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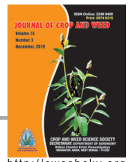

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Influence of six surface coatings on quality and storability of dehydrated Dutch rose flowers cv. Taj Mahal

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ABSTRACT

A study to enhance the quality and storability of dehydrated rose flowers by creating a thin, clear, hydrophilic layer on petal surface was conducted at the Department of Floriculture, Medicinal and Aromatic Plants, Uttar Banga Krishi Viswavidyalaya during 2019 and 2020. Dehydrated rose flowers of cv. Taj Mahal were subjected to six surface coating materials, namely - paraffin wax, epoxy resin, silicone resin, natural gum, egg-white and clear varnish, the effect of which were compared to untreated control regarding colour, texture, sensory qualities and shelf-life. Coating with silicone resin as aerosol spray created an unperceivable layer on the flowers which extended the natural look beyond 180 days and simultaneously increased hardness (3750g), firmness (1050g at first peak) and stiffness (187.5g sec^{-1}) of the product compared to control (2040g, 200g at first peak and 102g sec^{-1}, respectively). Paraffin wax coating, though created a thicker coat, received equivalent preference in sensory evaluation. The treatment provided maximum hardness (4000g) thus enhancing durability of the product. Clear varnish and epoxy resin imparted flexibility but caused significant change in colour.

Keywords **:** Dry flower, epoxy resin, paraffin wax, silicone resin, surface coating, texture analysis, color, shelf life

Flowers are one of the pure and wonderful creations of nature regarded as a symbol of love, respect, sacrifice, friendship, beauty and establish as a paradigm of life which becomes equivalently significant even in dehydrated form in today's life due to their bio-friendly features and aesthetic beauty. In recent times, the dehydrated products proved their tremendous potentiality as a substitute of fresh flowers for interior decorations, floristic ornaments and novel artifacts and became an indispensable item for trade. An enormous worldwide demand for dry flowers is perceived with an annual growth rate of 8-10% which has opened up a lot of opportunities for the Indian entrepreneurs to enter into the global floricultural trade (Singh, 2009). Consequently, India had acquired fourth position in the trade of flower export, of which, Rupees 363.3 crores was earned from the export of dry flowers in the year 2013-2014 (Periban *et al.,* 2014). The Indian floriculture export basket comprises 71% of dry flowers which are exported mainly to USA, Japan, Australia, Russia and Europe (Singh and Laishram, 2010 and De *et al.,* 2016).

The process of flower drying involves the reduction of moisture content from flower tissues to such an extent at which biochemical changes are minimized while maintaining the cell structure, pigment levels and flower shape (Singh *et al.,* 2003). Drying leads to reduced microbial activities and ageing effects and thus, freeing the flowers from bondage of seasonality and senescence (Bhutani, 1995). However, they have their own limitations too. Dry flowers are very delicate in nature and hence, require careful handling. They are vulnerable to air moisture and tend to lose their texture, form and colour (Waszkiewick, 1971). If exposed to humid condition, fungal growth develops on the dehydrated products. Hence, arrangements made with dry flowers should be kept under air-tight clear glass covering. Here lies the importance of coating with moisture-proof or water-resistant substances. The primary objective of coating dehydrated flowers is to create a thin, clear, hydrophobic layer to reduce moisture absorption and surface contact with air. Simultaneously, the coating is supposed to impart support to the fragile petals of the flowers and prevent it from wear and tear of handling. It is also intended to improve the appearance of the flowers over longer duration by retaining its colour and textural qualities. Substances like - paraffin wax, ester type acrylic resin, certain polymerizable monomer and silicone polymer film were tried for coating dehydrated flowers (Mazzucato and Mazzucato, 1969; Rovetti, 1975; Waszkiewick, 1971; Korn, 1990; Fukui *et al.*, 1996). The present investigation is undertaken to evaluate some conventional substances used for coating *viz.* paraffin wax, egg white and clear varnish against few nonconventional substances like natural gum, epoxy resin and silicone resin, with regards to the quality of coat they create on dehydrated rose flowers. Dried rose flowers are the most expensive in all dried flowers traded in the international market (Renuka *et al.,* 2016).

