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Research Article

EFFECT OF $CaCl_2$ AND $KMnO_4$ ON SHELF LIFE OF FIG FRUITS

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Abstract- Fig is subtropical fruit, hence it contains more moisture content 90 to 95%. Spoilage of fruits are more due to it's moisture content. Hence to maintain good shelf life of fruits. Post harvest treatments of fig with different treatments were studied and results were interpreted. Treatments with different concentration of Cacl2 and KMnO4 showed significant differences between the treatments and helps to increase the storage capacity of the fruits.

Keywords- Fig, Physiological loss in weight, Total sugars, Reducing sugars, Non reducing sugars.

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Introduction

Physiological and biochemical process such as transpiration, respiration and ripening continue after harvesting of the fruits. Fig fruits have very short life after harvest which is one of the major drawbacks for long distance transport and marketing. The extension of shelf life of fig fruits with minimum loss during storage would enable efficient transport and storage of fruits. Packaging plays a dominant role in storage and marketing activities of fruit industry .The increase in consumer demand for good quality fruits necessitated to search for suitable packaging material which can preserve the quality, the sensory and nutritive value of fruits till consumption and is also economically proficient and safe. [8] reported that the fruits packed in 100 gauge polyethylene bags of 2 per cent vents showed less loss in weight compared to control packed fruits (22.9%] weight loss as against 29.8% in unpacked fruits. Besides reduction in weight loss and maintaining turgidity of fruits polyethylene packaging was also found beneficial in arresting the ripening process of custard apple. [11] revealed that calcium chloride (6%) + polyethylene package showed its superiority over all other treatments during all the storage period of pear. The fruits under this combination recorded minimum spoilage loss and organoleptic rating of 7.50 points even after 21 days of storage. This combination also helped in increasing total sugars and reducing sugar content over a period of storage. [16] reported that physiological loss in weight of guava fruits was increased progressively irrespective of storage treatment. Highest PLW was recorded in case of control fruits by way of more respiration and it could be correlated to their more shriveling, browning and loss of glossiness which ultimately made the fruits unmarketable. [22] reported that packing of aonla fruits in different polyethylene bags significantly reduced the PLW in aonla as compared to unpacked control fruits. This might be due to reduction in respiration and transpiration in polyethylene packaging which changed the micro-environment of fruits by creating high CO2 and low O2 concentration and high relative humidity. [28] reported that organoletpic rating of guava fruits was affected by various treatments and storage periods. Higher scores were recorded with calcium nitrate both at 0.5 and 1.0 per cent after 6 days of storage. In the other hand the lowest scores was recorded in control fruits. This was mainly due to onset of senescence of tissues as a result of decrease in firmness, and dull appearance of skin colour. [29] reported that total soluble solids increased significantly with increasing periods of storage in peach. The highest increase in TSS was observed in fruits treated with 3000ppm KMnO4. Acidity of fruits increased in beginning and then decrease in all treatments. Minimum acidity was observed in fruits treated with 1000ppm KMnO4 and maximum in control or untreated fruits. This higher acidity contents might be due to anaerobic respiration and higher evapo-transpiration rate. [32] reported that an increase in PLW in all treatments with period of storage was obvious as the different physiological process, like transpiration and respiration, continued in fruit even after harvest. However, minimum PLW was found in perforated polyethylene bag followed by sealed polyethylene bags and plastic bags throughout the storage period.

Materials and Methods

Physiological loss in weight (%): Each package was weighed regularly using electronic balance until it was judged not suitable for marketing. The cumulative loss in weight was calculated and expressed in percentage. The PLW recorded at the end of shelf life was divided by storage life (days) at 2, 4, 8, and 10 days to get mean PLW per day.

$$PLW\,(\%) = Initial\ weight - \frac{Final\ weight}{Initial\ weight} * 100$$

Total soluble solids: The total soluble solids (TSS) were determined with the help of hand refractometer and expressed as ºBrix at 20 ºC using reference table for temperature. The TSS of fruit pulp was determined by soaking 10g of pulp in distilled water in 1:2 (product: water) ratio for 4 h and followed by crushing. Filtrate was extracted though cheese cloth and then put on prism of refractometer to record observations. These values were multiplied by dilution factor to represent TSS percentage in fig pulp [27].

Titrable Acidity: The method described by [26] was adopted for estimation of titratable acidity. A weighed amount of fig pulp (crushed to fine particles in mortle and pestel) was transferred to a volumetric flask and the volume was made upto 100 ml with distilled water. After 30 minutes, the suspension was filtered through Whatman No. 1 filter paper and the filtrate was used subsequently. An aliquot (10 ml) was taken from the filtrate and titrated against standard 0.1 N sodium hydroxide using phenolphthalein as an indicator. The titratable acidity was expressed as per cent citric acid by adopting the following formula.

$$\text{Titrable acidity(\%)} = \frac{\text{Titre value X N of NaOH X Volume made up X equivalent weight of citric acid}}{\text{Volume of sample X Weight of sample taken for titration}}$$

Sugars: Sugars were determined by Lane and Eynon Method as detailed by [26]. Invert sugar reduces the copper in Fehling's solution to red, insoluble cuprous oxide. The sugar contents in samples were estimated by determining the volume of the unknown sugar solution required to completely reduce a measured volume of Fehling's solution. Before using, the mixture [1:1] of Fehling's solution A and B (5 ml of each) was standardized against standard glucose for obtaining glucose equivalent and to arrive at a conversion factor.

