Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2021; 10(2): 1465-1468
Received: 15-01-2021
Accepted: 21-02-2021

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Effect of different post-harvest parameters on physiological and biochemical parameter of custard apple var. Arka Sahan

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Abstract
The custard apple (*Annona squamosa* L.) fruits were treated with different edible coating like chitosan (0.5%, 1.0% and 1.5%), benzyl adenine (50 ppm, 100 ppm and 150 ppm) and calcium chloride (2.0%, 4.0% and 6.0%) with or without combinations. After that fruits were stored at room temperature. The treated fruits were evaluated for physiological parameters (PLW and volume,) and biochemical parameters (Total Soluble Solids, total sugar, reducing and non reducing sugar and titrable acidity) during storage. The result concluded that the higher combination of treatments (Chitosan 1.5% + BA 150 ppm + $CaCl_2$ 6.0%) was found to be the best for enhanced the shelf life of fruit upto 12 days with good quality and appearance of fruits as compared to control.

Keywords: custard apple (*Annona squamosa* L.), chitosan, benzyl adenine, calcium chloride

Introduction
Custard apple (*Annona squamosa* L.) is one of the important tropical fruit crops belonging to the family Annonaceae which introduced in India from Tropical America. Fruit ripening nature of custard apple is climacteric i.e. sharp rise in respiration after harvest. Custard apple is very high perishable fruit crop with very short life of storage (Wills *et al*. 2001) [17]. The fruit is formed of loosely cohering carpels projecting to squamose or tuberculated surface. Seeds are black covered by white, creamy pulp which is sweet as well pleasant flavoured. (Mahadevbhai and Patel, 2018) [9]. The fruits contain vitamin C and minerals such as calcium, phosphorus and potassium. They are also an excellent source of carbohydrate base energy. Annonas are treated as table consumable fresh fruit because of high perishable in nature due to fruit could not be sent to distant market (Gutierrez *et al*. 1994) [4]. It is also necessary to develop a technology which enables to extend the sugar apple postharvest shelf life, reaching the consumer with good sensory qualities and available at compensatory prices. Among the different methods, fruit coatings are one such alternative as they do not only improve external appearance, but also modify the internal atmosphere of fruits (Trung *et al.* 2011) [17]. Among the different edible coating materials, Chitosan dissolved in diluted organic acids can be used as a casting fluid to form a preservative membranous coating on the fruits that have been successfully used to maintain the quality and shows antifungal activity against several fungi (Trung *et al.* 2011; Li and Yu, 2001) [17, 8], benzyl adenine (antioxidant) acts as antisenescent, stop the metabolic break down deterioration caused by various biochemical activities in the fruits (Bhardwaj *et al.* 2005) [2] and calcium chloride has found promising new technology in maintaining fruit quality during storage, which alternative to disinfestations of fruit and could modify its response to other stresses. (Netravati *et al*. 2018) [11]. An immediate consequence is a raise of the product's price. Hence, it is necessary to develop a technology which enables to extend the custard apple postharvest shelf life, reaching the consumer with good sensory qualities and available at compensatory prices by the application of edible coatings.

Materials and Methods
Custard apple fruits were obtained from a KVK of Chittorgarh, Rajasthan. The full matured fruits were subjected to manual sorting and used for experiment in the laboratory of department of fruit science, college of horticulture in Mandsaur, in plastic crates. The fruits were cleaned with running tap water to remove the adherent dirt material and then spread in room. The fruits were disinfected with 0.1% (w/v) bavistin solution for 2 minutes then fruits were dipped in the coating solutions of chitosan (0.5%, 1.0% and 1.5%), BA (50 ppm, 100 ppm and 150 ppm) and $CaCl_2$ (2.0%, 4.0% and 6.0%), singly or with combinations of treatments. After applications of treatments fruits were kept in the room temperature in plastic

trays. Determination of PLW of fruit determined by using digital balance and fruit volume by displacement of water. The TSS content of fruit was determined by using a digital refractometer, Acidity, Total sugar, reducing and non reducing sugar were determined by the method of Rangana (1996) [12].