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Considering the potential of Dutch roses in dry flower trade, the study was undertaken to find out the effect of different surface coating materials on dehydrated flowers of Dutch rose cv. 'Taj Mahal' with the objective to augment the overall acceptability and storability of the product and simultaneously to ease the handling processes.

MATERIALS AND METHODS

The present investigation was conducted in the laboratory of the Department of Floriculture, Medicinal and Aromatic Plants, Faculty of Horticulture, Uttar Banga Krishi Viswavidyalaya, during 2019 and 2020. Embedded drying of red flowers of Dutch rose cultivar Taj Mahal, of uniform size at partially opened stage in florists' silica gel and subsequent drying in hot-air oven at 45^0C for 27 hours were done during the preparatory stage. The dehydrated flowers (11% moisture content) thus obtained were subjected to six different surface coating materials *viz.* paraffin wax (fully refined grade, melting point 60^0C) (T_1), clear epoxy resin (Haksons High Gloss Epoxy Resin clear coat with 2:1 mixing ratio of resin and hardener) (T_2), silicone resin (Aerol Silicone Lubricant Spray) (T_3), natural gum (procured from local market and dissolved in boiling water @ 6.5%) (T_4), egg white (prepared by whipping the clear albumen of egg to flowing consistency liquid) (T_5) and clear varnish (Asianpaints Apcolite Clear Synthetic Varnish with flash point >30^0C and viscosity 90 ± 10 seconds by Ford Cup B4 at 30^0C) (T_6) and the effect was compared against untreated control (T_7). Coating with paraffin wax was done by quick dip in melted wax bath, whereas, epoxy resin, natural gum, egg white and clear varnish were applied with camel hair brush. Silicone resin was applied in the form of aerosol spray (Fig.2). After coating, the flowers were air dried and stored in open air condition. Quality parameters like the thickness of coating, colour and texture of the coated dry flowers were observed immediately after coating and also during the storage period. Any undesirable deviation, like fading or loss or colour, fragility or sogginess was considered as loss of quality. The colour of coated flowers was evaluated with the help of Royal Horticultural Society (RHS) colour chart. Texture was analyzed mechanically using TA.XT Plus texture analyzer (Stable Micro System, UK). After six months of storage, the quality and acceptability of the coated flowers were judged by a panel of thirty members comprising of students and staff of the Institute, based on sensory assessment of four parameters *viz.* colour, texture, appearance and overall acceptance. The samples were judged by scoring on a 9-point Hedonic scale (Peryam and Pilgrim,1957) where, the representations of the numbers were: 9 - liked extremely, 8 - liked very much, 7 - liked moderately, 6 - liked slightly, 5 - neither liked nor disliked, 4 - disliked slightly, 3 - disliked moderately, 2 - disliked very much and 1 - disliked extremely. The experiment was laid out following CRD (Panse and Sukhatme, 1985) and the data recorded was analyzed statistically using Microsoft Excel and OPSTAT software.

RESULTS AND DISCUSSION

Thickness of coating and coated petals

The thickness of the petals measured with digital calipers before and after coating the dehydrated flowers and the thickness of coat or layer was derived by deducting the thickness of uncoated petals form the thickness of coated petals. The data presented in Table 1 showed significant differences in thickness of coat over the petals which was evident among the treatments. Thinnest layer of coat, which could not be perceived by digital calipers, was obtained with silicone resin (T_3). It was followed by natural gum 0.003mm, whereas, the thickest layer (0.3mm) was obtained with paraffin wax. Untreated petals recorded a thickness of 0.1mm, with which coating with silicone resin (T_3) and natural gum coating (T_4) was found at par. The maximum thickness (0.397mm) was recorded in wax coating (T_1), followed by egg white (0.207mm) and epoxy resin (0.2mm). Thinner coatings are always desirable, as it is more likely to retain the original texture and colour of the dehydrated flowers. However, a thicker layer often provides more support to the fragile petals. Rovetti (1975) also recommended higher concentration of paraffin wax for coating flowers in order to provide desired protection.