Reducing Sugars: A weighed amount of the sample was taken in a volumetric flask and two millilitres of 45 % basic lead acetate solution was added for clarification. After 10 minutes, the solution was deleaded by adding potassium oxalate crystals in excess and the volume was made upto a known amount with distilled water and filtered through Whatman No. 1 filter paper. The filtrate was taken in a burette and titrated against boiling Fehling's mixture (5 ml of Fehling's solution A + Fehling's solution 5 ml of B) till the blue colour faded. Then, one ml of methylene blue indicator (1 %) was added and the titration was continued till the contents attained a brick red colour and titre value was noted. The per cent of reducing sugars were calculated according to the following formula:

$$\text{Reducing sugars (\%)} = \frac{\text{0.05 X Volume made up}}{\text{Titre value X Weight of sample}}$$

Total Sugars: For estimation of total sugars, the filtrate obtained during reducing sugars estimation was used. An aliquot from the filtrate was taken and to the one fifth of its volume, hydrochloric acid (1:1) was added and the inversion was carried out at room temperature for 24 hours. Subsequently, the contents were cooled and neutralized with 40 per cent sodium hydroxide using phenolphthalein as indicator and the final volume was made upto 100 ml. The solution was filtered and titrated using filtrate as detailed for reducing sugars. The total sugars were expressed as per cent in terms of invert sugars according to the following formula:

$$\text{Total sugars (\%)} = \frac{\text{0.05 X Volume made up}}{\text{Titre value X 25 X weight of sample}}$$

Non-reducing sugars: The non-reducing sugars in per cent were calculated by multiplying the differences of total and reducing sugars by factor of 0.95. The results were expressed as per cent.

$$\text{Non}-\text{reducing sugars}, \% = (\text{Total sugars}, \% - \text{Reducing sugars}, \%) \times 0.95$$

Results

The fig fruits were treated with 1 per cent and 2 per cent $CaCl_2$ and $KMnO_4$ respectively. The results of the physico-chemical properties of fig fruits treated with calcium chloride and potassium permanganate were presented.

Physiological loss in weight (%)

The results pertaining to PLW of fig fruit as influenced by calcium chloride and $KMnO_4$ is presented in [Table-1]. It is clear from this table that there is a significant difference in the PLW of fig fruits on 2, 4, 6 and 8 DAS. PLW was minimum (0.65%, 0.96%, 0.81% and 0.98% respectively) when fruits were stored along with 2 per cent $KMnO_4$ and these results are on par with 1% KMnO4 treatment (0.93%, 1.02%, 1.13% and 1.36% respectively). The control treatment PLW was maximum on 2 days (1.45%) 4 days (1.91%) 6 days (2.10%) and 8 days (1.98%) after storage. Treatment with KMnO4 extended the shelf life upto 10th day after storage and minimum and maximum PLW of 1.00 an 1.39 per cent was noticed in 2 per cent and 1 per cent KMnO4 treatments respectively.

Table-1 *Effect of CaCl2 and KMnO4 on physiological loss in weight (%) of fig fruits during storage*

	Treatments	Number of days after storage				
		2	4	6	8	10
T_1	Fruits dipped in 1 % $CaCl_2$ solution and packed in polyethylene cover	1.41 (6.10)	1.42 (6.85)	1.48 (6.96)	1.62 (7.31)	-
T_2	Fruits dipped in 2 % $CaCl_2$ solution and packed in polyethylene cover	1.25 (6.40)	1.70 (7.47)	1.80 (7.69)	1.82 (7.74)	-
T_3	Packing of fruits along with 1 % $KMnO_4$ placed in tea bags	0.93 (5.54)	1.02 (5.79)	1.13 (6.11)	1.36 (6.68)	1.39
T_4	Packing of fruits along with 2 % $KMnO_4$ placed in tea bags	0.65 (4.61)	0.96 (5.62)	0.81 (4.86)	0.98 (5.68)	1.00
T_5	Control (no packing)	1.45 (6.45)	1.91 (7.94)	2.10 (8.33)	1.98 (8.09)	-
	Mean	1.08 (5.88)	1.40 (6.73)	1.46 (6.79)	1.55 (7.10)	-
	F test	*	*	*	*	-
	SEm±	0.16 (0.47)	0.88 (0.21)	0.14 (0.51)	0.10 (0.25)	-
	C.D. at 5%	0.50 (1.40)	0.26 (0.66)	0.43 (0.54)	0.30 (0.74)	-
	C.V. (%)	30.55 (15.80)	12.63 (6.51)	19.63 (14.99)	13.11 (6.89)	-

* Significant at 5 %

\- Observations were not recorded as the fruits lost their keeping quality

Values in parenthesis are transformed values

Total soluble solids (%)

Data pertaining to total soluble solids content of fig fruits as influenced by $CaCl_2$ and KMnO4 treatments are presented in [Table-2]. There was a significant difference in total soluble solids content of fig fruits during storage. On 2 DAS higher total soluble solid content of 14.51 per cent was recorded when the fruits were stored under room condition (control). This result is on par with the three other treatments *viz.*, fruits treated with 1 per cent CaCl2 (14.11%), 1 per cent $KMnO_4$ (14.27%) and 2 per cent $CaCl_2$ (14.29%) minimum (13.58%) total soluble solids was recorded when fig fruits were packed along with 2 per cent $KMnO_4$. On 4 DAS of fig fruits, total soluble solid content was maximum wherein fruits were stored under room conditions (control). This result is on par with two other treatments namely fruits packed along with 1 per cent KMnO4 (14.56%) and fruits treated with 2 per cent $CaCl_2$ (14.50%). However, minimum (13.74%) total soluble solid content was noticed wherein fruits were stored along with 2 per cent $KMnO_4$. On 6 DAS of fruits maximum total soluble solid content (15.18%) was noticed in the fruits stored under room conditions (control). The other treatments which are on par with this are treatment with 2 per cent (15.01%) and 1 per cent $CaCl_2$ (14.84%) respectively. Total soluble solids content was minimum (14.60%) when fruits were packed with 2 per cent $KMnO_4$. On 8 DAS of fig fruits, maximum total soluble solid content of 15.40 per cent was noticed wherein fruits were stored under room condition (control). The other treatments which were on par with this treatment are fruits treated with 2 per cent $CaCl_2$ (15.22%), 1 per cent $CaCl_2$ (15.06%) and when fruits packed along with 1 per cent $KMnO_4$. Total soluble solids content was recorded upto 10 DAS when fruits were stored along with 1 and 2 per cent $KMnO_4$ and it was minimum (15.08%) and maximum (15.20%) respectively. Fruits in the other treatments lost their keeping quality.

