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Effect of different packaging materials on shelf life of African marigold (*Tagetes erecta* L.) loose flower during winter season

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Abstract
The present investigation was done on effect of different packaging material on keeping quality of loose African marigold (*Tagetes erecta* L.) flower with objective to Study the Effect of Different Packaging Materials on Shelf life of Marigold loose flower during Winter Season. The research was arranged in Completely Randomized Design (CRD) with 11 treatments. Treatment consist different packaging material i.e. polyethylene 200 gauge (0, 1, 2% ventilation), polyethylene 400 gauge (0, 1 and 2% ventilation), gunny bags, onion mesh bag, card board box, crates and control (without packaging) and treatments replicated thrice. Among the treatments, The maximum values for parameters including freshness index, shelf life, relative water content, minimum physiological loss in weight and minimum spoilage percentage has been observed in T_4 (polyethylene 400 gauge 0% ventilation) followed by T_1 (polyethylene 200 gauge 0% ventilation). Card board box has found better than gunny bag, onion mesh bag and crates. Polyethylene 400 gauge 0% ventilation has been beneficial for increase shelf life of loose marigold flowers as compared to crates. Therefore, it may be concluded that as far as packaging material is concerned, polyethylene 400 gauge 0% ventilation has been found to be superior and may be recommended for transition of loose marigold flowers.

Keywords: Winter season, packaging material, loose flower, shelf life, polyethylene, card board box, crates, gunny bag, onion mesh bag and ventilation

Introduction
African marigold (*Tagetes erecta* L.) is one of the important loose flowers grown commercially in different parts of India. The chromosome number of marigold is 2n=24. It is belongs to family Asteraceae and native to Central and South America specially Mexico. Common name in English is marigold derived from Mary's gold, which is initially applied to similar european native plant *Calendula officinalis*. Marigold is commonly known as *Gainda* in Hindi, belt of Central and northern India. Marigold introduced India by the Portuguese and they indiscriminately applied marigold name is several genera of Asteraceae with golden or yellow capitulum and there are about 33 species of the genus Tagetes, out of which, five species have been introduced into the Indian gardens viz. *Tagetes erecta* L. (Aztec or African Marigold), *Tagetes minuta* L. (*Tagetes glandulifera* Schrank), *Tagetes patula* L. (French Marigold), *Tagetes lucida* (Sweet-Scented Marigold), *Tagetes tenuifolia* (Striped Marigold). It is grown as annual flowers, short duration, free blooming and taller type crop. It has gained popularity because of adaptability to various soils and climatic conditions and longer blooming period. Flower colour varies from lemon yellow, bright yellow, golden yellow, orange and nearest to white. The Marigolds spread quickly because of the easy to cultivation, longer blooming period and beautiful flowers with excellent shelf life. They are extensively used for making garlands, religious offerings and exhibitions.
The acreage of marigold cultivation in India is about 64.65 thousand ha with a production of 608.97 thousand MT loose flowers and 7.90 thousand MT cut flowers (Anonymous, 2016-17) [1]. The area under Chhattisgarh is 5,131 ha with a production of 40448 MT, although marigold is the leading loose flower crop in the Chhattisgarh market with 6th ranks in term of production in India. (Anonymous, 2018-19) [2]. It has gained popularity in Chhattisgarh on accounts of its easy cultivation, wide adaptability and popularity throughout the year.

The market and climatic condition of Chhattisgarh is favourable for marigold. Hence an ample scopes for increasing area and production.

The production of flowers is increasing every year. However handling of flowers is a huge task and nearly 70 percent of the potential lasting quality of flowers is predetermined at harvest, while post-harvest factors like temperature, relative humidity, packaging and transportation are influence 30 percent of the effects. There is enormous loss in value of loose flowers during marketing channel which can be 50 percent of the farm value (Bhattacharjee and De, 2005) [4]. Post harvest behaviour and long-lasting quality of loose flower considerably vary from species to cultivars; generally flowers are extremely perishable maintaining their physiological functions very active even after harvest. The beginning of flower senescence often depends on ethylene production.

The most common and visibly apparent senescence symptom in flower petals is loss of cell turgidity, resulting in wilting and death, retaining the freshness and turgidity, improving the vase life and flower quality are essential for post harvest management of flowers, normally marigold flowers are lost in 3-4 days after harvest depending on the season. The packaging plays a key role in controlling senescence of flower and prolonging the shelf life of many ornamental crops. Besides this, the packaging has also play a key role in enhancing the quality parameters. Packaging and storage is an essential part of the floriculture industry for orderly marketing. Packaging is a fundamental tool for the post harvest management of highly perishable commodities. Packaging enhances shelf life of marigold by retaining their attractiveness.

