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Effect of wax coating treatments on physiological weight loss and shelf-life of custard apple (*Annona squamosa* L.) during storage

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Abstract
Custard apple (*Annona squamosa* L.) is one of the finest Tropical American fruit gifts to India, which belongs to the family Annonaceae. Custard apple are climacteric and have a very short storage life because of their rapid maturation after harvest. Under ordinary condition fruits can keep well only for 3-4 days after harvest. The physiological changes in the fruit occurs continuously after harvest. By reducing these changes, we can effectively increase shelf-life of mature fruits. Extending of shelf life may be possible by checking the transpiration rate, respiration rate and infection with microbes. The softening and reduction of firmness of the fruits are the main reasons for the reduction in quality and developing a major drawback to export market for this fruit. In order to increase the shelf-life of custard apple fruits an investigation was conducted at Horticulture Processing Laboratory, Department of fruit science, College of Agriculture, IGKV, Raipur during the year 2019-20 to study the effect of wax coating treatment son shelf life and physico-chemical composition of custard apple. The experiment was conducted in Completely Randomized Design (CRD) consisting ten different concentration of paraffin wax emulsion along with polythene wrap and KMnO4replicated thrice. The overall best result is observed by treatment T8 in all the physical parameters. Minimum physiological loss in weight (3.23, 6.33, 11.22, 15.33%) and minimum retention of unmarketable fruits (0, 0, 2.76, 19.45%), maximum retention of marketable fruits (100, 100,97.24, 80.55%) and marketable fruit retention over control (8.34, 33.12, 72.24, 80.55%) were observed under the superiority of treatment 10% paraffin wax emulsion coated fruits with wrapping polythene and KMnO4 (0.1%) during storage period.

Keywords: Custard apple, shelf-life, paraffin wax, physico-chemical composition, KMnO4 etc.

Introduction
Custard apple (*Annona squamosa* L.) is one of the finest Tropical American fruit gifts to India. They are grown particularly in America, Africa, Egypt, India and West Indies. In India, it is called Sitaphal, Saripha at different places. It is also known as 'Sweet sop' or Sugar apple. Custard apple is the "fruit of poor people". Fruits, seeds, leaves and roots of custard apple plant are valued for their medicinal properties. Fruits are heart shaped, fleshly syncarp formed by the fusion of the pistils and receptacle, pericarp is the edible part. The large aggregate fruits are composed of peel, pulp and seeds. Fruits contain 45 per cent edible portion, 100 grams of each protein, fats and carbohydrates and also rich in minerals which gives energy. Custard apple are climacteric and have a very short storage life because of a rapid maturation after harvest. The fruit is an excellent energy source as it is high in carbohydrate. The fruit contains minerals such as calcium, phosphorus, potassium and vitamin A & C.
All annonaceous fruits are indigenious to Tropical America where spread to different parts of the world. In India, custard apple is grown in an area reported to be about 38,000 ha among the total area under fruit crops with an annual production of 3,20,000 million tones. Andra Pradesh is the leading state in production. Chhattisgarh is one of the states in which custard apple is produced in 8,222 ha having annual production of 40,693 metric tonnes (Anon, 2019) [2]. Climate of Chhattisgarh is well-suited for cultivation of custard apple; therefore, it is being grown almost in all districts of Chhattisgarh.
Fruits are used mainly for fresh consumption. Products such as jam, jelly, squash, syrup, nectar, canned product and a fermented alcoholic beverage. The custard apple is climacteric in nature as they increase respiratory activity and production of ethylene during ripening (Jawadagi *et al*., 2013) [8]. under ordinary condition fruits can keep well only for 3-4 days after harvest. The physiological changes in the fruit occurs continuously after harvest. By reducing these changes, we can effectively increase shelf- life of mature fruits. Extending of shelf life may be possible by checking the transpiration rate, respiration rate and infection with microbes. The softening and reduction of firmness of the fruits are the main reasons for the reduction in quality and the major drawback to developing an export market for this fruit (Jholgiker and Reddy, 2007) [9]. Hence, the present study