Result and Discussion

Physiological parameters

The effect of $CaCl_2$, BA and Chitosan coating at room temperature on rate of changes of physical parameters on the day of 0, 4, 8 and 12 days of storage period respectively. PLW of custard apple was found to increase with the storage period. Significantly lowest physiological loss of weight was recorded in treatment T_{12} (0.00%, 6.26%, 11.94% and 14.31%) on 0, 4, 8 and 12 days of storage life over rest of the treatments. However, it was statistically at par with T_{11} (6.42%, 12.10% and 14.42%) on 4, 8 and 12 days of storage life, respectively and T_9 (6.45% and 12.17%) on 4 and 8 days, respectively. While maximum physiological loss in weight recorded in T_0 (0.00%, 11.41%, 15.40% and 20.61%) on 0, 4, 8 and 12 days of storage period respectively as compared to other all treatments on days of storage period (Table 1). T_{12} ($CaCl_2$ 6.0% + BA 150 ppm + Chitosan 1.5%) exhibited significantly minimum loss of fruit volume (0.00 ml, 2.67 ml, 3.10 ml and 3.60 ml) over rest of the treatments at 0, 4, 8, 12 days of storage period, respectively and it was also observed significantly at par with treatment T_{11} (4.00 ml, 4.44 ml and 4.94 ml) and T_9 (3.33 ml, 3.77 ml and 4.27 ml) at 0, 4, 8, 12 days of storage period, respectively. While the maximum decrease in fruit volume (0.00 ml, 7.67 ml, 8.10 ml and 8.60 ml) was found with treatment T_0 on the days of 0, 4, 8, 12 storage period of life, respectively (Table 1).

This may be due to the combined effect of chitosan, benzyl adenine and calcium chloride. Chitosan provided better way to reduce the evaporation and avoided shrinkage (Medlicott *et al*., 1987) [10]. The maintenance of flesh firmness of chitosan coated fruits might be due to the antifungal activity of chitosan and formation of semi permeable barrier around the fruit surface, thereby reducing infection, gas exchange and other ripening processes during storage (Shiekh, *et al*., 2013) [15]. BA has a free radical and to extinguish property which hinder ethylene biosynthesis, caused retardation of senescence and also reduced the PLW increased storage period in mango (Thokchom and Mandal., 2019). Similar result obtained in mandarin cv. Nagpur Santra (Bhardwaj *et al.,* 2005) [2]. Calcium chloride at higher concentrations served as a semi-permeable membrane around the fruit-surface resulting in reduction in evapo-transpiration and in the rate of respiration (Lal *et al.,* 2011) [7]. The lower microbial growth and weight loss when the combined effect of calcium chloride with chitosan was applied over the mangoes (Chouhan, *et al.*, 2014) [3]. Similar findings also reported by (Abdel *et al*., 2017) [1] on shelf life of peach fruit.

Biochemical Parameters

The biochemical parameters significantly influenced by the application of individual and combination of coatings on fruits during investigation. The effect of $CaCl_2$, BA and Chitosan coating at room temperature on rate of changes of biochemical parameters on the day of 0, 4, 8 and 12 days of storage period respectively. The higher combinations (T_{12} - $CaCl_2$ -6.0% + BA- 150ppm + Chitosan- 1.5%) recorded maximum total soluble solids (0.00 ^{0}B, 3.07 ^{0}B, 5.67 ^{0}B and 1.50 ^{0}B) on 0, 4, 8 and 12 days of storage period, respectively (Table 2). Maximum total sugar (0.00%, 34.95%, 44.28% and 48.28%) maximum reducing sugar (0.00%, 25.28%, 40.28% and 43.95%) and non reducing sugar (0.00%, 31.62%, 43.91% and 45.30%) acidity (0.00%, 42.25%, 45.59% and 46.37%) were observed with the application of higher combination of treatments T_{12} over all the treatment combinations at 4, 8 and 12 days of storage duration respectively. While, lowest total soluble solids (0.00 ^{0}B, 0.75 ^{0}B, 4.36 ^{0}B and 0.07 ^{0}B), on 0, 4, 8 and 12 days of storage period of duration, respectively. Total sugar (25.48%, 34.82% and 38.82%), reducing sugar (15.82%, 30.82% and 32.48%), Non reducing sugar (21.58%, 30.42% and 33.08%), acidity (10.03%, 20.03% and 22.70%) was found with treatment T_0 at 4, 8, 12 days of storage period respectively (Table 2).

