days were found to be unacceptable in all packages as flowers showed 50% spoilage and loss in physiological weight. So, the data for all the parameters *viz.* post-harvest quality, physiological and biochemical characters were recorded for one day storage in summer season. The loss in different quality parameters of marigold flowers in all packages after one day in summer season is in agreement to the findings of Verma and Jhanji (2021).

During summer season, the shelf life of flowers stored in different packaging materials was found to range from 1.12 days in onion mesh bags to 1.81 days in ice box (Table 1). Whereas in rainy season the flowers packed in different packaging materials differed significantly with maximum shelf life in ice box and minimum in gunny bag (Fig. 1). Higher shelf life was recorded in one day storage as compared to three days. The observation of significant increase in shelf life due to packaging and storage is more less similar to the findings of tuberose (Jawaharlal *et al.* 2012).

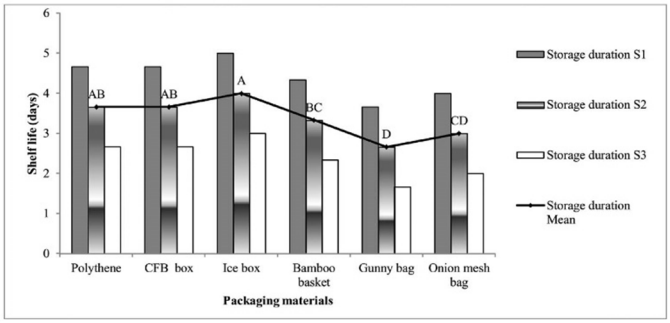

Fig. 1. Effect of packaging materials and storage durations on shelf life of marigold during rainy season.

The post-harvest quality parameters for one day storage in summer season revealed that with increase in storage duration, the flowers became unacceptable (Table 1). Among all the packaging materials, flowers stored in ice box for one day was recorded maximum moisture content (77.19%) which was at par with CFB box (75.67%) and polythene (76.95%) and flowers stored in onion mesh bag was recorded minimum moisture content (66.98%). Loss in physiological weight and spoilage percentage was highest in flowers stored in onion mesh bag (32.53%) whereas least loss in weight was recorded in flowers packed in ice box and polythene and least spoilage of flowers packed in ice box (10.23%). Freshness index ranged from 86.96% in polythene to 55.38% in onion mesh bag.

Table 1. Effect of packaging materials on post-harvest quality parameters of marigold flowers during summer season after 1 day of storage.

Sl. No.	Packaging	Moisture content	Loss in physiological weight	Shelf life	Freshness index	Spoilage	Membrane stability index	Relative water content	Total soluble sugars (mg g^{-1} FW)	Total soluble protein (mg g^{-1} FW)	Carotenoid content (mg g^{-1} FW)
1	Polythene	76.95^{A}	13.15^{C}	1.43^{C}	86.96^{A}	11.87^{C}	64.44^{A}	64.28^{A}	116.68^{B}	384.31^{B}	1.92^{B}
2	CFB box	75.67^{A}	24.72^{AB}	1.52^{B}	86.50^{A}	10.47^{D}	69.44^{A}	56.25^{B}	113.97^{C}	375.95^{C}	1.87^{C}
3	Ice box	77.19^{A}	13.15^{C}	1.81^{A}	87.61^{A}	10.23^{D}	65.27^{A}	66.51^{A}	119.56^{A}	389.90^{A}	2.02^{A}
4	Bamboo basket	73.51^{B}	26.18^{AB}	1.25^{D}	58.47^{C}	33.35^{B}	67.22^{A}	53.33^{B}	110.99^{D}	372.22^{C}	1.81^{D}
5	Gunny bag	70.49^{C}	26.99^{AB}	1.21^{D}	84.24^{B}	10.91^{D}	69.84^{A}	50.00^{C}	108.08^{E}	364.89^{D}	1.75^{E}
6	Onion mesh bag	66.98^{D}	32.53^{A}	1.12^{E}	55.38^{D}	43.51^{A}	62.50^{A}	46.66^{D}	100.63^{F}	349.56^{E}	1.64^{F}
	Mean	**73.47**	**21.92**	**1.39**	**76.53**	**20.68**	**66.45^{A}**	**56.17^{A}**	**111.65^{A}**	**372.80^{A}**	**1.83^{A}**
	Control	-	-	1.00	-	-	**72.91**	**64.18**	**125.98**	**391.76**	**1.54**
	CD (5%)	P=0.24	P=5.54	P=0.61	P=0.65	P=10.16	P=0.4	P=2.23	P=2.88	P=5.59	P=0.1

In contrast to summer season, the flowers stored during rainy season showed better keeping quality parameters. The fresh flowers recorded maximum moisture content (87.91%) which declined with increasing storage in all packages. Among all the packaging materials, flowers packed in ice box exhibited maximum moisture content *i.e.* 78.26% whereas least moisture content was recorded in onion mesh bag i.e. 72.05% (Table 2). Our results are in accordance with Devi *et al.* (2017). Among storage durations, one day storage recorded maximum moisture content (79.31%) as compared to two days (74.64%) and three days storage (71.71%). Positive influence of ice box and CFB box on moisture content could be attributed to thermal isolation, resistance to moisture and weathering (Leopold and Kriedemann 1975).