Materials and Methods

The experiment was done at Department of Floriculture and Landscape Architecture, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during the year 2019-2020. The study was designed under Completely Randomized Design (CRD) with three replications. The harvested fully opened loose flowers of marigold are packaged in different packaging material. The packaging materials used for this study were polyethylene 200 gauge (0, 1, 2% ventilation), polyethylene 400 gauge (0, 1 and 2% ventilation), gunny bags, onion mesh bag, card board box, crates. The experiments included 11 treatments namely, polyethylene 200 gauge 0% ventilation, polyethylene 200 gauge 1% ventilation, polyethylene 200 gauge 2% ventilation, polyethylene 400 gauge 0% ventilation, polyethylene 400 gauge 1% ventilation, polyethylene 400 gauge 2% ventilation, gunny bag and control (without packaging) onion mesh bag. The packaging of loose flowers was done in different packaging material and each packages carried 125 gm loose African marigold flowers. In each treatment contains five packages and arranging it in three replications. In control treatment, loose flowers are stored without packaging materials and stored under room temperature during winter season. The data on different parameters that is physiological loss in weight (%), spoilage percentage, freshness index, shelf life and relative water contents were recorded during experiment. The recorded data analysed for the completely randomized design *viz.* computation of mean, standard error and critical difference (CD) value P = 0.05 were carried out using ANOVA table.

Table 1: Details of different treatment

Treatments	Details
T_0	Control (without packaging)
T_1	Polyethylene 200 gauge 0% ventilation
T_2	Polyethylene 200 gauge 01% ventilation
T_3	Polyethylene 200 gauge 02% ventilation
T_4	Polyethylene 400 gauge 0% ventilation
T_5	Polyethylene 400 gauge 01% ventilation
T_6	Polyethylene 400 gauge 02% ventilation
T_7	Gunny bag
T_8	Onion mesh bag
T_9	Card board box with no ventilation
T_{10}	Crates

Results and Discussion

In the current study, the collected observational data was statistically analysed using the method of analysis of variance at 5% level of significance. ANOVA revealed that the influence of different packaging material showed significant on parameters at 1st 2nd and 3rd DAS.

The minimum physiological loss in weight 2.07, 4.40 and 8.10% has been observed in treatment T_4 (polyethylene 400 gauge with 0% ventilation) at 1st, 2nd and 3rd day after storage. The maximum physiological loss in weight 18.54, 22.40 and 32.10% has been recorded in treatment T_0 (without packaging) followed by treatment T_8 (onion mesh bag) at 1st, 2nd and 3rd day after storage during winter season. The minimum physiological loss in weight was noted in PE 400 gauge 0% ventilation under ambient condition which is mainly due to maintains humidity inside the packages which in turn slows down the process of moisture loss and proper balance of carbon di-oxide and oxygen concentrations which lower down the respiration. (Anzueto and Rizve 1985) [3] The results of this study are close agreement with the findings of Khongwir *et al*. (2017) [8] in tuberose and Ravi *et al*. (2004) [15], Karuppaiah *et al*. (2006) [7] in jasmine.

The minimum spoilage flower percentage 0.00, 0.94 and 1.58% has been observed in treatment T_4 (polyethylene 400 gauge 0% ventilation) which was *at par* with T_1 (polyethylene 200 gauge 0% ventilation) at 1st, 2nd and 3rd day after storage during winter season. The minimum spoilage percentage had observed in T_4 (polyethylene 400 gauge 0% ventilation) reduce rotting in flowers resulting reduced spoilage of flower which is mainly due to maintaining optimum humidity and ratio of oxygen and carbon dioxide, moisture retention and thus reducing the rate of evapo-transpiration and respiration leading to lower spoilage. Similar finding were reported by Madaiah and Reddy (1994) [9] in tuberose, Nirmala and Reddy (1994) [16] in jasmine flowers, and Verma and Jhanji (2019) [14] in loose marigold flowers where minimum spoilage was recorded in polyethylene.

The maximum freshness index 5.00 has been recorded in treatment T_4 (polyethylene 400 gauge 0% ventilation) and T_1 (polyethylene 200 gauge 0% ventilation), 5.00 and 4.80 has been recorded in treatment T_4 (polyethylene 400 gauge 0% ventilation) which has *at par* with T_1 (polyethylene 200 gauge 0% ventilation) at 2nd and 3rd DAS, T_5 (polyethylene 400 gauge 1% ventilation) at 1st and 2nd DAS, T_6 (polyethylene 400 gauge 2% ventilation) at 1st and 2nd DAS, T_2 (polyethylene 200 gauge 1% ventilation) at 1st DAS, T_3 (polyethylene 200 gauge 2% ventilation) at 2nd DAS and T_9 (Card board box with no ventilation) at 2nd DAS. The minimum freshness index 4.00, 3.60 and 3.03 has been observed in treatment T_0 (without packaging) at 1st, 2nd and

3rd day after storage during winter season. Polyethylene 400 gauge 0% ventilation has attributed to reduces the permeability of moisture leading to the reduction in the loss of moisture and preventing the wilting of flower thus maintaining the freshness of flowers by delaying the symptoms of senescence. Lepold and Kriedmann (1975) [17] stated retention of freshness of flowers in polyethylene due to their ability to maintain humid condition in the vicinity of flowers by acting as a barrier for loss of moisture inside the packaging. Similar results were reported by Khongwir *et al.* (2017) [8] with tuberose loose flowers.