The combined effect of chitosan, calcium chloride and benzyl adenine maintain the quality and biochemical parameters due to the changes brought about in total soluble solids of fruits during ripening are mainly due to degradation of starch and accumulation of sugar. Chitosan and calcium chloride coating with combinations improve the quality and shelf life of mango (Chauhan, *et al.,* 2014) [3]. These results are in accordance with the findings of Jholgiker and Reddy (2007) [6] in custard apple and Reddy *et al*., (2014) [14] in guava.

Table 1: Effect of postharvest treatments on physical parameters of custard apple fruits

Symbol	Treatment details	Initial	Physiological loss in weight (%)				Initial	Fruit volume (ml)			
		Value	0 days	4 day	8 day	12 day	Value	0 days	4 day	8 day	12 day
To	Control	109.8	0.00	11.41	15.40	20.61	127.67	0.00	7.67	8.10	8.60
T_1	$CaCl_2$ (2.0%)	197.4	0.00	11.04	14.83	19.52	127.33	0.00	6.33	6.77	7.27
T_2	$CaCl_2$ (4.0%)	147.0	0.00	9.08	14.68	18.62	127.00	0.00	4.50	4.93	5.43
T_3	$CaCl_2$ (6.0%)	103.6	0.00	8.96	13.61	17.42	127.67	0.00	4.00	4.44	4.88
T_4	Benzyl adenine (50 ppm)	159.4	0.00	10.74	14.51	18.21	126.00	0.00	5.67	6.10	7.35
T_5	Benzyl adenine (100 ppm)	103.6	0.00	9.61	13.74	17.19	128.00	0.00	5.00	5.43	5.91
T_6	Benzyl adenine (150 ppm)	125.8	0.00	8.31	13.14	16.35	129.67	0.00	5.00	5.38	5.88
T_7	Chitosan (0.5%)	128.2	0.00	9.03	14.31	17.75	126.00	0.00	6.00	6.43	7.00
T_8	Chitosan (1.0%)	200.2	0.00	7.70	12.98	16.29	129.00	0.00	4.00	4.49	4.99
T_9	Chitosan (1.5%)	145.0	0.00	6.45	12.17	15.44	130.00	0.00	3.33	3.77	4.27
T_{10}	$CaCl_2$ (2.0%) +BA (50 PPM) +Chitosan (0.5%)	148.8	0.00	8.51	13.57	17.46	126.67	0.00	5.67	6.10	6.60
T_{11}	$CaCl_2$ (4.0%) +BA (100 PPM) +Chitosan (1.0%)	131.0	0.00	6.42	12.10	14.42	131.00	0.00	4.00	4.44	4.94
T12	CaCl2 (6.0%) +BA (150 PPM) +Chitosan (1.5%)	130.0	0.00	6.26	11.94	14.31	132.33	0.00	2.67	3.10	3.60
	SEm±		0.00	0.11	0.10	0.10		0.00	0.46	0.46	0.43
	CD at 5%		0.00	0.32	0.28	0.29		0.00	1.35	1.34	1.26

Table 2: Effect of postharvest treatments on Biochemical parameters of custard apple fruits

