International Journal of Agricultural Sciences
Volume 13 | Issue 2 | June, 2017 | 371-377 ■ e ISSN-0976-5670
DOI:10.15740/HAS/IJAS/13.2/371-377
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RESEARCH PAPER

Effect of preharvest application of chemicals and plant growth regulators on physical parameters and shelf-life of custard apple (*Annona squamosa* L.)

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Abstract : The three varieties of custard apple were subjected to various preharvest chemicals and plant growth regulators treatments, *viz.*, $CaCl_2$ @ 2 %, KNO_3 @ 2 %, GA_3 @ 50 mg/l, NAA @ 50 mg/l and no spray. Then mature, uniformed sizes fruit were harvested and observation were recorded under ambient storage condition. Balanagar recorded maximum fruit weight (180.32 g), volume (109.42 cc) and pulp weight per fruit (90.52 g) while minimum peel weight per fruit (53.87 g) and seed weight per fruit (10.43 g) recorded in Local variety at harvest. GA_3 @ 50 mg/l were found to best since they have maximum fruit weight (159.60 g), volume (96.85 cc) and pulp weight per fruit (79.54 g) at harvest. In case of fruit diameter (7.39 cm, 7.09 cm) in both factors were recorded maximum at 3rd day of storage. $CaCl_2$ @ 2 % recorded minimum PLW (23.54 % at 6th day) and spoilage percentage (32.22 %) and maximum fruit firmness (0.25 kg/cm^2 at 6th day), shelf-life of fruits (7.25 days) and marketable fruit percentage (67.78 %) during storage. Thus, it can be inferred from the study that Balanagar variety and GA_3 @ 50 mg/l rated as most acceptable and superior, over all the other treatments in term of physical parameters and in term of quality and shelf-life $CaCl_2$ @ 2 % treatment observed during ambient storage.

Key Words : Calcium chloride, Potassium nitrate, NAA, GA_3, Physical parameters, shelf-life

View Point Article : Bagul, A.A. and Masu, M.M. (2017). Effect of preharvest application of chemicals and plant growth regulators on physical parameters and shelf-life of custard apple (*Annona squamosa* L.). *Internat. J. agric. Sci.*, **13** (2) : 371-377, **DOI:10.15740/HAS/IJAS/13.2/371-377.**

Article History : Received : 03.02.2017**; Revised :** 02.05.2017**; Accepted :** 17.05.2017

INTRODUCTION

Custard apple is hardy in nature which require dry climate with mild winter. Moreover, the area under custard apple cultivation is increasing day by day in the State. The mature fruits after harvest ripen quickly and become excessively soft at ambient condition and become unfit for consumption. Therefore, the increase in shelf life of custard apple fruit will be an advantage to the growers (Gohlani and Bisen, 2012). Chemicals and plant growth regulator are very essential substances for increased the physical parameters and shelf-life of fruit. Among various chemicals, calcium is known to be essential plant nutrient involved in a number of physiological processes concerning membrane structure,

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function and enzyme activity (Jones and Lunt, 1970). Whereas, among the various plant growth regulators, gibberellic acid in proper concentration and application at appropriate time enhance the setting and retention of fruits, increase the yield, improve the physical and chemical characteristics and extend the shelf-life of fruits. Now-a-day, plant growth regulators are given considerable importance for their value in regulating the various growth and development process in plant. They are useful in increasing the size and thereby increase the fruit yield and also improved quality of fruits. Use of plant growth regulators has become more popular in increasing the yield and quality particularly in horticultural crops. The various chemicals and plant growth regulators also decrease the physiological loss in weight and increase the shelf-life through delaying ripening process, increase in firmness, reduced respiration, reducing the incidence of physiological disorder and storage rots. The main objective of present investigation was find out the preharvest effect of $CaCl_2$, KNO_3, GA_3 and NAA at specific concentrations on some physical and biochemical parameters of custard apple fruits.