The maximum shelf life 5.60 days has been found in treatment T_4 (polyethylene 400 gauge 0% ventilation) which was *at par* with T_1 (polyethylene 200 gauge 0% ventilation) and T_5 (polyethylene 400 gauge 1% ventilation). The minimum shelf life 3.03 days respectively has been recorded after storage in control (without packaging) followed by onion mesh bag, gunny bag and crates during winter season. The minimum shelf life 3.03 days respectively has been recorded after storage in control (without packaging) followed by onion mesh bag, gunny bag and crates during winter season. The maximum shelf life had recorded in polyethylene 400 gauge 0% ventilation might be reduce physiological loss in flowers resulting increased shelf life of flower which is mainly due to the moisture retentive nature of polyethylene packaging material prevents moisture loss and increase the relative humidity inside the packed flowers resulting rate of respiration and other enzymatic activity was probably much lower, there by delaying the senescence process in the petals. Similar findings reported by Madaiah and Reddy (1994) [9], Khongwir *et al*. (2017) [8] in tuberose loose flower, Nirmala and Reddy (1994) [16] in jasmine, Verma and Jhanji (2019) [14] in marigold under ambient condition.

The maximum relative water content 76.27% 72.46% and 68.13% has been recorded in treatment T_4 (polyethylene 400 gauge 0% ventilation) at 1st, 2nd and 3rd day which was *at par* with T_1 (polyethylene 200 gauge 0% ventilation) at 1st, 2nd and 3rd DAS, T_5 (polyethylene 400 gauge 01% ventilation) at 1st and 2nd DAS, T_2 (polyethylene 400 gauge 1% ventilation) at 1st and 2nd DAS, T_6 (polyethylene 400 gauge 2% ventilation), T_9 (card board box) and T_3 (polyethylene 200 gauge 2% ventilation) at 2nd DAS. The minimum relative water content 67.53, 63.35 and 55.62% has been found in treatment T_0 (without packaging) at 1st, 2nd and 3rd day after storage during winter season. Polyethylene 400 gauge 0% ventilation increase relative water content of flowers which is mainly due to maintenance of relative humidity inside the packages results least moisture loss and maintaining the membrane integrity. Relative water contents manifest the water status of the petals it's higher when moisture content is high and weight loss is low. Similar findings also noted by Nagaraja *et al* (1999) [10] in loose flower of jasmine, Khongwir *et al.* (2017) [8] in tuberose loose flower and Verma and Jhanji (2019) [14] in marigold under ambient condition.

Table 2: Effect of different packaging material on Physiological loss in weight (%), Spoilage percentage, Freshness index (Score Card), Relative Water Contents (%) and Shelf life (Days) of loose marigold flower under ambient condition

Treat.	Physiological loss in weight (%)			Spoilage percentage			Freshness index (Score Card)			Relative Water Contents (%)			Shelf life (Days)
	1st DAS*	2nd DAS	3rd DAS	1st DAS	2nd DAS	3rd DAS	1st DAS	2nd DAS	3rd DAS	1st DAS	2nd DAS	3rd DAS	Winter
T_0	18.54	22.40	32.10	4.47	8.57	14.49	4.00	3.60	3.00	67.53	63.35	55.62	3.03
T_1	3.27	7.40	11.52	0.32	1.02	2.39	5.00	4.80	4.60	75.87	72.33	67.87	5.13
T_2	7.86	9.61	15.60	1.67	2.53	4.52	4.87	4.40	4.07	74.80	70.00	64.20	4.30
T_3	9.33	12.43	20.43	1.80	4.47	7.09	4.60	4.20	3.53	72.07	69.00	62.42	3.87
T_4	2.07	4.41	8.10	0.00	0.94	1.40	5.00	5.00	4.80	76.27	72.46	68.13	5.60
T_5	4.51	8.57	12.58	1.47	2.16	3.65	4.80	4.60	4.07	74.87	70.07	65.04	4.73
T_6	7.97	11.95	15.67	1.80	3.77	6.56	4.73	4.40	3.40	72.77	69.64	62.64	4.07
T_7	13.06	18.33	26.41	3.47	8.60	12.04	4.13	3.80	3.33	69.01	65.23	57.73	3.93
T_8	14.45	18.49	28.49	4.40	7.89	13.82	4.13	3.73	3.13	68.49	63.56	56.07	3.53
T_9	7.30	10.39	16.61	1.60	4.35	10.63	4.60	4.27	3.33	72.36	69.14	62.78	4.67
T_{10}	13.24	20.40	28.23	3.53	7.38	13.98	4.27	3.80	3.27	69.00	64.92	56.48	3.60
$SE_{m\pm}$	0.22	0.36	0.37	0.11	0.23	0.44	0.10	0.25	0.23	0.68	1.27	0.74	0.30
CD	0.65	1.08	1.11	0.32	0.70	1.30	0.31	0.74	0.69	2.00	3.74	2.17	0.88

Conclusion

The results revealed that polyethylene packaging material with 0% ventilation would be the best packaging material for increasing shelf life of loose marigold flowers. Among the entire treatments polyethylene 400 gauge 0% ventilation maintained minimum physiological loss in weight, maximum relative water content, maximum freshness index and lower spoilage percentage resulting maximum shelf life of loose marigold flowers during winter season.

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