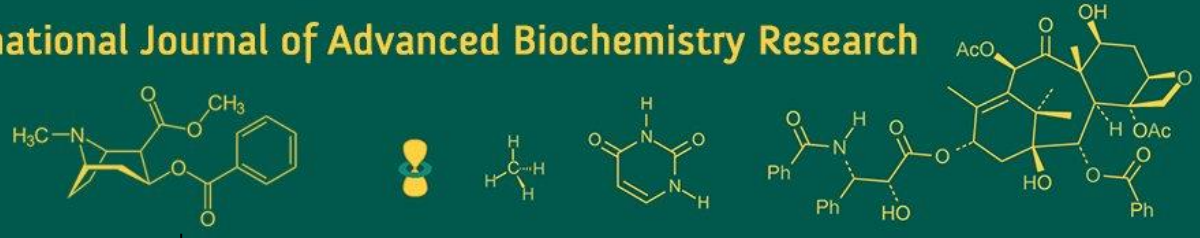
International Journal of Advanced Biochemistry Research



ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2024; 8(5): 892-896
www.biochemjournal.com
Received: 02-03-2024
Accepted: 06-04-2024

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Studies on packaging and storage behaviour of champaca (*Michelia champaca* Linn.)

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DOI: https://doi.org/10.33545/26174693.2024.v8.i5k.1214

Abstract
An experiment entitled, "Studies on packaging and storage behaviour of champaca (*Michelia champaca* Linn.)" was conducted at the Department of PHM of fruit, vegetable and flower crops, PGI-PHTM, Killa-Roha during the year 2022-23. The experiment was laid out in Factorial Completely Randomized Block Design (FCRD) comprising six treatment combinations of different chemicals along with control *viz*., Sodium Benzoate (100 ppm and 150 ppm), Boric Acid (1 and 2 percent) and Ascorbic Acid (100 ppm and 150 ppm) and were packed in three different types of packaging material *viz*., LDPE bags, polypropylene bags, stand up pouches and control were stored in refrigerator at 7 ℃. The quality of the champaca flower could be improved by treating with different chemical at different concentration and packed in various packaging material. From the present investigation, it was observed that the physical parameter such as L* and b* value for colour exhibited an decreasing trend while increasing trend was observed in a* value for colour of the champaca flower irrespective of treatments during storage. From the results of present studies, it can be concluded that the champaca flowers treated with 2 percent boric acid could be stored up to 7 days at low temperature (7± 2 ℃) conditions, when packed in LDPE bags.

Keywords: Champaca, packaging materials, boric acid, LDPE bags, refrigerated storage, retention, shelf life

Introduction
Michelia is a historical genus of flowering plants belonging to the family Magnoliaceae (Mane *et al.*, 2019) [8]. This valuable tree species is found wild in the forests of eastern sub-himalayan zone from Nepal eastwards, along the foothills up to 900 m elevation including West Bengal and Assam. The common names for champaca are Golden champa (English), Sampige (Kannada), Sampangi (Tamil), Chattusampangi (Telugu), Sonachapha (Marathi) (Desai and Lalitha, 2018) [6]. The generis name has been assigned in the honor of P. A. Micheli, a famous Florentine botanist. The flowers are axillary or terminal, trimerous and often enormous. Petal and sepal characteristics are often comparable and deciduous (Shejale and Yeligar, 2019). In India, as per 2nd advanced estimate (2021-22) of area and production of horticultural crops released by The Department of Agriculture and Farmers Welfare, the area and production of loose flower is 2,76,000 hectare and 22,98,000 MT, respectively (Anon., 2021) [1]. *Michelia champaca* is famous for the sweet odour of its blossoms. Methyl benzoate (heavy-sweet, deep-floral), indole (floral character highly reminiscent of jasmine and orange blossom) and 1,8-cineole (fresh camphoraceous) are contributing significantly to the fragrance of *Michelia champaca* flowers. *Michelia* (champaka) species is commonly known to produce high value essential oil. 'Joy' the second Best Selling perfume in the world which is derived in part from the essential oil of champaca flowers (Desai, 2018) [6].
The chemicals play a key role in increasing shelf life of loose flowers (florets) where a single day enhancement of shelf life is an important issue to extend the availability for costumers (Chawla *et al*., 2020) [4]. Ascorbic acid is an antioxidant that extends the vase life of flowers by lowering the rate of respiration and ethylene generation (Rakesh *et al*., 2022) [12]. It has been suggested that using boric acid as a mineral salt could improve the water balance and longevity of cut flowers by raising the osmotic concentration and pressure potential of the petal cells (Choudhury *et al*., 2019) [5]. In case of sodium benzoate, the shelf life of flowers are increasing due to its action on decreasing the pH and creating an unsuitable environment for the growth of micro-organisms, especially bacteria and fungi (Kumar *et al*., 2020) [7].