MATERIAL AND METHODS

The investigation was conducted at Horticultural Research Farm and P.G. Laboratory, Department of Horticulture, B.A. College of Agriculture, Anand Agricultural University, Anand, during *Kharif-Rabi* of the year 2015. There were fifteen treatments embedded in Completely Randomized Design with factorial concept replicated thrice. Fifteen uniform size tree of each variety of custard apple were selected and sprayed with different chemicals ($CaCl_2$ @ 2% and KNO_3 @ 2 %) and different level of plant growth regulators (GA_3 @ 50 mg /l and NAA @ 50 mg /l) and no spray at fifteenth days before harvest. The details of the treatments applied in the present investigation were T_1: Balanagar + $CaCl_2$ @ 2 %, T_2: Balanagar + KNO_3 @ 2 %, T_3: Balanagar + GA_3 @ 50 mg/l, T_4: Balanagar + NAA @ 50 mg/l, T_5: Balanagar + no spray, T_6: Sindhan + $CaCl_2$ @ 2 %, T_7: Sindhan + KNO_3 @ 2 %, T_8: Sindhan + GA_3 @ 50 mg/ l, T_9: Sindhan + NAA @ 50 mg/l, T_{10}: Sindhan + no spray, T_{11}: Local + $CaCl_2$ @ 2 %, T_{12}: Local + KNO_3 @ 2 %, T_{13} : Local + GA_3 @ 50 mg/l, T_{14}: Local + NAA @ 50 mg/l, T_{15}: Local + no spray.

The mature and uniform sized fruits were harvested from the representative trees and kept in ambient storage condition where observations were recorded regarding the physical parameters of fruits. Data were recorded periodically and analyzed statistically following the Complete Randomized Design as outlined by Panse and Sukhatme (1967). Fruit weight, pulp weight per fruit, peel weight per fruit, seed weight per fruit was recorded by electrical weight balance in gram, fruit diameter by digital vernier calipers in cm, fruit volume by water displacement method in cc and the observations were recorded at harvest to 6th day of storage (Madhavi *et al.,* 2005 and Vijayalakshmi *et al.,* 2004).

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Physical parameters :

The results obtained from the present investigation indicated that, preharvest treatments of various chemicals and PGRs influenced on the physical characteristics of custard apple fruit under ambient storage condition and presented in Table 1 to 4.

Balanagar variety registered significantly highest fruit weight at harvest upto fully ripening stage under ambient storage condition as compared to other varieties. These might be due to genetical difference among the varieties. Similar, results were reported by Rao and Subramanyam (2011) in custard apple and Ulemale and Tambe (2015) in guava. The fruits preharvest sprayed with GA_3 @ 50 mg/l retained significantly highest fruit weight (159.60 g) at harvest as compared to other treatments. It might be due to gibberellic acid promotes the cell elongation and cell enlargement of fruit. Similar result was also reported by Jagtap *et al.* (2013) in Kagzi lime, Kumar and Sharma (2016) in grape and Lal *et al.* (2013) in guava. This was gradually decreased during storage period upto 6th day and significantly maximum fruit weight (114.11 g) was reported with $CaCl_2$ @ 2 % treatment at fully ripening stage. It might be due to minimum loss of moisture in fruit and maintenance of firmness of fruit by calcium which decreased the enzyme activity responsible for disintegration of cellular structure and decreased the gaseous exchange. The present investigation is in conformity with result reported by Kirmani *et al.* (2013) in plum and Jayachandran *et al.* (2005) in guava.