Table-2 *Effect of $CaCl_2$ and $KMnO_4$ on total soluble solids (%) content of fig fruits during storage*

Treatments		Number of days after storage				
		2	4	6	8	10
		Initial value - 13.56				
T1	Fruits dipped in 1 % CaCl2 solution and packed in polyethylene cover	14.11	14.32	14.84	15.06	-
T_2	Fruits dipped in 2 % $CaCl_2$ solution and packed in polyethylene cover	14.29	14.71	15.01	15.22	-
T_3	Packing of fruits along with 1 % $KMnO_4$ placed in tea bags	14.27	14.50	14.70	14.94	15.08
T_4	Packing of fruits along with 2 % $KMnO_4$ placed in tea bags	13.58	13.74	14.16	14.37	15.20
T_5	Control (no packing)	14.51	14.86	15.18	15.40	-
	Mean	14.15	14.43	14.78	15.00	-
	F test	*	*	*	*	-
	SEm±	0.15	0.13	0.14	0.16	-
	C.D. at 5%	0.45	0.38	0.41	0.48	-
	C.V. (%)	2.14	1.75	1.86	2.12	-

* Significant at 5 %

\- Observations were not recorded as the fruits lost their keeping quality

Titratable acidity (%)

Data pertaining to titratable acidity content of fig fruits as influenced by $CaCl_2$ and KMnO4 treatments are presented in [Table-3]. There was a non significant difference in titratable acidity of fig fruits on 2 and 4 DAS. However, minimum (0.26% and 0.23%) and maximum (0.32% and 0.29%) titratable acidity was recorded in 2 per cent $CaCl_2$ treated fruits and control treatment on 2 and 4 DAS respectively. Both on 6 and 8 DAS there was a significant difference in the titratable acidity content of fig fruits. The titratable acidity content was minimum when fruits were treated with 2 per cent $CaCl_2$ chemical (0.20% and 0.17% respectively) on 6 and 8 DAS. This treatment is on par with 1 per cent $CaCl_2$ treatment (0.25% and 0.21% respectively). Maximum of 0.30 per cent and 0.26 per cent of titratable acidity was noticed in the control fruits. On 10 DAS only fruits treated with 2 per cent $KMnO_4$ and control treatments extended the shelf life of fig fruits and recorded minimum (0.21%) and maximum (0.22%) titratable acidity.

Table-3 *Effect of $CaCl_2$ and $KMnO_4$ on titratable acidity (%) content of fig fruits during storage*

Treatments		Number of days after storage				
		2	4	6	8	10
		Initial value - 0.33				
T_1	Fruits dipped in 1 % $CaCl_2$ solution and packed in polyethylene cover	0.31	0.28	0.25	0.21	-
T_2	Fruits dipped in 2 % $CaCl_2$ solution and packed in polyethylene cover	0.26	0.23	0.20	0.17	-
T_3	Packing of fruits along with 1 % $KMnO_4$ placed in tea bags	0.33	0.30	0.28	0.24	-
T_4	Packing of fruits along with 2 % $KMnO_4$ placed in tea bags	0.29	0.28	0.26	0.24	0.21
T_5	Control (no packing)	0.32	0.29	0.30	0.26	0.22
	Mean	0.30	0.28	0.26	0.23	-
	F test	NS	NS	*	*	-
	SEm±	0.02	0.17	0.17	0.02	-
	C.D. at 5%	0.051	0.05	0.05	0.05	-
	C.V. (%)	11.75	12.06	13.05	14.23	-

* Significant at 5%

NS - Non significant

\- Observations were not recorded as the fruits lost their keeping quality

Total sugars (%)

There was a significant difference in total sugar content of fig fruits when fruits were treated with 1 and 2 per cent $CaCl_2$ and when fruits were packed along with 1 and 2 per cent $KMnO_4$ on 2, 4, 6 and 8 DAS [Table-4]. On 2 DAS maximum total sugars of 13.67 per cent was noticed in control fruits and rest all the treatments were on par with these results. On 4 DAS the maximum total sugars content of 14.60 per cent was noticed in control fruits and rest all the treatments are on par with this results. On 6 DAS the significantly maximum total sugar content of 16.42 per cent was noticed in control fruits. Significantly minimum total sugar content of 14.05 per cent was noticed when fruits were packed along with 2 per cent $KMnO_4$. On 8 DAS significantly higher total sugar content of 17.85 per cent was noticed in control fruits. Minimum total sugar content of 14.82 per cent was noticed when fruits were packed along with 2 per cent $KMnO_4$. On 10 DAS fruits in all treatments except control and fruits packed with 2 per cent $KMnO_4$ have lost their keeping quality, hence values are not recorded. Fruits packed along with 2 per cent $KMnO_4$ recorded total sugar content of 17.03 per cent while in control fruits recorded 16.22 per cent total sugars.