The flowers packed in onion mesh bags exhibited highest loss in physiological weight (20.96%) after storage and flowers packed in ice box and polythene recorded least loss in physiological weight 6.80 and 7.52%, respectively (Table 2). The less loss of physiological weight in ice box and polythene could be attributed to high moisture content in these packages. Increased loss in physiological weight and moisture content of flowers resulted in lower shelf life (Nagaraja *et al*. 1999). The loss in physiological weight of flowers was maximum in summer season because of high temperature and low relative humidity. Less humid environment results in more water loss from flowers due to low vapor pressure during summer season (Premachandra 1990).

Maximum freshness index was exhibited by the flowers packed in ice box and minimum freshness index was recorded in the flowers packed under onion mesh bag (Table 2). The flowers stored for one day had significantly higher freshness index than flowers stored for two and three days. Retention of freshness of flowers in icebox, polythene and CFB box could be due to their ability to maintain humid conditions in the vicinity of flowers by acting as a barrier for loss of moisture inside the packing. The present results are in concomitant with findings of Sharma *et al*. (2021) in marigold.

Minimum spoilage percentage was recorded in flowers packed in ice box, followed by CFB box and polythene (Table 2). Further, flowers packed for three days in various packaging materials experienced more spoilage as compared to one and two days. The lesser spoilage of flowers packed in ice box, CFB box and polythene could be due to their ability to maintain optimum humidity which leads to moisture retention and also enhances shelf life (Jaleel *et al*. 2006).

Physiological and biochemical analysis from tepals of flowers in summer season revealed that Membrane stability index (MSI) of fresh flowers was 72.91 that declined after storage to 62.50 in onion mesh bag to 69.44 in CFB box (Table 1). Relative water content (RWC) was highest in ice box (66.51) and least in onion mesh bag (46.66). Among all the packaging materials, flowers stored in ice box recorded maximum total soluble sugar (TSS, 119.56 mg g^{-1} FW), total soluble protein (TSP, 389.90 mg g^{-1}FW) and carotenoid content (2.02 mg g^{-1}FW) and corresponding values were least in onion mesh bag (Table 1).

In rainy season too, the fresh flowers recorded maximum MSI (87.18, Table 3). The flowers packed in ice box exhibited maximum MSI (77.35) and minimum was exhibited by flowers in onion mesh bag (57.83). The flowers packed for one day recorded maximum MSI (73.47) as compared to the flowers stored for two days (69.70) and three days (59.87). The decline in MSI with the onset of senescence is an indication of membrane integrity which is irreversible and final phase of senescence associated with lipid peroxidation in membrane (Nicholas 1966). With increased lipid peroxidation, permeability of membrane also increases, resulting in lost cell integrity (Hossain *et al.* 2004). Concomitant with results of MSI, the fresh flowers had maximum RWC. The flowers packed in ice box recorded maximum RWC of 73.50 after storage and minimum relative water content was recorded in the onion mesh bag (56.39, Table 3). The RWC of flowers stored for one day (69.76) was relatively higher as compared to the flowers stored for

Table 2. Effect of packaging materials and storage durations on post harvest quality of marigold flowers during rainy season.