Packaging is a tool for controlling flower quality in the distribution chain. Apart from preventing mechanical damage, the package serves as a barrier between the conditions inside and outside the package (Nowak and Rudnicki, 1979) [9]. Since flowers are delicate and highly perishable, they need great attention through advanced technologies in packaging to keep them fresh to consumer's satisfaction. By improving the packaging techniques farmers can get more income by extending the storage life and keeping them fresh for longer time (Bhattacharjee, 1997) [2] (Rakesh *et al*., 2022) [12].

Near about, 30-50 percent losses of flowers occur due to improper post harvest handling during entire market chain. Post harvest treatments are aimed at encouraging the process under quality traits, including flower size, shape, colour and longevity (Chander, 2017) [3]. The flowers have good demand for export due to its attractive fragrance. But one of the major problems faced by farmers are lack of suitable packaging material, less shelf life of flowers and browning of petals on the second day of harvest with abrupt loss in fragrance (Choudhury, 2019) [5]. Therefore, the present investigation is planned to study the effect of different chemical pretreatments, packaging material and low temperature storage impact on shelf life of champaca flower. Therefore, keeping in mind, the above discussed factors regarding the champaca flowers, the present investigation was planned.

Materials and Methods

Materials

The half bloom champaca flowers were plucked during morning hours from PGI- PHTM campus, A/P.: Killa, Taluka: Roha, District: Raigad (MS). Harvested flowers were brought to the department of PHM of FVF laboratory and washed. Chemical, glassware, instrument and other material were procured from the Department of Post Harvest Management of Fruit, Vegetable and Flower Crops, Post Graduate Institute of Post Harvest Technology and Management, Killa-Roha, Dist.- Raigad. 25g of uniform size, freshly harvested flowers are used for each treatments and observation like colour value (L*, a* and b*), carotenoid content and total phenol content were recorded during storage of flowers at 24 hours of intervals.

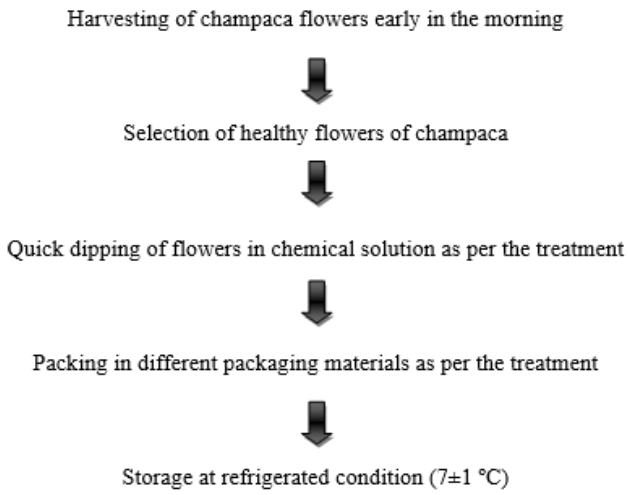
Methods

The colour of champaca flower was measured using Colorimeter (Colour Reader CR-10) and expressed as L*, a*, b* values. The data were statistically analyzed by using Factorial Completely Randomized design (FCRD) described by Panse and Sukhatme (1985) [10].

Pretreatment and packaging of champaca flower

Fresh flowers was treated with different concentrations of sodium benzoate, boric acid and ascorbic acid as per the treatment and dipped for few seconds in solution. Later on, the flowers were air dried, packed in different packaging material on pre- treatment and stored at refrigerated storage at 7 °C. This experiment was laid out in FCRD design with 7 treatments and 3 replication. The treatments are: T_1- 100 ppm sodium benzoate, T_2- 150 ppm sodium benzoate, T_3- 1% boric acid, T_4- 2% boric acid, T_5- 100 ppm ascorbic acid, T_6- 150 ppm ascorbic acid, T_7- control and sub treatments are packaging material: P1- LDPE bags, P2- polypropylene bags, P3- standup pouch and P4- control. The flowers were kept in refrigerated storage and stored at 7 ± 2 °C.