Colour

Colour is a perceptual phenomenon which depends on the viewer. Retention of colour after coating is an important parameter which governs the quality and acceptability of the dry flower products. So, it is always intended to retain the colour of the coated flowers as close as possible to the original colour of the flower. The colours of coated rose flowers were evaluated with RHS colour chart and were compared with untreated control which matched with Greyed purple group 187 A, on the outer side of the petals and Greyed purple group 187 B on the inner side (Table 1). Any colour change could not be perceived in flowers treated with paraffin wax, while, a little change in the inner side of the petal was noted with silicone resin coat and egg white (Greyed purple group 187 A). Egg white however, developed some whitish translucent layers over the flowers. On the contrary, noticeable changes in colour were observed in treatments with epoxy resin, natural gum and clear varnish. These chemicals lead to fading of colour, which may be due to the degradation of anthocyanin pigments present in the tissue in reaction

Table 1: Thickness of coating, coated petals and colour of petals as affected by different coating treatments on dehydrated rose flowers cv. Taj Mahal

Treatment	Thickness of coating (mm)	Thickness of coated petal (mm)	Colour of outer side of petals	Colour of inner side of petals
T_1	0.3	0.397	Greyed purple 187 A	Greyed purple 187 B
T_2	0.1	0.2	Purple N79 A	Purple N79 A
T_3	0	0.1	Greyed purple 187 A	Greyed purple 187 A
T_4	0.003	0.1	Purple group N77 A	Purple group N77 A
T_5	0.1	0.207	Greyed purple 187 A	Greyed purple 187 A
T_6	0.033	0.133	Red purple 59 A	Red purple 59 A
T_7	0	0.1	Greyed purple 187 A	Greyed purple 187 B
LSD (0.01)	0.011	0.014	—	——
SE(m) ±	0.004	0.005	—	——
C.V. (%)	8.051	4.478	——	—

Note: T_1 = Paraffin Wax, T_2 = Epoxy resin, T_3 = Silicone resin, T_4 = Natural gum, T_5 = Egg white, T_6 = Clear varnish, T_7 = Control

Table 2: Effect of surface coatings on textural attributes of dehydrated rose flowers cv. Taj Mahal

Treatment	Peak Force at 20sec (g)	Force at the first peak (g)	Stiffness (g sec^{-1})
T_1	4000	90	200
T_2	720	50	36
T_3	3750	1050	187.5
T_4	1140	-	57
T_5	2500	50	125
T_6	2300	30	115
T_7	2040	200	102

Note: T_1 = Paraffin Wax, T_2 = Epoxy resin, T_3 = Silicone resin, T_4 = Natural gum, T_5 = Egg white, T_6 = Clear varnish, T_7 = Control

Table 3: Effect of coating on sensory scores of dehydrated rose flowers of cultivar Taj Mahal after treatment

Treatment	Colour	Texture	Appearance	Overall acceptance	Total	Rank
T_1	6.94	6.79	6.58	6.42	26.73	4th
T_2	5.63	5.75	5.25	5.92	22.54	5th
T_3	8.38	8.25	8.63	8.56	33.81	1st
T_4	5.29	4.79	4.42	4.71	19.21	6th
T_5	3.21	2.83	2.67	3.13	11.83	7th
T_6	7.50	7.21	7.17	7.25	29.13	3rd
T_7	8.04	8.21	8.38	8.50	33.13	2nd
LSD (0.01)	0.950	1.066	1.138	1.019	3.622	
SE(m) ±	0.336	0.377	0.402	0.360	1.280	
C.V. (%)	18.088	20.835	22.625	19.641	17.598	

Note: T_1 = Paraffin Wax, T_2 = Epoxy resin, T_3 = Silicone resin, T_4 = Natural gum, T_5 = Egg white, T_6 = Clear varnish, T_7 = Control

with the chemicals. Similar findings were reported by Fukui *et al.* (1996) from their experiment with silicone polymer film for surface coating of dry flowers. They suggested that silicone polymer provides resistance against moisture absorption and maintains shape and colour of dry flowers even at adverse conditions.