Sl. No.	Packaging	Moisture content (%)				Physiological loss in weight (%)				Freshness index				Spoilage (%)			
		S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
1	Polythene	80.08^{b}	74.39^{efg}	72.13^{ghi}	**75.53^{C}**	1.88^{i}	5.75^{ghi}	14.93^{de}	**7.52^{D}**	86.66^{a}	83.65^{b}	79.34^{g}	**83.21^{B}**	13.71^{gh}	16.25^{efg}	20.53^{b}	**16.83^{BCD}**
2	CFB box	81.14^{b}	78.65^{bc}	73.11^{fgh}	**77.10^{B}**	7.31^{ghj}	15.54^{cde}	22.20^{b}	**15.02^{C}**	86.26^{a}	84.41^{b}	77.17^{hi}	**82.61^{C}**	12.37^{h}	14.49^{fgh}	21.36^{b}	**16.07^{D}**
3	Ice box	82.39^{a}	77.29^{cd}	74.39^{efg}	**78.26^{A}**	3.16^{hi}	4.11^{hi}	13.13^{ef}	**6.80^{D}**	88.75^{a}	86.39^{a}	84.42^{b}	**86.52^{A}**	12.55^{b}	13.67^{gh}	18.29^{cdef}	**14.83^{E}**
4	Bamboo basket	78.65^{bc}	73.58^{efgh}	70.71^{ij}	**74.31^{D}**	9.88^{fg}	19.69^{be}	29.07^{a}	**19.55^{B}**	84.31^{b}	81.98^{e}	76.68^{i}	**80.99^{D}**	13.95^{gh}	16.98^{defg}	22.70^{b}	**17.88^{BC}**
5	Gunny bag	76.81^{bcd}	72.76^{efg}	69.68^{ij}	**73.08^{D}**	11.99^{ef}	18.90^{bcd}	28.59^{a}	**19.82^{AB}**	83.04^{de}	80.38^{fg}	77.91^{h}	**80.44^{E}**	19.28^{bcde}	15.42^{fgh}	19.28^{bcde}	**17.99^{B}**
6	Onion mesh bag	75.83^{de}	71.22^{hij}	69.09^{j}	**72.05^{E}**	13.95^{ef}	22.03^{b}	26.91^{a}	**20.96^{A}**	80.80^{f}	77.42^{hi}	73.35^{j}	**77.19^{F}**	14.82^{fgh}	20.07^{b}	26.88^{a}	**20.59^{A}**
	Mean	**79.31^{A}**	**74.64^{B}**	**71.71^{C}**		**8.03^{C}**	**14.34^{B}**	**22.47^{A}**		**84.97^{A}**	**82.37^{B}**	**78.14^{C}**		**14.00^{c}**	**16.14^{B}**	**21.50^{A}**	
	Control	**87.91**				**31.21**				**-**				**-**			
	CD(5%)	P=0.72 S=0.50 PxS=1.09				P=2.40 S=1.70 PxS=3.31				P=0.35 S=0.24 PxS=3.09				P=1.20 S=0.85 PxS=3.12			

*Different uppercase letters in the vertical column represent significant differences between packaging materials and in the horizontal row represent significant differences between storage durations. Different lowercase letters represent significant differences between interaction of packaging materials and storage durations. *S_1-one day, S_2-two day, S_3-Three days.

Table 3. Effect of packaging materials and storage durations on post harvest quality of marigold flowers during rainy season.

Sl. No.	Packaging	Membrane stability index				Relative water content				Total soluble sugar (mg g^{-1} FW)				Total soluble protein (mg g^{-1} FW)				Carotenoid content (mg g^{-1} FW)			
		S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean	S_1	S_2	S_3	Mean
1	Polythene	76.66^{b}	71.42^{cd}	64.04^{ghi}	**70.70^{B}**	72.29^{c}	69.23^{e}	64.28^{g}	**68.60^{C}**	126.99^{c}	124.31^{d}	116.86^{fg}	**122.72^{C}**	382.03^{c}	370.97^{ef}	356.67^{h}	**369.89^{C}**	2.18^{b}	2.00^{d}	1.83^{fg}	**2.00^{C}**
2	CFB box	74.72^{bc}	70.51^{d}	65.40^{fgh}	**70.21^{B}**	75.00^{b}	69.23^{e}	66.66^{f}	**70.29^{B}**	129.15^{c}	128.24^{c}	121.70^{e}	**126.37^{B}**	398.95^{b}	377.26^{cd}	364.27^{g}	**380.16^{B}**	2.22^{b}	2.11^{c}	1.94^{e}	**2.09^{B}**
3	Ice box	82.93^{a}	77.73^{b}	71.39^{cd}	**77.35^{A}**	77.77^{a}	72.72^{c}	70.00^{d}	**73.50^{A}**	135.22^{a}	132.15^{b}	124.38^{d}	**130.58^{A}**	420.16^{a}	404.20^{b}	371.73^{ef}	**398.70^{A}**	2.46^{a}	2.21^{b}	2.03^{d}	**2.23^{A}**
4	Bamboo basket	71.19^{cd}	69.96^{de}	61.00^{i}	**67.38^{C}**	69.23^{e}	64.28^{g}	60.00^{h}	**64.50^{D}**	120.38^{e}	117.45^{f}	115.02^{gh}	**117.62^{D}**	364.27^{g}	369.73^{f}	350.59^{i}	**366.80^{D}**	2.10^{c}	1.92^{e}	1.85^{f}	**1.96^{D}**
5	Gunny bag	69.24^{def}	66.52^{efg}	52.10^{j}	**62.62^{D}**	64.28^{g}	60.00^{h}	57.14^{i}	**60.47^{E}**	114.54^{h}	115.40^{fgh}	108.18^{i}	**112.71^{E}**	376.15^{de}	361.92^{gh}	342.65^{j}	**360.24^{E}**	1.92^{e}	1.81^{fg}	1.79^{g}	**1.84^{E}**
6	Onion mesh bag	66.09^{fg}	62.10^{hi}	45.30^{k}	**57.83^{E}**	60.00^{h}	56.25^{j}	52.94^{k}	**56.39^{F}**	108.18^{i}	106.63^{i}	99.49^{j}	**104.76^{F}**	357.71^{h}	343.89^{j}	332.15^{k}	**344.58^{F}**	2.00^{d}	1.74^{h}	1.74^{h}	**1.82^{E}**
	Mean	**73.47^{A}**	**69.70^{B}**	**59.87^{C}**		**69.76^{A}**	**65.28^{B}**	**61.83^{C}**		**122.41^{A}**	**120.69^{B}**	**114.27^{C}**		**385.85^{A}**	**371.33^{B}**	**353.01^{C}**		**2.15^{A}**	**1.96^{B}**	**1.86^{C}**	
	Control	**87.18**				**82.65**				**138.18**				**425.98**				**2.30**			
	CD(5%)	P=1.20 S=0.85 PxS=7.75				P= 0.16 S=0.11 PxS=1.83				P=0.79 S=0.56 PxS=10.44				P=1.67 S=1.18 PxS=14.18				P=0.01 S=0.01 PxS=0.09			