Table-4 *Effect of $CaCl_2$ and $KMnO_4$ on total sugars (%) content of fig fruits*

Treatments		Number of days after storage				
		2	4	6	8	10
		Initial value - 13.15				
T_1	Fruits dipped in 1 % $CaCl_2$ solution and packed in polyethylene cover	13.17	14.03	15.58	16.96	-
T_2	Fruits dipped in 2 % $CaCl_2$ solution and packed in polyethylene cover	13.34	14.47	15.62	17.13	-
T_3	Packing of fruits along with 1 % $KMnO_4$ placed in tea bags	13.35	13.84	14.63	15.97	-
T_4	Packing of fruits along with 2 % $KMnO_4$ placed in tea bags	13.52	13.62	14.05	14.82	17.03
T_5	Control (no packing)	13.67	14.60	16.42	17.85	16.22
	Mean	13.21	14.11	15.26	16.54	-
	F test	*	*	*	*	-
	SEm±	0.24	0.20	0.15	0.17	-
	C.D. at 5%	0.71	0.59	0.44	0.52	-
	C.V. (%)	3.57	2.78	1.91	2.08	-

* Significant at 5 %

\- Observations were not recorded as the fruits lost their keeping quality

Reducing sugar (%)

The data pertaining to reducing sugar content of fig fruits as influenced by $CaCl_2$ and $KMnO_4$ treatment are presented in [Table-5]. On 2 and 4 DAS there was a non-significant difference in reducing sugar of fig fruits. On 2 DAS the maximum reducing sugar content of 11.98 per cent was found in control treatment while it was minimum (11.19%) in fruits packed along with 2 per cent $KMnO_4$. On 4 DAS the maximum reducing sugar content of 12.32 per cent was found in control treatment and minimum of 11.76 per cent when fruits were packed along with 2 per cent KMnO4. On 6 DAS there was a significant difference in reducing sugar content between the treatments. The maximum reducing sugar content of 13.00 per cent was found when fruits treated with 2 per cent $CaCl_2$ and this result are on par with 1 per cent $CaCl_2$ treatment (12.92%). Both in control and 2 per cent $KMnO_4$ treatment the reducing sugar content was minimum (11.93%). On 8 DAS there was a significant difference in the reducing sugar content of fig fruits between the treatments. The maximum reducing sugar content (14.31%) was found in the control treatment. This result is on par with treatment 2 per cent $CaCl_2$ treated fruits (13.99%). The minimum reducing sugar content (12.17%) was found when fruits are treated with 2 per cent $KMnO_4$. On 10 DAS the observations with respect to reducing sugar content was recorded except in control (13.2%) and fruits treated with 1 per cent KMnO4 (13.71%) as the all other treatments lost their keeping quality.

Non-reducing sugar (%)

Data pertaining to non-reducing sugar content of fig fruits as influenced by $CaCl_2$ and $KMnO_4$ treatments are presented in [Table-6]. On 2, 4, 6 and 8 DAS there was a significant difference in non-reducing sugar content of fig fruits. On 2 DAS the significantly highest non reducing sugar content was noticed in control treatment (11.93%). This result is on par with three other treatment *viz.* fruits treated with 1 per cent $CaCl_2$ solution (1.84%), fruits treated with 2 per cent $CaCl_2$ (1.75%) and fruits packed along with 1 per cent $KMnO_4$ (1.68%). The minimum non-reducing sugar content (1.33%) was found when fruits are packed along with 2 per cent $KMnO_4$. On 4 DAS the maximum non reducing sugar content of 2.28 per cent was found when fruits were stored under room condition (control). This result is on par with two other treatments *viz.* fruits treated with 2 per cent and 1 per cent $CaCl_2$ solution (2.16% and 2.15% respectively). On 6 DAS the non-reducing sugar content was significantly highest (3.00%) in the control treatment and it was least in fruits stored along with 2 per cent $KMnO_4$ (2.14%). On 8 DAS significantly highest non reducing sugar content of 3.55 per cent was noticed in the control fruits and it was minimum in 2 per cent $KMnO_4$ treatment (2.65%). On 10 DAS observations was recorded only with respect to control and 2 per cent $KMnO_4$ treatment. In 2 per cent $KMnO_4$ treated fruits the non reducing sugar content was maximum (3.26%) while it was minimum.

Table-5 *Variation in reducing sugar (%) content of fig fruits during storage as influenced by CaCl2 and KMnO4*

Treatments		Number of days after storage				
		2	4	6	8	10
		Initial value - 11.11				
T_1	Fruits dipped in 1 % $CaCl_2$ solution and packed in polyethylene cover	11.40	12.08	12.92	13.91	-
T_2	Fruits dipped in 2 % $CaCl_2$ solution and packed in polyethylene cover	11.58	12.16	13.0	13.99	-
T_3	Packing of fruits along with 1 % $KMnO_4$ placed in tea bags	11.70	12.08	12.23	12.87	-
T_4	Packing of fruits along with 2 % $KMnO_4$ placed in tea bags	11.19	11.76	11.93	12.17	13.71
T_5	Control (no packing)	11.98	12.32	11.93	14.31	13.20
	Mean	11.57	12.09	12.69	13.45	-
	F test	NS	NS	*	*	-
	SEm±	0.18	0.15	0.12	0.11	-
	C.D. at 5%	0.55	0.44	0.37	0.34	-
	C.V. (%)	3.16	2.41	1.91	1.67	-

* Significant at 5 %

NS Non - Significant

\- Observations were not recorded as the fruits lost their keeping quality

Table-6 *Variation in non-reducing sugar (%) content of fig fruits during storage as influenced by CaCl2 and KMnO4*

Treatments		Number of days after storage				
		2	4	6	8	10
		Initial value - 1.30				
T_1	Fruits dipped in 1% $CaCl_2$ solution and packed in polyethylene cover	1.84	2.15	2.65	3.05	-
T_2	Fruits dipped in 2 % $CaCl_2$ solution and packed in polyethylene cover	1.75	2.16	2.62	3.14	-
T_3	Packing of fruits along with 1 % $KMnO_4$ placed in tea bags	1.68	1.98	2.47	3.10	-
T_4	Packing of fruits along with 2 % $KMnO_4$ placed in tea bags	1.33	1.88	2.14	2.65	3.26
T_5	Control (no packing)	1.93	2.28	3.00	3.55	3.02
	Mean	1.71	0.09	2.58	3.31	-
	F test	*	*	*	*	-
	SEm±	0.04	0.07	0.10	0.12	-
	C.D. at 5%	0.29	0.22	0.30	0.37	-
	C.V. (%)	11.04	7.13	7.75	7.93	-