Texture

The texture of the coated flowers and untreated control were analyzed mechanically using TA.XT Plus texture analyzer. Texture was analyzed to evaluate the brittleness versus elasticity of the product and similarly the hardness versus suppleness. A compression force

Table 4: Effect of surface coating treatments on colour of petals during storage

Treatments		Paraffin Wax	Epoxy resin	Silicone resin	Natural gum	Egg white	Clear varnish	Control
15 DAC	OP	GPG187A	GOG164A	GPG187A	PGN77A	GPG187A	YOG22A	GPG187A
	IP	GPG187B	GOG164A	GPG187A	GOG165A	GOGN167C	YOG22A	GPG187B
45 DAC	OP	GPG187A	GOG164A	GPG187A	PGN77A	GPG187A	YOG22A	GPG187A
	IP	GPG18 B	GOG164A	GPG187A	GOG165A	GOGN167C	YOG22A	GPG18 B
75 DAC	OP	GPG187A	GOG164A	GPG187A	PGN77A	GPG187A	YOG22A	GPG187A
	IP	GPG187B	GOG164A	GPG187A	GOG165A	GOGN167C	YOG22A	GPG187B
105 DAC	OP	GPG187A	GOG164A	GPG187A	PGN77A	GPG187A	YOG22A	GPG187A
	IP	GPG187B	GOG164A	GPG187A	GOG165A	GOGN167C	YOG22A	GPG187B
135 DAC	OP	GPG187A	GOG164A	GPG187A	PGN77A	GPG187A	YOG22A	GPG187A
	IP	GPG187B	GOG164A	GPG187A	GOG165A	GOGN167C	YOG22A	GPG187B
165 DAC	OP	GPG18 A	GOG164A	GPG187A	PGN77A	GPG187A	YOG22A	GPG18 A
	IP	GPG187B	GOG164A	GPG187A	GOG165A	GOGN167C	YOG22A	GPG187B

Note: DAC=Days after coating, GPG=Greyed purple group, GOG=Greyed orange group, PG= Purple group, YOG=Yellow orange group; OP = Outer side of the petal, IP= inner side of the petal,

Table 5: Effect of coating on sensory scores of dehydrated rose flowers of cultivar Taj Mahal after six months of storage

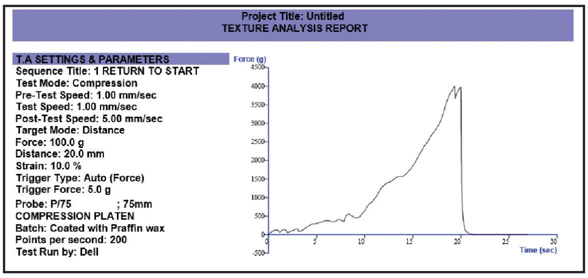
Treatment	Colour	Texture	Appearance	Overall acceptance	Total	Rank
T_1	5.50	6.20	4.80	5.30	21.80	3rd
T_2	3.30	3.30	2.92	2.40	11.92	5th
T_3	6.80	6.98	7.20	7.74	28.72	1st
T_4	2.70	3.58	3.10	2.80	12.18	4th
T_5	2.96	3.00	2.80	3.00	11.75	6th
T_6	1.50	1.68	1.42	1.40	6.00	7th
T_7	6.00	5.90	6.60	6.724	25.224	2nd
CD at 1%	0.953	1.122	1.014	0.902	2.024	
SE(m) ±	0.325	0.382	0.345	0.307	0.689	
C.V. (%)	17.663	19.521	18.743	16.378	9.177	

Note: T_1 = Paraffin Wax, T_2 = Epoxy resin, T_3 = Silicone resin, T_4 = Natural gum, T_5= Egg white, T_6 = Clear varnish, T_7 = Control

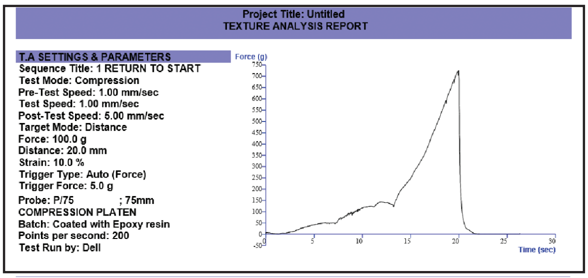
was applied on the flowers using P/75, 75mm Compression Platen. A force of 100.0g was applied on the product with 1mm/sec test speed for a distance of 20mm. post-test relaxation was done at a speed of 5mm/sec. The force time curves of the compression tests are provided in Fig.1 to Fig.7. From the force-time curve, three properties of the products namely hardness, fracture ability, stiffness and crispiness were assessed and summarized in Table 2.