The fruit volume were recorded significantly maximum in Balanagar variety at harvest upto fully

ripening stage under ambient storage condition. A similar view was also shared by Patidar *et al.* (2012) in guava. The fruit volume then gradually decreased upto fully ripening stage under the ambient storage condition. The decreased fruit volume during storage period may be due to the shrinking of fruit due to transpiration (Kirmani *et al.,* 2013). The plants of custard apple were preharvest sprayed with GA_3 @ 50 mg/l reported significantly highest fruit volume (96.85 cc) at harvest as compared to no spray treatment which was gradually decreased but remain significantly highest (70.35 cc) at 6th day with $CaCl_2$ @ 2 % treatment under the ambient storage condition. It might be due to calcium decreased the loss of weight by maintenance of the fruit firmness, retardation of respiratory rate and delayed senescence (Yadav and Shukla, 2009). Increase volume of fruit with GA_3 sprays were possibly due to accelerated rate of fruit growth. Exogenous application of GA_3 promoted cell enlargement and cell division. The present investigation is in conformity with the result reported by Singh *et al.* (2009) and Katiyar (2008) in guava.

The fruit diameter was reported significantly maximum in Balanagar variety at harvest upto fully ripening stage under ambient storage condition. Similar view was also shared by Singh *et al.* (2013) in guava. The plants of custard apple were preharvest sprayed with GA_3 @ 50 mg/l recorded significantly highest fruit diameter at harvest upto fully ripening stage as compared to other treatments. This might be due to compounds of gibberellic acid promotes the cell elongation and cell enlargement of fruit (Jagtap *et al.,* 2013).

The firmness of fruits decreased during the storage. The fruit firmness of different varieties of custard apple was recorded non-significant at harvest upto full ripening stage under the ambient storage condition. The preharvest treatment with $CaCl_2$ @ 2 % showed the highest fruit firmness as compared to no spray treatment during 3rd day (4.20 kg/cm^2), 4th day (1.50 kg/cm^2), 5th day (0.59 kg/cm^2) and 6th day (0.25 kg/cm^2) in custard apple fruit while showed non-significant effect during 1st, 2nd and 3rd day under ambient storage condition. Preharvest sprays with $CaCl_2$ retained highest firmness. It was probably due to added calcium in peel and pulp which helped to maintain the structure and function of cell wall (Ramkrishna *et al.*, 2001). Similar view also reported by Saran *et al.* (2004) in ber and Vandana *et al.* (2015) in Jamun.

The physiological loss in weight of custard apple

Table 1: Effect of different varieties and preharvest application of chemicals and PGRs on fruit weight and fruit volume (cc) of custard apple

Treatments	Fruit weight (g)							Fruit volume (cc)						
	At harvest	1st day	2nd day	3rd day	4th day	5th day	6th day	At harvest	1st day	2nd day	3rd day	4th day	5th day	6th day
Varieties														
V_1	180.32	176.60	172.89	169.35	153.45	145.96	131.43	109.42	107.17	104.92	102.77	93.12	88.57	79.76
V_2	136.67	133.63	130.89	128.42	115.29	109.85	99.21	82.94	81.09	79.43	77.63	69.96	66.66	60.20
V_3	128.26	125.53	122.90	120.20	108.34	103.13	90.69	77.83	76.18	74.58	72.95	65.74	62.58	55.03
S.E. ±	3.34	3.27	3.21	3.13	2.86	2.87	2.72	2.02	1.98	1.95	1.90	1.73	1.74	1.65
C.D. (P=0.05)	9.65	9.44	9.26	9.06	8.25	8.29	7.85	5.86	5.73	5.62	5.50	5.00	5.03	4.77
Chemicals and PGRs														
C_1	151.46	148.53	146.74	144.53	135.61	126.70	115.93	91.91	90.14	89.04	87.51	82.30	76.89	70.35
C_2	146.29	143.36	141.45	138.72	127.98	121.47	110.02	88.77	86.99	85.84	84.18	77.66	73.71	66.77
C_3	159.60	156.19	152.57	148.68	133.72	128.24	114.11	96.85	94.78	92.58	90.22	81.15	77.82	69.25
C_4	148.37	145.17	141.49	138.31	123.56	119.40	107.38	90.03	88.10	85.86	83.93	74.98	72.46	65.16
C_5	136.35	133.00	128.89	126.41	107.60	102.41	88.10	82.74	80.71	78.22	76.71	65.30	62.14	53.46
S.E. ±	4.32	4.22	4.14	4.05	3.69	3.71	3.51	2.62	2.56	2.51	2.46	2.24	2.25	2.13
C.D. (P=0.05)	12.46	12.19	11.65	11.95	10.65	10.71	10.14	7.56	7.39	7.25	7.10	6.46	6.50	6.15
Interaction (V x C)														
S.E.±	7.47	7.31	7.17	7.01	6.39	6.42	6.08	4.54	4.43	4.35	4.26	3.87	3.90	3.69
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	8.72	8.72	8.73	8.73	8.80	9.30	9.83	8.72	8.72	8.73	8.73	8.80	9.30	9.83