* Significant at 5 %

\- Observations were not recorded as the fruits lost their keeping quality

Organoleptic characters

A panel of five judges evaluated the fig fruits treated with 1 and 2 per cent $CaCl_2$ and $KMnO_4$ respectively and stored for 6 days. Organoleptic characters such as appearance, texture of fruits taste of pulp and overall acceptance of fruits for four score is presented in [Table-7]. It is clear from this table that there was a significant difference in the appearance of fruit, texture of fruit, taste of pulp and overall acceptance of fruit between the treatments. With respect to appearance, fruits packed with 2 per cent $KMnO_4$ secured significantly higher score of 3.68 out of 4.00. Whereas, appearance of control fruits was very poor (2.06 score out of 4.00). The fruits treated with 2 per cent $CaCl_2$ were significantly superior with respect to texture of fruits (3.31 score out of 4.00). In this character also the texture of fruits was very poor in the control treatment (2.18 score out of 4.00).

Fruits treated with 2 per cent $KMnO_4$ were superior in taste (3.46 score out of 4.00). This was on par with fruits packed along with 1 per cent $KMnO_4$ (3.06 score out of 4.00). The overall acceptance of the fruit was found to be the best when fruits were treated with 2 per cent $KMnO_4$ (3.43 score out of 4.00). This result is on par with the other two treatments *viz.* fruits packed with 1 per cent $KMnO_4$ (3.06 score out 4.00) and fruits treated with 2 per cent $CaCl_2$ (2.87 score out of 4.00). The fruits in the control treatment was least acceptable (2.25 score out of 4.00).

Table-7 *Effect of $CaCl_2$ and $KMnO_4$ on organoleptic characters of fig fruits after 6 days of storage*

Treatments		Appearance of fruit (5.00)	Texture of fruit (5.00)	Taste of pulp (5.00)	Overall acceptance (5.00)
T_1	Fruits dipped in 1% $CaCl_2$ solution and packed in polyethylene cover	2.62	2.56	2.50	2.75
T_2	Fruits dipped in 2 % $CaCl_2$ solution and packed in polyethylene cover	2.81	3.31	2.81	2.87
T_3	Packing of fruits along with 1 % $KMnO_4$ placed in tea bags	3.12	2.75	3.06	3.06
T_4	Packing of fruits along with 2 % $KMnO_4$ placed in tea bags	3.68	2.71	3.43	3.43
T_5	Control (no packing)	2.06	2.18	2.00	2.25
	Mean	2.86	2.71	2.76	2.87
	F test	*	*	*	*
	SEm±	0.15	0.18	0.17	0.20
	C.D. at 5%	0.44	0.54	0.52	0.59
	C.V.(%)	10.14	13.08	12.41	13.56

* Significant at 5%

Spoilage of fruits (%)

The data on loss of fruits due to post harvest spoilage at 5, 6, 7 and 8 DAS as influenced by 1 and 2 per cent $CaCl_2$ and $KMnO_4$ treatments are presented in [Table-8] and illustrated in [Fig-4]. The treatments differed significantly with respect to decay loss after 5, 6, 7 and 8 DAS. All the treatments recorded increased decay loss with the advancement of storage period. On 5, 6, 7 and 8 DAS fruits treated with 2 per cent $KMnO_4$ recorded significantly minimum decay loss (0, 0, 4.18% and 9.12% respectively). Whereas, fruits under control treatment recorded significantly maximum spoilage of 20.34, 44.35, 60.97 and 83.20 per cent respectively.

Table-8 *Per cent spoilage of fig fruits during storage as influenced by CaCl2 and KMnO4*

Treatments		No. of days after storage			
		5	6	7	8
T_1	Fruits dipped in 1 % $CaCl_2$ solution and packed in polyethylene cover	4.50 (6.27)	8.50 (12.17)	22.17 (27.73)	50.62 (45.36)
T_2	Fruits dipped in 2 % $CaCl_2$ solution and packed in polyethylene cover	8.12 (11.88)	8.62 (12.26)	22.12 (27.65)	53.50 (47.02)
T_3	Packing of fruits along with 1 % $KMnO_4$ placed in tea bags	5.0 (6.64)	9.12 (12.63)	13.75 (15.57)	25.87 (25.04)
T_4	Packing of fruits along with 2 % $KMnO_4$ placed in tea bags	0.00 (0.00)	0.00 (0.00)	4.18 (6.03)	9.12 (9.29)
T_5	Control (no packing)	17.50 (21.38)	36.25 (36.15)	42.87 (40.88)	62.75 (52.49)
	Mean	7.025 (9.23)	12.50 (14.64)	21.02 (23.57)	39.97 (35.84)
	F test	*	*	*	*
	SEm±	4.92 (6.16)	5.95 (6.42)	5.80 (5.55)	7.73 (6.52)
	C.D. at 5%	14.85 (18.58)	19.74 (19.34)	17.50 (16.72)	23.29 (19.65)
	C.V. (%)	140.35 (133.53)	104.83 (87.67)	55.26 (47.07)	38.68 (36.39)

* Significant at 5 %

Values in the parenthesis are transformed values

Shelf life (days)

The data pertaining to shelf life of fig fruits as influenced by different concentrations of calcium chloride and $KMnO_4$ is presented in [Table-9]. The fig fruits treated with 2 per cent KMnO4 had a maximum shelf life (10.33 days) and this treatment was on par with 1 per cent KMnO4 treatment (9.86 days). However, fruits stored under room conditions (control) had a very poor shelf life of 6.55 days.