was undertaken on postharvest handling of custard apple through different post- harvest treatments of custard apple with potassium permanganate, wax emulsion, packing and wrapping materials. Fruit coatings are one such alternative as they improve not only the external appearance, but also modify the internal fruits atmosphere (Saftner, 1999) [17]. Use of coatings has gained importance in reducing the moisture loss and maintaining firmness (Farooqhi *et al*., 1988; Chauhan *et al*., 2005; and Patel *et al*., 2011) [5, 3, 15]. Keeping the above facts in view the present investigation was conducted to study the effect of wax coating treatments on shelf life and physico-chemical composition of custard apple.

Methods and Materials

The investigation was carried out during the year 2019-20 at Horticulture Processing Laboratory, Department of fruit science, College of Agriculture, IGKV, Raipur. The experiment was laid out in Completely Randomized Design (CRD) with 3 replications. The experiment was conducted with ten different treatment combinations of paraffin wax emulsion along with polythene wrap and KMnO4 (0.1%) *viz*. T_0: Control, T_1: paraffin wax emulsion (8%), T_2: paraffin wax emulsion (10%), T_3: paraffin wax emulsion (12%), T_4: paraffin wax emulsion (8%) + polythene wrap, T_5: paraffin wax emulsion (10%) + polythene wrap, T_6: paraffin wax emulsion (12%) + polythene wrap, T_7: paraffin wax emulsion (8%) + polythene wrap + KMnO4 (0.1%), T_8: paraffin wax emulsion (10%) + polythene wrap + KMnO4 (0.1%), T_9: paraffin wax emulsion (12%) + polythene wrap + KMnO4 (0.1%). Fresh and fully grown uniform sized fruits were harvested at proper stage of maturity from Kanker district and brought to the fruit science laboratory for further studies. The custard apple fruits were washed clean, dried and divided into main lots each containing 12 fruits and proceed to various treatments. Then the fruits were coated with various concentration of paraffin wax (8%, 10%, 12%) with polythene film and ethylene absorber (KMnO4 @ 0.1%) dissolved in distilled water with equal proportion for 1 minutes. Thereafter, coated custard apples were placed in trays for dried at room temperature. The experiment was kept for 8 days and observation were recorded.

Under the physical parameters of fruits, the observations i.e. physiological weight loss, retention of marketable fruit, unmarketable fruit and marketable fruit retention over control were recorded.

Results and Discussion

The results of trial pertaining to various aspects of physical parameters of fruits are summarized as follows:

Physiological weight loss (%) The result revealed regarding physical parameters of fruits that the physiological reduction of fruits weight was observed to rise as the storage time continued with respect of treatments. Fruit coated with treatment (T_8) paraffin wax (10%) with KMnO4 wrapped with Polythene cover registered minimum physiological loss in weight (3.23, 6.33, 11.22 and 15.33%) after storage period at 2, 4, 6, and 8 days, respectively followed by treatment (T_9) Paraffin wax (12%) with KMnO4 and polythene wrapping having the physiological weight loss 3.46, 6.83, 11.74 and 16.28% at same alternate days of storage period. The maximum physiological weight loss 7.15, 13.16, 17.35, 25.66% were recorded under control treatment at 2, 4, 6, and 8 days of storage. The physiological weight in loss increases with increase in storage period due to paraffin wax coating it retards the rate of transpiration loss and by KMnO4 reduces respiration rate in coated fruits. The similar results were found by Kamthe *et al*. (2004) [10] in custard apple fruit weight loss was reduced in fruits stored in the cool chambers than under ambient conditions.