Flow Chart



Results

The data related to changes in L* values for colour of champaca flower influenced by different chemical treatments during storage at refrigerated temperature are given in Table 4.1. It was observed from the Table 4.1 that in LDPE bags, the treatment T_4 recorded significantly maximum mean L* value. The treatment T_7 recorded significantly lowest mean L* value. In polypropylene bags, the treatment T_4 recorded significantly maximum mean L* value and the treatment T_7 recorded significantly lowest mean L* value at 7th day of storage. In standup pouch, the treatment T_4 recorded significantly maximum mean L* value and the treatment T_7 recorded significantly lowest mean L* when the flowers were packed in standup pouch and in control, the treatment T_4 recorded significantly maximum mean L* value. The treatment T_7 recorded significantly lowest mean L* value. After 2nd day of storage, the shelf life of flowers was over when the flowers were packed in standup pouch and kept loose without any packaging material. During storage, the L* value for colour of champaca flower shows decreasing trend.

In the present experiment, the data related to changes in a* values for colour of champaca flower influenced by different chemical treatments and packaging material during storage at refrigerated temperature are given in Table 4.2. It was noticed from the results that in LDPE bags, the a* value was significantly varied with the treatments. The maximum mean a* value for tepals of champaca flower were observed in the treatment T_7. The average minimum a* value was recorded in the treatment T_4. In polypropylene bags, the treatment T_7 recorded significantly maximum mean a* value. The treatment T_4 recorded significantly lowest mean a* value. In standup pouch, the treatment T_7 recorded significantly maximum mean a* value. The treatment T_4 and T_2 recorded significantly lowest mean a* value. After 2nd day of storage, the flowers were discarded as the flower lost their shelf life. In control, the treatment T_7 recorded significantly maximum mean a* value. The treatment T_4 recorded significantly lowest mean a* value. After 2nd day of storage, the flowers were discarded as the flower lost their shelf life. During storage, the a* value for colour of champaca flower shows increasing trend.

There was significant effect of treatment on b* value for petal colour of champaca flower. It was observed from the data that in LDPE bags, the significantly maximum mean b* value was observed in the treatment T_4. The minimum b* value for colour was recorded in the treatment T_7. In polypropylene bags, the significantly maximum mean b* value for colour of champaca flower was observed in treatment T_4. The minimum b* value was recorded in the treatment T_7. In standup pouch, the maximum mean b* value was observed in the treatment T_4. The minimum b* value for colour of champaca flower was recorded in the treatment T_7. In control, the maximum mean b* value was observed in the treatment T_4. The minimum b* value for colour was recorded in the treatment T_7. The flowers were discarded due to loss of shelf life after 2nd day of storage which was packed in standup pouch and unpacked flowers. During storage, the b* value for colour of champaca flower shows increasing trend.

Table 4.1: Effect of chemical treatments on L* value for colour of champaca flower packed in different packaging material during storage

L* value for colour																					
Treatment Storage (days)	**Packaging material**																				
	LDPE bags (P1)							**Mean**	**PP bags (P2)**							**Mean**	**SP (P3)**		**Mean**	**Control (P4)**		**Mean**
	1	**2**	**3**	**4**	**5**	**6**	**7**		**1**	**2**	**3**	**4**	**5**	**6**	**7**		**1**	**2**		**1**	**2**	
T_1	56.76	55.59	54.69	53.78	52.61	51.59	48.30	53.33	56.74	54.27	53.25	52.09	50.77	49.00	48.82	52.13	56.19	53.07	54.63	55.19	52.07	53.63
T_2	58.45	57.21	56.04	55.34	54.52	53.96	52.84	55.48	58.02	56.79	55.93	54.44	52.51	51.87	50.30	54.27	53.07	56.34	54.71	52.07	55.34	53.71
T_3	57.67	56.85	55.96	54.75	53.39	52.65	51.74	54.72	57.86	55.69	54.88	53.62	52.41	50.68	49.89	53.58	57.11	52.16	54.64	56.11	51.16	53.64
T_4	58.62	58.43	57.89	56.58	55.76	54.93	54.04	56.61	58.55	57.34	56.41	55.62	54.87	53.90	52.56	55.61	56.34	55.65	56.00	55.34	54.65	55.00
T_5	56.22	55.16	54.07	48.69	46.53	44.42	40.00	49.30	55.47	52.83	50.65	48.52	45.47	43.24	40.31	48.07	55.82	52.79	54.31	54.82	51.79	53.31
T_6	55.00	53.76	51.86	47.38	44.54	42.76	39.76	47.87	54.68	50.50	47.89	45.17	42.76	39.74	37.74	45.50	52.16	51.72	51.94	51.16	50.72	50.94
T_7	54.23	52.41	49.62	45.17	43.86	39.39	37.84	46.07	49.96	48.24	44.86	42.04	40.24	37.50	35.50	42.62	57.06	42.34	49.70	56.06	41.34	48.70
Mean	56.71	55.63	54.30	51.67	50.17	48.53	46.36		55.90	53.67	51.98	50.21	48.43	46.56	45.02		55.39	52.01		54.39	51.01	
	S.Em.			CD 5%					S.Em.			CD 5%					S.Em.	CD 5%		S.Em.	CD 5%	
Treatment (T)	1.30			3.66					1.09			3.06					1.29	3.73		1.20	3.47	
Storage (S)	1.30			3.66					10.9			3.06					0.69	1.99		0.64	1.85	
Interaction (T*S)	2.61			NS					2.18			NS					1.97	NS		1.84	NS	