Table-9 *Effect of $CaCl_2$ and $KMnO_4$ on shelf life of fig fruits under storage*

	Treatments	Shelf life (days)
T_1	Fruits dipped in 1 % $CaCl_2$ solution and packed in polyethylene cover	8.00
T_2	Fruits dipped in 2 % $CaCl_2$ solution and packed in polyethylene cover	8.50
T_3	Packing of fruits along with 1 % $KMnO_4$ placed in tea bags	9.86
T_4	Packing of fruits along with 2 % $KMnO_4$ placed in tea bags	10.66
T_5	Control (no packing)	6.55
	Mean	8.33
	F test	*
	SEm±	0.337
	C.D. at 5%	0.978
	C. V. (%)	12.15

* Significant at 5%

Control treatment (3.02%). In all other treatments the fruit have lost their keeping quality.

Discussion

Physiological loss in weight (%)

Fig fruits were treated with $CaCl_2$ or stored along with $KMnO_4$ in polyethylene cover showed lesser PLW of fruits when compared to control. In the first experiment when the fruits were stored in polyethylene cover the lesser PLW may be due to presence of polyethylene cover between the fruits and atmosphere. It acts as a barrier during the process of ripening. Similarly, in the second experiment $CaCl_2$ chemical coating on the fruit surface might have prevented respiration and thereby reduced PLW. Similarly, $KMnO_4$ helped in absorbing the synthesized ethylene and thereby delayed the process of ripening. Various workers who studied on PLW of fruits also were of the opinion that by storing the fruits in polyethylene cover the processes of ripening can be delayed and the PLW of fruits was lower [Fig-1]. [8] observed reduction in weight loss of custard apple fruit and maintenance of turgidity of fruits by arresting the process of ripening in polyethylene stored fruits. [15] was of the opinion that when sapota fruits were stored in polyethylene cover there was reduction in loss of moisture from the fruits. [20] observed reduction in transpiration rate of ber fruits when stored in polyethylene cover due to restricting diffusion of gasses and feedback mechanism.

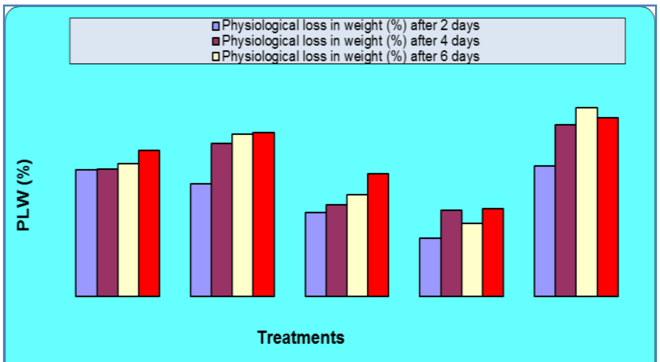

Fig. 1. Effect of $CaCl_2$ and $KMnO_4$ on physiological loss in weight (%) of fig fruits during storage

Total soluble solids (%)

Calcium chloride treated fruits or $KMnO_4$ treated fruits were stored in the polyethylene cover there is a significant difference in the TSS content of fruits at 2, 4, 6 and 8 DAS. However, the variation between the treatments is rather very narrow. The slight variation in the TSS content may be attributed to the better environmental conditions provided by calcium chloride and $KMnO_4$ chemicals. Calcium chloride treated fruits have enhanced the calcium content of fig fruits cells, thereby altering the permeability of the cell membrane, enhanced the shelf life of fruit and there by fruit remains healthy and attractive even upto 8 DAS and correspondingly there is a slight improvement in the TSS content from 14.11, 14.29 per cent to 15.06 and 15.22 per cent on 2 and 8 DAS in 1 and 2 per cent $CaCl_2$ treated fruits respectively. In case of fig fruits stored along with $KMnO_4$ also there was a very slight improvement in TSS content of fruits between 2 and 8 DAS and this is due to $KMnO_4$ act as absorbent of ethylene which is synthesized during ripening of fruits and as a result there was improvement in TSS content. Fig is a typical example for climateric fruit as such at the harvesting stage of fruit itself maximum accumulation of TSS will be there. Various workers who worked with a large number of fruits crops were also of the opinion that by storing the fruits either in polyethylene cover or storing the fruits along with $KMnO_4$ or $CaCl_2$ treatment there was a slight improvement in the TSS content of fruits. [5,13,16] worked on guava crop for improving the shelf life in various parts of India and are of the opinion that storing fruits in polyethylene cover or storing fruits along with KMnO4 have helped in slight accumulation of TSS content in guava fruit. Guava being a climateric fruit the accumulation of TSS is very narrow. Similarly, [18,21] have worked with another climacteric fruit *viz.,* apple and found that there is a slight accumulation in the TSS of fruit with the advance in storage period.

Titratable acidity (%)

There was a maximum reduction in organic acids of fig fruits during storage period as a result of wrapping the fruits with polyethylene cover with ventilation. It is attributed to the fact that it reduces the rate of respiration of the fruits thereby oxidative breakdown of acids proceeds at a slower rate as compared to the fruits in unventilated polyethylene covers and unwrapped fruits of control. The results obtained in the present investigation can be compared to those obtained by [9,10]. There was a non significant difference in titratable acidity on 2 and 4 DAS when fig fruits were treated with CaCl2 and KMnO4. On 6 and 8 DAS significant difference were found. In general all treatments recorded increasingly in acidity content. Fruits treated with 2% KMnO4 and packed in polyethylene cover and control recorded gradual decrease in acidity content. [16] reported that guava fruits in control recorded maximum acidity, minimum acidity was recorded when chalk impregnated with KMnO4. Decrease in acid content may be due to conversion of acid into sugars by enzyme invertase during storage period. Similar findings were also reported by [10] in ber, [14] in ber fruits. and [19] in guava fruits,

Sugars (%)