Hardness of a product is denoted by the peak force or maximum force exerted on it during the compression at a set time. From the data it is revealed that maximum hardness (peak force 4000g) was obtained with paraffin wax coating followed by silicone resin coating (3750g) and egg white coating (2500g). Minimum peak force of 720g was noted with epoxy resin coat. The hardness of flowers coated with clear varnish and egg-white were comparable with that of control.

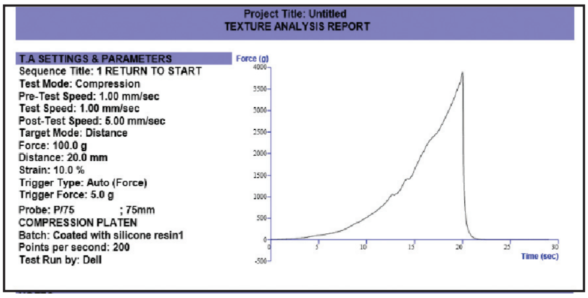
The crispness of a product is represented by the nature of fractures registered during compression and the force required to cause the first fracture. The later is termed as fracture-ability in texture analysis and is recorded by the force at the first peak. Comparing the data of fracture-ability (Table 2) for the six treatments and control, it is observed that the flowers treated with silicone resin required maximum force (1050g) for the first fracture which is more than five-times higher than the untreated control (200g). This indicates that coating with silicone resin can significantly ameliorate the stability and firmness of dehydrated rose flowers. Rest of the treatments registered fracture-ability at the range of 30g to 90g. In case of flowers treated with natural gum no such peak was noted.