Note:- V_1- Balanagar, V_2- Sindhan, V_3- Local, C_1- $CaCl_2$ @ 2%, C_2- KNO_3 @ 2%, C_3-GA_3 50 mg/l, C_4-NAA 50 mg/l and C_5-No spray NS= Non-significant

fruit increased at harvest upto fully ripening stage. The lowest physiological loss in weight was recorded in Balanagar variety during 1st day (2.07 %) as compared to another varieties whereas, the physiological loss in weight during the 2nd day upto 6th day observed non-significant effect in three varieties of custard apple under ambient storage condition. In present investigation, the fruits preharvest spray with $CaCl_2$ @ 2 % recorded lowest physiological loss in weight during 1st day upto 6th day as compared to no spray treatment under ambient storage condition. The decreased in weight loss by application of calcium might be due to its role in the maintenance of the fruit firmness, retardation of respiratory rate and delayed senescence (Yadav and Shukla, 2009). Similar view was also reported by Ramkrishna *et al.* (2001) in papaya and Kirmani *et al.* (2013) in plum.

The pulp weight per fruit was recorded significantly highest in the Balanagar variety at harvest (90.52 g) and fully ripening stage (48.34 g) under ambient storage condition. This might be due to fruit weight of Balanagar was highest as compared to other varieties. Similar results were reported by Rao and Subramanyam (2011) in custard apple and Chaudhary *et al.* (2012) in guava. The plants of custard apple were preharvest sprayed with GA_3 @ 50 mg/l reported significantly highest pulp weight per fruit (79.54 g) at harvest while, $CaCl_2$ @ 2 % treatment treatment recorded highest pulp weight per fruit (46.85 g) at fully ripening stage as compared to no spray treatment under ambient storage condition. The increased in pulp weight might be due to accumulation of more water and food substances in the aril along with increase in size of cell and intercellular space reported by Brahmachari and Rani (2000) in litchi fruits. Calcium applications had been known to be effective in membrane functionality and intergrity maintenance which may be the reason for the lower weight loss found in calcium treated fruits reported by Karemera and Habimana (2014) in mango.

The peel weight per fruit was observed lowest in Local variety at harvest (53.87 g) and at fully ripening stage (49.48 g). It might be due to fruit weight of Local variety was lowest as compared to Balanagar and Sindhan varieties of custard apple. Similar view was also observed by Rao and Subramanyam (2011) in custard apple. The peel weight decreased during the storage might be due loss of water by transpiration from the peel. The effect of chemicals and plant growth regulators was

Table 2 : Effect of different varieties and preharvest application of chemicals and PGRs on fruit diameter (cm) and fruit firmness (kg/cm^2) of custard apple