*Different uppercase letters in the vertical column represent significant differences between packaging materials and in the horizontal row represent significant differences between storage durations. Different lowercase letters represent significant differences between interaction of packaging materials and storage durations. *S_1-one day, S_2-two day, S_3-Three days.

two days (65.28) and three days (61.83). Increased loss in physiological weight leads to decline in fresh weight of flowers, that leads to wilting of flowers as reported in Carnation. Similar results were reported in gladiolus where decrease in moisture content resulted in decreased RWC of tepals that caused dehydration of tissues and in turn wilting of flowers (Van Staden1995).

The flowers packed in ice box exhibited maximum TSS (130.58 mg g^{-1} FW) and minimum TSS in onion mesh bag (104.76 mg g^{-1} FW). The content of TSS decreased with increase in storage duration (Table 3). Unpacked flowers recorded minimum TSS (82.21 mg g^{-1}FW). Role of sugars in the senescence of cut flowers had been extensively studied (Mansee *et al.* 2013). Longevity of the flower is associated with sugar content as the flowers are devoid of hormones, food and water supply after detachment from the plant. Total soluble sugar content was high in flowers exhibiting higher shelf life than the flowers exhibiting lower shelf life (Van Doorn and Woltering 2004). Like TSS, TSP also decreased with increase in storage duration in all packages (Table 3). The maximum TSP was exhibited in ice box for one day (337.54 mg g^{-1} FW). Unpacked flowers recorded minimum TSP (264.90 mg g^{-1} FW). The expression of proteolytic enzymes leads to protein degradation due to breakdown of internal peptide bonds. Enhanced shelf life could be due to maintenance of fresh weight, total soluble sugar content, stabilized protein degradation which leads to higher protein content (Woolhouse 1984).

Carotenoid content was higher in flowers stored in ice box (2.23 mg g^{-1} FW) and minimum in onion mesh bag (1.82 mg g^{-1} FW; Table 3). The flowers packed for one day (1.68 mg g^{-1}FW) had significantly maximum carotenoid than flowers packed for two days (1.60 mg g^{-1} FW) and three days (1.40 mg g^{-1} FW). Pigments like carotene, monohydroxy, dihydroxy and xanthophyll content decreased with increasing period of storage from 1st day to 13th day of storage (Tokas *et al.* 2018).

The packaging materials, storage durations and seasons influenced the post-harvest life of marigold. The shelf life of marigold flowers stored during rainy season was better than summer season as flowers could be stored for just 1 day in summer season. Among packaging materials, ice box packaging up to three days in rainy season was best but at par with CFB boxes and polythene packaging for few post-harvest quality parameters. The overall quality of flowers after storage and packaging was best in CFB boxes and could be recommended for commercial purposes. Thus, the present results have potential to offer appropriate methods for storing flowers even for short term to provide solution during unforeseen circumstances.

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