Table 4.2: Effect of chemical treatment on a* value for colour of champaca flower packed in different packaging material during storage

a* value for colour																					
Treatment Storage (days)	**Packaging material**																				
	LDPE bags (P1)							**Mean**	**PP bags (P2)**							**Mean**	**SP (P3)**		**Mean**	**Control (P4)**		**Mean**
	1	**2**	**3**	**4**	**5**	**6**	**7**		**1**	**2**	**3**	**4**	**5**	**6**	**7**		**1**	**2**		**1**	**2**	
T_1	10.69	11.16	11.84	13.53	13.96	15.63	17.1	13.42	10.96	11.42	12.83	14.76	16.67	18.32	19.06	14.86	10.54	15.46	13.00	11.57	17.49	14.53
T_2	10.06	10.44	10.97	12.22	13.86	14.74	15.71	12.57	10.45	10.65	11.64	12.71	14.63	15.84	17.28	13.31	10.89	11.82	11.36	11.92	13.85	12.89
T_3	10.57	12.03	12.06	12.67	14	15.28	16.48	13.30	11.34	11.94	13.9	13.38	15.47	17.08	18.15	14.47	11.86	15.22	13.54	12.89	17.25	15.07
T_4	9.39	9.75	10.34	11.83	12.57	13.21	14.84	11.70	9.34	10.72	11.46	11.76	13.55	15.36	16.51	12.67	9.87	12.84	11.36	10.9	12.87	11.89
T_5	10.71	12.25	12.27	13.84	14.56	15.83	17.56	13.86	11.77	12.17	14.17	16.39	17.34	19.63	20.43	15.99	12.81	17.76	15.29	13.84	19.79	16.82
T_6	10.64	11.77	14.58	17.49	18.37	18.41	19.27	15.79	12.47	14.57	15.62	17.57	18.58	19.76	20.56	17.02	13.22	20.76	16.99	14.2	22.79	18.50
T_7	10.78	12.34	14.71	18.42	20.67	21.62	21.04	17.08	13.27	15.48	17.59	20.64	21.87	22.09	23.96	19.27	14.69	21.81	18.25	14.73	23.84	19.29
Mean	10.41	11.39	12.40	14.29	15.43	16.39	17.43		11.37	12.42	13.89	15.32	16.87	18.30	19.42		11.99	16.53		12.86	18.27	
	S.Em.			CD 5%					S.Em.			CD 5%					S.Em.	CD 5%		S.Em.	CD 5%	
Treatment (T)	0.61			1.71					0.70			1.96					0.95	2.74		1.08	3.12	
Storage (S)	0.61			1.71					0.70			1.96					0.51	1.47		0.58	1.67	
Interaction (T*S)	1.22			NS					1.40			NS					1.45	NS		1.65	NS	

Table 4.3: Effect of chemical treatment on b* value for colour of champaca flower in different packaging material during storage