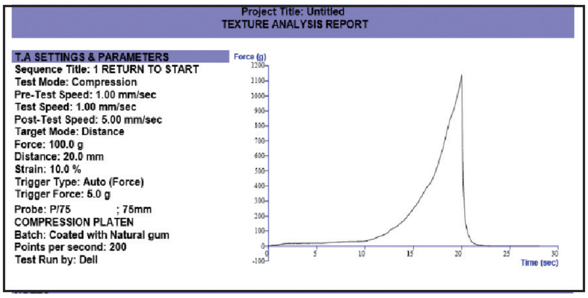
A: Paraffin wax coating



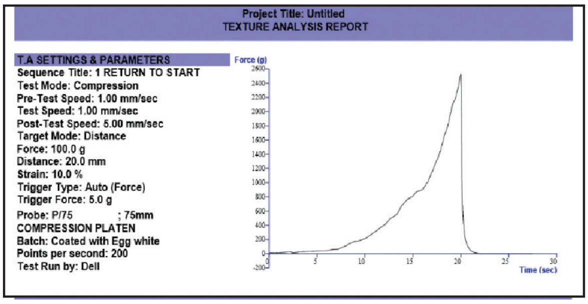
B: Epoxy resin coating



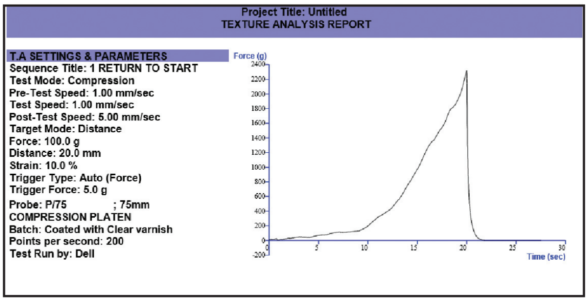
C: Silicone resin coating



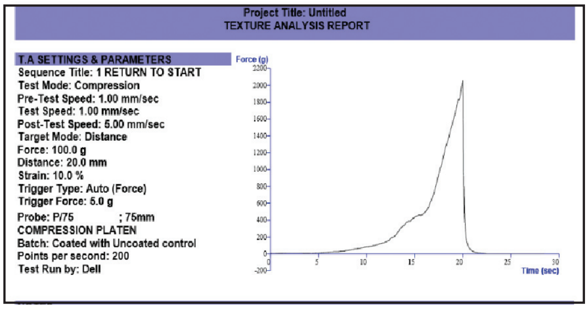
D: Natural gum coating



E: Egg white coating



F: Clear varnish coating



G: Uncoated control

Fig. 1: Force time curves obtained on texture analysis of dehydrated rose flowers coated with paraffin wax, Epoxy resin, silicone resin, natural gum, egg white, clear varnish and uncoated control

Stiffness is another textural attribute of products which is assessed by the slope of the compression curve. From the data it is evident that flowers treated with paraffin wax exhibited maximum stiffness (200g sec^{-1}) which was comparable with silicone resin treatment (187.5g sec^{-1}). Minimum stiffness (36g sec^{-1}) was recorded in epoxy resin treatment.

The force-time curves were further examined to study the presence or absence of multiple fractures and also nature of fractures (Fig.1: A to G). Presence of multiple fractures in the curve indicates crispiness of the product. Typical multiple fractures were noted in T_2, whereas multiple fluctuations were present in the

Coating with paraffin wax | **Coating with egg-white** | **Dehydrated rose flower cv. 'Taj Mahal' just after coating**

Fig.2: Different processes of coating dehydrated rose flowers and coated flowers just after treatment

T_1 T_2 T_3

T_4 T_4 and T_6 T_7

Fig.3: Dehydrated rose flower cv. 'Taj Mahal' coated with different coating materials after six months of storage

curve of T_1 and few fluctuations were present in T_7. On the other hand, only few waves were present in T_3, T_5 and T_6. No fracture was present in T_4, *i.e.,* natural gum coated flowers which indicated the suppleness of the product. In a textural characteristic study of rose flowers preserved with glycerin and propylene glycol, Yoo *et al.* (2009), reported that preserved flowers showed higher flexibility and lower hardness and stiffness compared to untreated flowers. In the present study, paraffin wax coating exhibited higher hardness and stiffness but lower crispness compared to control. Silicone resin coating on the other hand, increased hardness, stiffness and firmness of the flowers.

Sensory evaluation of quality just after coating

The quality of the coated rose flowers was judged by sensory evaluation of colour, texture, appearance and overall acceptability just after coating and six months after storage on a 9 points Hedonic scale. Colour is one of the most important sensory attributes which governs customers' preference for dehydrated flower products. The data presented in Table 3, reveals that maximum sensory score for colour (8.38) was recorded in silicone resin coating (T_3), which is at par with uncoated control. Minimum score of 3.21 was recorded with egg-white coating which imparted whitish translucent marks on the flowers, thereby, became unacceptable.

The scores for texture in the sensory evaluation (Table 3) showed significant variation among the treatments that followed a similar pattern with that of colour. Maximum score was recorded in silicone resin treatment (8.25) and control (8.21), followed by clear varnish (7.21) and paraffin wax (6.79) coatings. The lowest score was offered to T_5.

The parameter appearance includes form and shape of the product and presence of blemishes, deformities etc. which influences consumers' preference. Data on appearance also followed similar pattern as of colour and texture. The overall acceptance of the product as judged by the panel (Table 3) revealed relative and substantial preference of some products over others. Flowers treated with silicone resin was given maximum preference (score = 8.56) among the coated flowers, however, this score was at par with untreated control (8.50). Minimum score was recorded in T_5 (3.13). Consequent to the similar pattern of scores in all the sensory attributes, total score and rank of the treatments reflected the same. Silicone resin coating scored the maximum (33.81out of 36.00) which was at par with untreated control (33.13 out of 36.00). Paraffin wax coating gained similar preference as of clear varnish coating.