Symbol	Treatment details	Initial	TSS (^{0}B)				Initial	Total sugar (%)				Initial	Reducing sugar (%)			
		Value	0 days	4 day	8 day	12 day	Value	0 days	4 day	8 day	12 day	Value	0 days	4 day	8 day	12 day
To	Control	18.56	0.00	0.75	4.36	0.07	10.16	0.00	25.48	34.82	38.88	6.77	0.00	15.82	30.82	32.48
T_1	$CaCl_2$ (2.0%)	19.54	0.00	0.94	4.52	0.18	10.28	0.00	26.03	35.37	39.57	6.80	0.00	16.37	31.37	35.03
T_2	$CaCl_2$ (4.0%)	19.64	0.00	1.07	5.23	0.96	10.42	0.00	27.97	37.30	41.37	6.92	0.00	18.30	33.30	36.97
T_3	$CaCl_2$ (6.0%)	20.03	0.00	2.08	5.42	1.12	11.50	0.00	29.68	39.01	43.11	6.94	0.00	20.01	35.01	38.68
T_4	Benzyl adenine (50 ppm)	19.55	0.00	0.97	4.90	0.66	10.43	0.00	27.31	36.64	40.68	6.92	0.00	17.64	32.64	36.31
T_5	Benzyl adenine (100 ppm)	20.11	0.00	1.60	5.26	1.07	10.71	0.00	28.42	37.75	41.82	6.97	0.00	18.75	33.75	37.42
T_6	Benzyl adenine (150 ppm)	20.68	0.00	2.30	5.44	1.32	11.56	0.00	28.77	38.10	42.17	6.97	0.00	19.10	34.10	37.77
T_7	Chitosan (0.5%)	19.73	0.00	0.99	4.96	0.92	10.45	0.00	27.54	36.87	40.94	6.93	0.00	17.87	32.87	36.54
T_8	Chitosan (1.0%)	20.86	0.00	1.78	5.39	1.11	11.52	0.00	28.68	38.01	42.08	6.99	0.00	19.01	34.01	37.68
T_9	Chitosan (1.5%)	20.98	0.00	2.92	5.53	1.40	11.64	0.00	30.91	40.24	44.31	7.02	0.00	21.24	36.24	39.91
T_{10}	$CaCl_2$ (2.0%) +BA (50 PPM) +Chitosan (0.5%)	21.02	0.00	2.99	5.55	1.38	11.90	0.00	29.32	38.65	42.75	7.24	0.00	19.65	34.65	38.32
T_{11}	$CaCl_2$ (4.0%) +BA (100 PPM) +Chitosan (1.0%)	21.21	0.00	3.05	5.60	1.42	12.31	0.00	32.08	41.41	45.48	7.44	0.00	22.41	37.41	41.08
T_{12}	$CaCl_2$ (6.0%) +BA (150 PPM) +Chitosan (1.5%)	21.73	0.00	3.07	5.67	1.50	12.70	0.00	34.95	44.28	48.35	7.64	0.00	25.28	40.28	43.95
	SEm±		0.00	0.32	0.14	0.16		0.00	0.19	0.33	0.34		0.00	0.58	0.58	1.01
	CD at 5%		0.00	0.94	0.41	0.47		0.00	0.56	0.97	0.98		0.00	1.70	1.70	2.93

Table 3: Effect of postharvest treatments on biochemical parameters of custard apple fruits

Symbol	Treatment details	Initial Value	Non reducing Sugar (%)				Initial Value	Acidity (%)			
			0 days	4 day	8 day	12 day		0 days	4 day	8 day	12 day
To	Control	3.40	0.00	21.58	30.42	33.08	0.00	6.55	7.06	5.60	0.00
T_1	$CaCl_2$ (2.0%)	3.47	0.00	23.52	32.40	36.26	0.00	6.55	7.06	5.60	0.00
T_2	$CaCl_2$ (4.0%)	3.49	0.00	24.64	34.63	38.29	0.00	6.55	7.06	5.60	0.00
T_3	$CaCl_2$ (6.0%)	4.56	0.00	26.35	35.68	40.01	0.00	6.55	7.06	5.60	0.00
T_4	Benzyl adenine (50 ppm)	3.51	0.00	23.98	33.98	37.64	0.00	6.55	7.06	5.60	0.00
T_5	Benzyl adenine (100 ppm)	3.74	0.00	24.99	35.41	38.75	0.00	6.55	7.06	5.60	0.00
T_6	Benzyl adenine (150 ppm)	4.59	0.00	25.44	35.55	39.10	0.00	6.55	7.06	5.60	0.00
T_7	Chitosan (0.5%)	3.52	0.00	24.54	33.93	37.87	0.00	6.55	7.06	5.60	0.00
T_8	Chitosan (1.0%)	4.52	0.00	25.68	35.34	37.34	0.00	6.55	7.06	5.60	0.00
T_9	Chitosan (1.5%)	4.62	0.00	27.58	38.58	41.35	0.00	6.55	7.06	5.60	0.00
T_{10}	$CaCl_2$ (2.0%) +BA (50 PPM) +Chitosan (0.5%)	4.66	0.00	25.99	36.21	39.68	0.00	6.55	7.06	5.60	0.00
T_{11}	$CaCl_2$ (4.0%) +BA (100 PPM) +Chitosan (1.0%)	4.87	0.00	28.75	39.15	42.41	0.00	6.55	7.06	5.60	0.00
T_{12}	$CaCl_2$ (6.0%) +BA (150 PPM) +Chitosan (1.5%)	5.06	0.00	31.62	43.91	45.30	0.00	6.55	7.06	5.60	0.00
	SEm±		0.00	1.51	1.15	1.06	0.00	6.55	7.06	5.60	0.00
	CD at 5%		0.00	4.38	3.35	3.09	0.00	6.55	7.06	5.60	0.00

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