Treatments	Fruit diameter (cm)							Fruit firmness (kg/cm^2)						
	At harvest	1st day	2nd day	3rd day	4th day	5th day	6th day	At harvest	1st day	2nd day	3rd day	4th day	5th day	6th day
Varieties														
V_1	7.27	7.33	7.38	7.39	7.38	7.33	7.30	18.19	14.58	11.40	3.59	1.21	0.50	0.19
V_2	6.44	6.50	6.73	6.74	6.73	6.70	6.88	18.14	14.43	11.30	3.47	1.20	0.50	0.18
V_3	6.27	6.32	6.34	6.36	6.35	6.32	6.27	18.23	14.66	11.19	3.41	1.16	0.49	0.18
S.E. ±	0.14	0.15	0.15	0.15	0.15	0.15	0.14	0.31	0.22	0.12	0.09	0.03	0.02	0.003
C.D. (P=0.05)	0.39	0.43	0.43	0.43	0.42	0.43	0.42	NS	NS	NS	NS	NS	NS	NS
Chemicals and PGRs														
C_1	6.66	6.71	7.08	7.09	7.08	7.05	7.01	18.58	15.04	11.68	4.20	1.50	0.59	0.25
C_2	6.58	6.64	6.68	6.69	6.68	6.65	6.96	18.10	14.33	11.12	3.31	1.29	0.57	0.19
C_3	7.15	7.19	7.22	7.23	7.22	7.18	7.17	18.11	14.39	11.38	3.47	1.36	0.57	0.20
C_4	6.60	6.65	6.69	6.70	6.69	6.66	6.63	18.07	14.68	11.29	3.38	1.30	0.56	0.18
C_5	6.32	6.38	6.43	6.45	6.43	6.38	6.30	18.07	14.35	10.99	3.10	0.51	0.20	0.004
S.E. ±	0.17	0.19	0.19	0.19	0.19	0.19	0.17	0.40	0.28	0.16	0.11	0.04	0.01	0.01
C.D. (P=0.05)	0.50	NS	0.55	0.55	0.55	0.56	0.54	NS	NS	NS	0.33	0.11	0.03	0.01
Interaction (V x C)														
S.E. ±	0.30	0.33	0.33	0.33	0.33	0.33	0.32	0.69	0.49	0.28	0.19	0.07	0.01	0.007
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	0.02
C.V. %	7.84	8.53	8.40	8.43	8.40	8.52	8.19	6.58	5.77	4.27	9.69	8.77	5.53	6.97

Note:- V_1- Balanagar, V_2- Sindhan, V_3- Local, C_1- $CaCl_2$ @ 2%, C_2- KNO_3 @ 2 %, C_3- GA_3 50 mg/l, C_4- NAA 50 mg/l and C_5- No spray
NS= Non-significant

Table 3 : Effect of different varieties and preharvest application of chemicals and PGRs on physiological loss in weight (%) of custard apple

Treatments	Physiological loss in weight (%)					
	1st day	2nd day	3rd day	4th day	5th day	6th day
Varieties						
V_1	2.07	4.15	6.11	15.05	19.17	27.30
V_2	2.22	4.22	6.02	15.63	19.69	27.52
V_3	2.13	4.20	6.28	15.62	19.67	29.38
S.E.±	0.04	0.08	0.12	0.35	0.61	0.72
C.D. (P=0.05)	0.12	NS	NS	NS	NS	NS
Chemicals and PGRs						
C_1	1.94	3.13	4.59	10.51	16.44	23.54
C_2	2.01	3.30	5.17	12.54	16.96	24.90
C_3	2.14	4.39	6.84	16.24	19.52	28.52
C_4	2.17	4.64	6.77	16.74	19.56	27.80
C_5	2.45	5.49	7.30	21.14	25.08	35.58
S.E. ±	0.05	0.10	0.16	0.46	0.78	0.94
C.D. (P=0.05)	0.15	0.31	0.46	1.31	2.26	2.70
Interaction (V x C)						
S.E.±	0.09	018	0.28	0.79	1.36	1.62
C.D.(P=0.05)	NS	NS	NS	NS	NS	NS
C.V. %	7.63	7.92	7.85	8.84	12.05	10.00

Note:- V_1- Balanagar, V_2- Sindhan, V_3- Local, C_1- $CaCl_2$ @ 2%, C_2- KNO_3 @ 2 %, C_3- GA_3 50 mg/l, C_4- NAA 50 mg/l and C_5- No spray
NS= Non-significant

Table 4 : Effect of different varieties and preharvest application of various chemicals and PGRs on custard apple fruit