Retention of marketable fruit (%)

The data presented regarding the retention of marketable fruit (%) showed that the retention in marketable fruits were getting lower with increase in storage duration and the results considered to be Significant. It showed that the 100 per cent marketable fruit is kept without degradation until 4 day after storage for fruits handled with paraffin wax (8%) along with KMnO4& wrapped with polythene followed by paraffin wax (10% & 12%) along with KMnO4 wrapped with polythene. Whereas minimum marketable fruit retained (66.88%) in control after 4th day of storage. At 6thand 8thday of storage significantly highest retention of marketable fruit recorded in paraffin wax (10%) with KMnO4 along with wrapped polythene (97.24, 80.55%), it is followed by T_9 (94.44, 58.33%) and T_7 (94.44, 47.22%). However, minimum (25.08%) marketable fruit retain under control (25.08 and 0%) after 6, and 8th day of storage. Among all the treatments maximum retention of marketable fruit (80.55%) were observed in T_8 Paraffin wax emulsion (10%) + polythene + KMnO4 (0.01%) and minimum in control after 8thday of storage.

Close finding found in guava fruit, the cause of extended shelf-life of the fruit under coating may be a reduction in the rate of water loss with lower fruit maturation and slowing down of colour transition, while the minimum retention of marketable fruit has been recovered under pressure. This could be due to the unsealing of lenticles responsible for highest transpiration and respiration rate (Pandey *et al*. 2010) [14].

Unmarketable fruit (%)

Data pertaining to impact of post-harvest treatments on unmarketable fruit of custard apple after storage showed that the unmarketable fruits (%) were getting increase with increase in storage duration. The minimum retention of unmarketable fruits was noticed in T_8 (Paraffin wax emulsion (10%) + polythene + KMnO4 (0.01%)) with 0, 0, 2.76 & 19.45 percentage during alternate days of storage, which followed by T_9 (0, 0, 5.56, 41.67) under same storage period. The treatment T_8 proved to be significant among all other treatments during the 2, 4, 6 and 8 days

of storage. The maximum retention of marketable fruit 8.33, 33.12, 74.92, 100 were observed under control at 2, 4, 6, 8 days of storage. Among all treatments the fruit coated with paraffin wax emulsion (10%) along with KMnO4 (0.01%) and wrapped with polythene were show minimum retention of marketable fruits. Similar findings have been published by Sahu (2016) [18] in custard apple, Jawadagi *et al*. (2013) [13] in guava and Patel *et al*. (2011) in Passion fruit.

Marketable fruit retention over control (%)

The data presented regarding the marketable fruit retention over control (%) showed that the highest retention percentage of marketable fruits over control were observed by T_8 (8.34, 33.12, 72.24, 80.55%) during alternate days of storage period followed by T_9 (8.34, 33.12, 69.44, 58.33) and T_7 (8.34, 33.12, 69.44, 47.22) under same storage period. Whereas in control noticed the minimum percentage of retention during the storage. Minimum control values under marketable fruit retention over control was attributed to less marketable fruit retention on untreated fruit. Mahajan *et al*. (2010) [11] made similar observation in pear and in guava fruit by Hiwale and singh (2003) [7]. The maximum percentage of marketable fruits retained under paraffin wax coating due to the retention of more marketable fruits under these treatments and the less rate of physiological loss in weight and also retention in qualitative characters of fruit that results in the maximum marketable fruits in process.

Table 1: Effects of post-harvest treatments on physiological loss in weight (%) in Custard apple

Physiological loss in weight (%)					
Notations	**Treatments**	**Storage days**			
		2	4	6	8
T_0	Control	7.15	13.16	17.35	25.66
T_1	Paraffin wax emulsion (8%)	4.42	10.07	15.46	21.43
T_2	Paraffin wax emulsion (10%)	4.34	9.76	14.87	21.11
T_3	Paraffin wax emulsion (12%)	4.12	9.3	14.55	20.87
T_4	Paraffin wax emulsion (8%) + polythene	4.07	7.92	14.09	20.51
T_5	Paraffin wax emulsion (10%) + polythene	3.93	7.76	13.86	19.95
T_6	Paraffin wax emulsion (12%) + polythene	3.94	7.31	13.10	19.46
T_7	Paraffin wax emulsion (8%) +	3.82	7.12	12.26	16.76
T_9	Polythene + KMnO4 (0.01%) Paraffin wax emulsion (12%) +	3.46	6.83	11.74	16.28
	Polythene + KMnO4 (0.01%)				
	SEm±	0.02	0.06	0.09	0.10
	CD at 5%	0.08	0.20	0.29	0.30