There was a significant increase in total sugars, reducing sugar and non reducing sugar content in all treatments as the storage period advanced [Fig-2]. The general increase in the sugar content of fig fruits irrespective of the treatment has been recorded by [9,10,14]. This increase in sugar content of fig fruits during storage could be due to normal ripening process leading to senescence. In both the experiments where fruits are packed in different gauge of polyethylene covers [with or without ventilation) and treating with $CaCl_2$ and $KMnO_4$ treatments registered relatively lower total sugars, reducing sugar and non reducing sugars as compared to control on all the days of storage. Fruits stored in 50, 100 and 200 gauge polyethylene cover with 1 per cent ventilation recorded consistently higher total sugars, reducing sugar and non reducing sugar content even after 6 DAS. Whereas control fruits recorded sudden increase in sugar content and fruits lost their keeping quality after 6 DAS. When fruits are treated with $CaCl_2$ and $KMnO_4$ the sugar content increased over a period of time. Fruits stored in 200 gauge polyethylene cover with 2 per cent $KMnO_4$ recorded consistently higher sugar content and fruits remained in good marketable condition. Whereas, in control, even though fruits recorded increase in sugar content upto 8 DAS but declined further as the fruits lost keeping quality. This can be attributed mainly due to reduced rate of respiration and delayed ripening due to treatments imposed in the form of $CaCl_2$ and $KMnO_4$ with 200 gauge polyethylene cover (1% ventilation). Similar findings were reported by [5] in guava fruits. [9,1014]. [22] reported that increase in total sugars, reducing sugar or non reducing sugars irrespective of thickness of polyethylene cover used. Increase in sugars may be attributed to conversion of polysaccharides into sugars. Various other workers reported similar results in other fruits. [23] reported sugar content increasing from harvesting till ripening, as senescence approaches sugars will decline. Similar results are reported by [32] in ber fruits and [33].

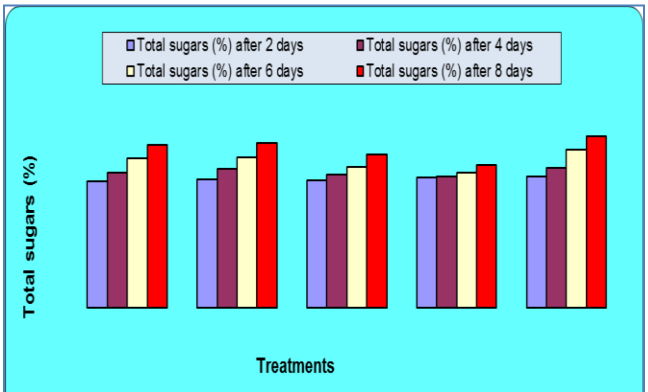

Fig 2. Effect of $CaCl_2$ and $KMnO_4$ on total sugars (%) content of fig fruits

Organoleptic characters

Fig fruits stored in 200 gauge polyethylene cover appeared better than other treatments even the texture of the fruit, taste of pulp and over all acceptance of the fruit appeared to be the best in this treatment. When fruits were stored along with 2 per cent $KMnO_4$ secured significantly highest score for the appearance of fruit, taste of pulp and over all acceptance of fruit character. This clearly shows presence of polyethylene cover and that to of 200 gauge having 1 per cent of ventilation act as a barrier between the fruits and atmosphere. The fruits stored in the polyethylene cover or when the fruits are stored in polyethylene cover along with $KMnO_4$ in tea bags have helped the fruits to appear better even 6 DAS. Absorption of ethylene (synthesized during fruit ripening) by $KMnO_4$ might have helped in delaying the further ripening of fruit and there by the fruits in this treatments appeared better, improved texture of fruits, good taste of pulp and thus fetched highest score even for the overall acceptance character. Reduction in the transpiration rate, development of modified atmosphere within the polyethylene cover might have helped the fruits to remain attractive in the different treatment when compared to control. [31] also observed that guava fruit can be stored for a longer time in the polyethylene cover compared to control. Tamil [28] while working with guava fruit and treated with 1 and 2 per cent $CaCl_2$ fetched the highest score for the organoleptic characters when compared to control treatment. They are also of the opinion that senescence of the tissue as a result of decrease in firmness, more rotting and shrievellage of fruits in the control treatment. [6] observed better organoleptic characters in sapota fruits even after storing for 10 days when fruits were wrapped with paper shreds and impregnated with $KMnO_4$. [24] observed that ethylene absorbent inserted in polyethylene bags retained higher score for organoleptic qualities in banana crop. [25] was of the opinion that packing plays a dominant role in preserving sensory and nutritive values of fruits till consumption. The consumer acceptance was good when banana fruits were stored in perforated polyethylene bags with ethylene absorbent [34].

Spoilage (%)

Fig fruits packed in 100 and 200 gauge polyethylene cover with 1 per cent ventilation recorded less percentage of spoilage. Among these two treatments fruits stored in 200 gauge polyethylene cover with 1 per cent ventilation recorded lowest spoilage percentage (12.86%) after 8 days of storage. This is comparatively superior over control fruits where in 83.20 per cent of spoilage was recorded. Perforations in polyethylene cover helped in free exchange of gases and prevented from build up of higher moisture levels inside polyethylene cover which more in polyethylene cover without ventilation. When fig fruits were treated with $CaCl_2$ and $KMnO_4$ both packed in 200 gauge polyethylene cover with 1 per cent ventilation spoilage decreased significantly. Fruits stored in 200 gauge polyethylene cover with 2 per cent $KMnO_4$ recorded minimum spoilage. After 8 days of storage it has recorded 9.12 per cent spoilage whereas, in control it is 62.75 per cent [Fig-3]. This difference in spoilage could be attributed to $KMnO_4$ as ethylene absorbent helped in scrubbing of ethylene released during ripening process which ultimately helped delaying the softening of fruits. These results of these two experiments are in line with findings of [1] in ber fruits, [16] in guava, [26] in strawberry and [32].