Colour of products during storage

After coating the dehydrated rose flowers, the products were stored in open condition in room for six months. The colour of the flowers were judged with reference to RHS colour chart at regular intervals during the entire storage period and is presented in Table 4. Visually recognizable changes were noted in few of the treatments just after coating (Table 1). The colours remained unchanged in treatments T_1, T_3 and T_7 throughout the entire storage period. Minor changes were observed in T_4 and T_5 at the inner side of the petals. However, major change in colour was noted in T_2 and T_6 *i.e.,* coating with epoxy resin and clear varnish. For epoxy resin coated flowers, the colour changed from Purple group N 79 A to Greyed-orange group 164 A and for clear varnish coated flowers the colour changes from Red purple group 59 A to Yellow-orange group 22 A within 15 days of storage and continued to remain so throughout the entire storage period. As the coating materials are chemical compounds, they often react with the pigments present in the flower tissue leading to fading and browning. The organic pigments, primarily anthocyanins and carotenoids, derive their colour from double bonds mainly between carbon atoms. Breaking of these double bonds by oxidation, photodegradation, metal complexing, pH etc. leads to colour degradation as observed by Griesbach (1992) in *Eustoma grandiflora*.

Sensory evaluation after six months of coating

The sensory evaluation of quality attributes of the coated flowers was performed again after six months of storage in room ambience to evaluate the storability of the flowers. The data presented in Table 5, reveals that silicone resin coating (T_3) received highest preference by the panel. The treatment received maximum scores for colour (6.80), texture (6.98), appearance (7.20) and overall acceptance (7.74) with a total of 28.72 out of 36.00, which was at par with uncoated control (T_7) with respect to all the parameters, except for overall acceptance. Paraffin wax coating also registered at par scores with control for colour and texture and was ranked third. Minimum scores for all the parameters were recorded in flowers treated with clear varnish (T_6). It is interesting to note that, while evaluated just after coating, T_6 scored remarkably in all the parameters and ranked third among the treatments (Table 3), but after six months of storage it scored the minimum and secured the lowest rank as the colour of the flowers treated with clear varnish changed from Red purple group 59 A to Yellow orange group 22 A during storage that ultimately made those disagreeable. This drastic change in colour affected the scores under all other parameters, and overall acceptance of the product by the judges. It is also noted that though in mechanical texture analysis, T_6 showed better textural quality over few other treatments, but in human judgment, texture was highly influenced by the colour of the product.

Shelf-life (days)

The shelf-lives of the coated flowers were assessed visually at periodic interval till the sixth month of storage (Table 4). Treatments T_1, T_3 and T_7 displayed their prime-beauty for the entire duration of the study and did not show any deviation from the initial stage (Fig.3). Hence, the shelf-life of these products was considered to be more than six months. Rest of the treatments showed typical changes in quality parameters, primarily, colour. Based on colour deviation the minimum shelf-life of 3 days was recorded in clear varnish coated flowers, where radical change occurred within a week of coating. Epoxy resin coating also exhibited similar results where the flowers changed to Greyed-orange group 164 A within 15 days.

An ideal coating material is the one which creates an unperceivable layer that is hard enough to retain the original shape and texture yet supple enough to impart flexibility in handling, and simultaneously, holds the original look of the flower for long time, provide moisture resistance and is eventually easy to apply. Coating dehydrated rose flowers of 'Taj Mahal' cultivar with silicone resin is effective to maintain the natural look of the freshly dehydrated flowers in all sensory aspects of colour, texture and appearance as compared to the other treatments studied. Results of texture analysis indicated that the treatment imparted firmness and hardness to the product which reduces the fragileness of the product making it easier to handle. This also enhances the shelf-life of the product. As silicone resin is an aerosol-based product, it is easy to apply as a spray providing good coverage. The chemical is also odour-free. Paraffin wax coated flowers received equivalent preference in sensory evaluation. This treatment provided maximum hardness thus enhancing durability of the product. It is an easy and effective process of coating, since, this was applied by the quick deep method. Coating with epoxy resin and clear varnish, though increased the flexibility of the product, changed the colour of the flowers with time which made them unacceptable to the customers. Future research can be directed to address this problem as epoxy resin is increasingly gaining popularity in dry-flower industry, but colour distortion is the major hindrance faced by the producers. Hence, coating dehydrated rose flowers of cv. Taj Mahal either with silicon resin or with paraffin wax may be recommended to increase the durability and ease in handling the dried products.

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