b* value for colour																					
Treatment Storage (days)	**Packaging material**																				
	LDPE bags (P1)							**Mean**	**PP bags (P2)**							**Mean**	**SP (P3)**		**Mean**	**Control (P4)**		**Mean**
	1	**2**	**3**	**4**	**5**	**6**	**7**		**1**	**2**	**3**	**4**	**5**	**6**	**7**		**1**	**2**		**1**	**2**	
T_1	57.29	52.43	47.33	42.63	37.96	36.37	35.17	44.17	50.71	47.84	44.61	41.59	38.44	31.7	28.33	40.46	53.87	41.67	47.77	52.87	40.67	46.77
T_2	58.74	56.51	53.49	50.28	47.15	44.06	43.32	50.51	53.64	51.79	49.83	47.94	46.56	44.38	42.56	48.10	55.64	42.14	48.89	54.64	41.14	47.89
T_3	57.86	53.38	49.49	45.86	41.72	41.45	39.07	46.98	52.47	50.26	48.23	46.19	43.03	37.51	35.7	44.77	53.25	38.76	46.01	52.25	37.76	45.01
T_4	59.67	57.46	55.63	53.84	51.67	50.71	49.26	54.03	55.76	54.29	53.36	52.57	51.68	49.75	48.43	52.26	54.38	49.31	51.85	53.38	47.31	50.35
T_5	56.85	50.55	45.99	38.44	32.47	26.73	24.36	39.34	54.89	46.26	43.83	37.45	31.87	25.03	23.83	37.59	49.65	36.57	43.11	48.65	35.57	42.11
T_6	56.48	48.53	44.89	37.62	31.42	25.77	20.57	37.90	52.48	45.76	42.91	36.01	30.99	24.21	19.21	35.94	48.87	35.94	42.41	47.87	33.94	40.91
T_7	55.05	47.83	43.61	36.52	30.43	24.34	18.36	36.59	51.81	45.07	42.37	35.4	29.83	23.95	17.61	35.15	47.32	34.12	40.72	45.32	32.12	38.72

Mean	57.42	52.38	48.63	43.60	38.97	35.63	32.87	53.11	48.75	46.45	42.45	38.91	33.79	30.81	51.85	39.79	50.71	38.36
	S.Em.		CD 5%		S.Em.		CD 5%			S.Em.		CD 5%			S.Em.	CD 5%	S.Em.	CD 5%	
Treatment (T)	1.23		3.45		1.42		3.98			1.43		4.14			1.05	3.03			
Storage (S)	1.23		3.45		1.42		3.98			0.76		2.21			0.56	1.62			
Interaction (T*S)	2.46		NS		2.84		NS			2.19		NS			1.60	NS			

Note: The champaca flowers packed in standup pouch and control were discarded after 2nd day of storage due to loss of shelf life.

Discussion

According to the present studies, at the end of storage period, there was significant difference in the mean L* value for colour. The boric acid treatment helped to prevent loss of the champaca flower irrespective of packaging treatment. The L* value showed the decreasing trend with increase in storage time in refrigerated conditions and increased browning during storage. Similar observations were recorded by Qazi *et al*. (2016) [11] in marigold flower. Varpe *et al*. (2020) [15] stated that pre chemical treatment with 4 and 6 percent boric acid helped to retain the lightness of colour by preventing browning reactions in jasmine flower. The L* value of champaca flower shows best result when packed in LDPE bags. The champaca flowers packed in standup pouch and control were discarded after 2nd day of storage. Identical trend was noticed in jasmine flower buds by Varpe *et al*. (2020) [15] in same packaging material. The redness in the champaca flower was determined from a* value for colour of champaca flower. The a* value of champaca observed in treatment T_4 (2% Boric acid) packed in LDPE bags was lower than that of T_7 (control) when packed in LDPE bags. Redness of flower increased in storage period due to increase in browning and decrease in lightness of flowers during storage. These results are in accordance with the findings of Varpe *et al*. (2020) [15] and Siriamornpun *et al*. (2012) [14]. The a* colour value was significantly lower than the other packaging material like standup pouches and polypropylene bags. The champaca flowers were discarded due to loss of their shelf life which were packed in standup pouch and control (without packaging) after 2nd day of storage. The similar results were observed in jasmine flower buds by Varpe *et al*. (2020) [15] in same packaging material. A continuous decreasing trend with significant difference was observed in mean b* value for colour during storage. On the 1st day of storage, the mean of b* value of colour was highest in treatment T_4 and at 7th day of storage and it was decreased as compared to the control when packed in LDPE bags. As regards to the packaging materials, the b* value of champaca flower was lowest in Polypropylene bags. The champaca flowers packed in standup pouch and control were discarded after 2nd day of storage. These observations are in accordance with the findings recorded by Varpe *et al*. (2020) [15] in jasmine buds and Siriamornpun *et al*. (2012) [14] in marigold flower for b* value of colour.

Conclusion

An investigation entitled "Studies on packaging and storage behaviour of champaca (*Michelia champaca* Linn.)" was carried out to assess effect of different chemical treatments and packaging materials on physical of champaca flower. The champaca flowers from different treatments were evaluated for changes in their physiological, physical and chemical parameters such as colour L*, a*, b*, during refrigerated storage.

The present study revealed that the quality parameters such as colour a* was increased during storage. The colour L*, b* values was decreased during storage. From the result of present studies, it can be concluded that the flowers treated with 2% boric acid treatment packed in LDPE bag helps in maintaining quality and shelf life of champaca flowers up to 7th day of storage under refrigerated condition.

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