Table 2: Effect of post-harvest treatments on retention of marketable fruits (%) of Custard apple

	Retention of marketable fruit (%)				
Notations	**Treatments**	**Storage**			
		2	4	6	8
T_0	Control	91.66	66.88	25.08	0
T_1	Paraffin wax emulsion (8%)	94.44	86.77	58.33	5.55
T_2	Paraffin wax emulsion (10%)	97.22	88.88	66.66	8.35
T_3	Paraffin wax emulsion (12%)	97.22	88.85	75	22.28
T_4	Paraffin wax emulsion (8%) + polythene	100	97.24	83.32	25.03
T_5	Paraffin wax emulsion (10%) + polythene	100	100	86.11	27.94
T_6	Paraffin wax emulsion (12%) + polythene	100	100	88.88	33.33
T_7	Paraffin wax emulsion (8%) +	100	100	94.44	47.22
T_8	Polythene + KMnO4 (0.01%) Paraffin wax emulsion (10%) +	100	100	97.24	80.55
T_9	Polythene + KMnO4 (0.01%) Paraffin wax emulsion (12%) +	100	100	94.44	58.33
	Polythene + KMnO4 (0.01%)				
	SEm±	0.22	0.31	0.59	0.46
	CD at 5%	0.67	0.92	1.75	1.38

Table 3: Effects of post-harvest treatments on retention of unmarketable fruits (%) of custard apple

	Unmarketable fruits (%)				
Notations	**Treatments**		**Storage**	**days**	
		2	4	6	8
T_0	Control	8.33	33.12	74.92	100
T_1	Paraffin wax emulsion (8%)	5.56	13.23	41.67	94.45
T_2	Paraffin wax emulsion (10%)	2.78	11.12	33.33	91.65
T_3	Paraffin wax emulsion (12%)	2.78	2.76	25.66	77.75
T_4	Paraffin wax emulsion (8%) + polythene	0	0	16.68	75.66
T_5	Paraffin wax emulsion (10%) + polythene	0	0	13.88	72.06
T_6	Paraffin wax emulsion (12%) + polythene	0	0	11.12	66.67
T_7	Paraffin wax emulsion (8%) +	0	0	5.56	52.78
T_8	Polythene + KMnO4 (0.01%) Paraffin wax emulsion (10%) +	0	0	2.76	19.45

T_9	Polythene + KMnO4 (0.01%) Paraffin wax emulsion (12%) +	0	0	5.56	41.67
	Polythene + KMnO4 (0.01%)				
	SEm±	0.09	0.23	0.49	0.30
	CD at 5%	0.28	0.68	1.47	0.93

Table 4: Effects of post-harvest treatments marketable fruit retention over control (%) of custard apple

	Marketable fruit retention over control (%)				
Notations	**Treatments**	**Storage days**			
		2	4	6	8
T_0	Control	0	0	0	0
T_1	Paraffin wax emulsion (8%)	2.78	19.89	33.33	5.55
T_2	Paraffin wax emulsion (10%)	5.56	22.00	41.66	8.35
T_3	Paraffin wax emulsion (12%)	5.56	21.97	50.00	22.28
T_4	Paraffin wax emulsion (8%)+ polythene	8.34	30.36	58.33	25.00
T_5	Paraffin wax emulsion (10%) + polythene	8.34	33.12	61.12	27.94
T_6	Paraffin wax emulsion (12%) + polythene	8.34	33.12	63.88	33.33
T_7	Paraffin wax emulsion (8%) +	8.34	33.12	69.44	47.22
T_8	Polythene + KMnO4 (0.01%) Paraffin wax emulsion (10%) +	8.34	33.12	72.24	80.55
T_9	Polythene + KMnO4 (0.01%) Paraffin wax emulsion (12%) +	8.34	33.12	69.44	58.33
	Polythene + KMnO4 (0.01%)				
	SEm±	0.02	0.38	0.50	0.39
	CD at 5%	0.07	1.13	1.50	1.17

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