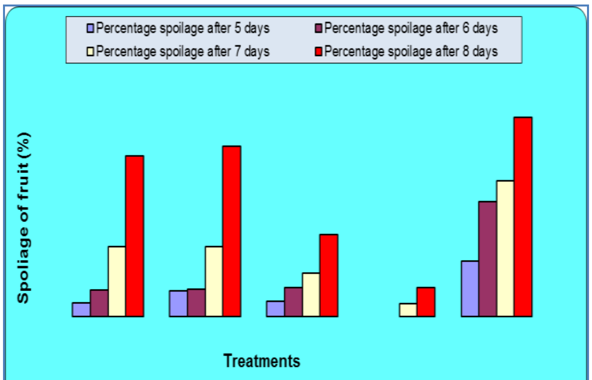

Fig. 3 Percent spoilage of fig fruits during storage as influenced by $CaCl_2$ and $KMnO_4$

Shelf life (days)

Shelf life is a important parameter in perishable horticultural crops and more so in the perishable fruit like fig. The shelf life of some of the fruits like, strawberry and phalsa is just 1 to 2 days where as fig can be stored upto 6 to 7 days (both under room conditions). The shelf life of the fig fruits ends with the attack of fungal growth or growth of mucor on fruit surface or the fruits become very soft, there will be degradation of sugars resulting in the fruits unfit for consumption. In the present experiment an attempt was made to extend the shelf life of fig fruits by storing the fruits in different gauges of polyethylene covers with or without ventilation and also to extend the shelf life of fruits with the aid of chemicals like $CaCl_2$ and $KMnO_4$ (ethylene absorbent). Whenever polyethylene covers were used to store the fruits in different gauges it is clear that with the increase in the gauge of polyethylene cover and presence of ventilation help to extend the shelf life of fruits. In fact fig fruits can be stored as high as 8 days while storing the fruits in 200 gauge polyethylene cover with 1 per cent ventilation as against mere 6 days under control treatment. This clearly shows that polyethylene cover act as a barrier between the fruits and atmosphere and helped in extending the shelf life of fruits. The polyethylene cover might have helped in creating a modified atmosphere within the cover where the fruits are stored. Further, the presence of polyethylene cover helped in reduction of moisture loss from the fruit by the process of transpiration, it has also helped in arresting the process of ripening and thereby helped further extension of shelf life of fruits. Similarly when fruits either treated with $CaCl_2$ are stored along with $KMnO_4$ in polyethylene covers has helped in extending the shelf life of fig fruits to as high as 10.66 days. This clearly shows KMnO4 acts as an ethylene absorbent chemical and thereby helped to extend the shelf life of fruits. Similar studies have been reported in various fruit crops where shelf life of fruits can be extended by storing the fruits either in polyethylene cover or storing of fruits along with $KMnO_4$ or $CaCl_2$ treatments [Fig-4]. [7] extended the shelf life and fruit quality of brinjal fruits when fruits were stored in 200 gauge polyethylene cover with 1 per cent ventilation. [24] observed additional 2 days of shelf life of banana when stored along with $KMnO_4$ against the control treatment. The storage life and marketability of mango fruits was enhanced upto 10 days by storing fruits in ventilated cover [30]. [2] extended the shelf life of sapota fruits upto 18 days by storing them in polyethylene cover with KMnO4 chemical. [3] observed better storage life in sapota fruits when stored them in 1 to 2 per cent ventilated polyethylene covers of 200 gauges. [4] extended the shelf life of fig fruits upto 10 days by storing them in partially perforated plastic film as against 6 days in unwrapped fruits. When guava fruits were treated with 4 per cent calcium nitrate maximum shelf life was observed due to increase content of calcium in fruits which resulted in reduced rate of ripening [5]. [6] also observed better shelf life in sapota fruits when treated with 2 per cent $CaCl_2$. The treated fruits had a shelf life of 11 days as compared to 8.5 days in control. [12] successfully extended the shelf life of banana fruits upto 6 weeks by storing fruits in polyethylene bags with $KMnO_4$ as ethylene absorbent compared to mere 3 weeks in fruits packed without chemical. [31] extended the shelf life of guava fruits upto 10 days by storing them in 300 polyethylene bags with ventilation as against just 3 days in control.

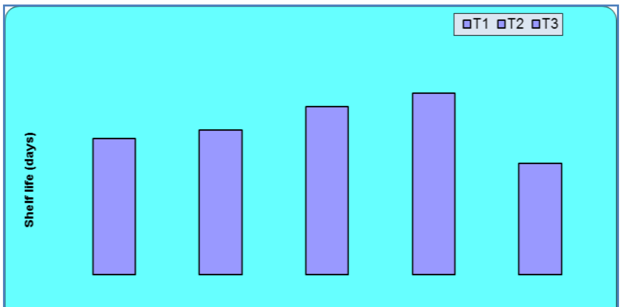

Fig 4. Effect of $CaCl_2$ and $KMnO_4$ on shelf life of fig fruits under storage

Conclusion

When fig fruits were stored in different gauge of polyethylene cover with or without ventilation the gaseous exchange takes place within the cover is needs to be estimated. It is also worthwhile to estimate oxygen and carbon dioxide concentration within the polyethylene cover correlating with shelf life of fig fruits. When fig fruits are treated with $CaCl_2$ the changes that occur at cellular level is need to be estimated. Formation of Calcium pectate and pectin substance developed in the fruits need to be estimated which are responsible for extending the shelf life of fruits. The quantum of ethylene produced during the shelf life period of fig fruits need to be estimated similarly the quantum of ethylene absorbed by $KMnO_4$ needs to be studied.

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Author Contributions

Paramesha D- Conception and design of the work, data collection, data analysis and interpretation, drafting the article, Critical revision of the article, final approval of the version to be published and acted as corresponding author

Keerthishree M- Reviews collection, Critical revision of the article, final approval of the version to be published.

Chethan Prasad H. P.- Reviews collection, Critical revision of the article, final approval of the version to be published.

Conflict of Interest: None declared

Abbreviations

PLW- Physiological loss in weight; TSS- Total soluble solids; %- Percentage; DAS- Days after storage.

Ethical approval: This article contain studies with human participants during sensory evaluation of the product.

Conflict of Interest: None declared

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