Treatments	Pulp weight per fruit (g)		Peel weight per fruit (g)		Seed weight per fruit (g)		Marketable fruits (%)	Spoilage (%)	Shelf-life (Days)
	At harvest	At fully ripening stage	At harvest	At fully ripening stage	At harvest	At fully ripening stage			
Varieties									
V_1	90.52	48.34	74.81	68.72	14.67	14.36	63.33	36.67	6.59
V_2	67.58	36.25	56.70	52.08	11.12	10.87	62.67	37.33	6.53
V_3	64.50	30.99	53.87	49.48	10.43	10.21	60.67	39.33	6.47
S.E. ±	1.58	1.35	1.48	1.35	0.29	0.28	1.44	1.44	0.10
C.D. (P=0.05)	4.56	3.91	4.26	3.91	0.83	0.82	NS	NS	NS
Chemicals and PGRs									
C_1	75.46	46.85	62.92	57.80	12.29	12.05	67.78	32.22	7.25
C_2	74.08	42.30	61.01	56.04	11.92	11.68	63.33	36.67	6.64
C_3	79.54	40.97	65.91	60.55	12.88	12.59	65.56	34.44	6.97
C_4	74.49	38.82	61.77	56.74	12.07	11.81	63.33	36.67	6.79
C_5 : No spray	67.44	24.47	57.35	52.69	11.20	10.95	51.11	48.89	5.00
S.E. ±	2.04	1.75	1.90	1.75	0.37	0.37	1.86	1.86	0.13
C.D. (P=0.05)	5.89	5.05	NS	NS	NS	NS	5.37	5.37	0.36
Interaction effect (V x C)									
S.E. ±	3.53	3.02	3.30	3.03	0.64	0.63	3.22	3.22	0.22
C.D. (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
C.V. %	8.25	13.62	9.24	9.24	9.24	9.31	8.96	14.76	5.78

Note:- V_1- Balanagar, V_2- Sindhan, V_3- Local, C_1- $CaCl_2$ @ 2%, C_2- KNO_3 @ 2 %, C_3- GA_3 50 mg/l, C_4- NAA 50 mg/l and C_5- No spray
NS= Non-significant

found non-significant on peel weight per fruit at harvest and fully ripening stage under ambient storage condition.

The seed weight per fruit was observed lowest in Local variety at harvest (10.43 g) and fully ripening stage (10.21 g) as compared to other varieties of custard apple under ambient storage condition. It may be due to smaller size of fruit of Local variety as compared to Balanagar and Sindhan varieties. Similar view was also shared by Rao and Subramanyam (2011) in custard apple. The preharvest effect of chemicals and plant growth regulators was found non-significant on seed weight per fruit at harvest and fully ripening stage under ambient storage condition.

The result indicates non-significant effect on marketable fruits (%) by different varieties of custard apple. The preharvest applications of $CaCl_2$ @ 2 % recorded significantly highest marketable fruit (67.78 %) as compared to other treatments under ambient storage condition. It might be due to calcium decrease the spoiling of fruit by reduction in process of respiration whereas, the calcium plays number of roles such as an increase the fruit firmness which leads benefits like slower ripening and increased the shelf-life (Karemera and Habimana, 2014).

The result indicates non-significant effect on spoilage percentage of fruits by different varieties of custard apple. The custard apple plants were preharvest sprayed with $CaCl_2$ @ 2 % found significantly lowest spoilage (32.22 %) as compared to no spray treatment under ambient storage condition. It might be due to calcium compounds significantly thickened the middle lamella of fruit cells owing to increased deposition of calcium pectate and thereby maintained the cell wall rigidity which inhibits the penetration and spread of pathogens in fruits (Gupta *et al.*, 1987). These results are in accordance with the findings of Vandana *et al.* (2015) in Jamun, Jawandha *et al.* (2007) and Yadav and Shukla (2009) in ber.

The result indicates non-significant effect on shelf-life of fruits by different varieties of custard apple. The shelf-life of custard apple fruits was significantly extended when trees were preharvest sprayed with $CaCl_2$ @ 2 % (7.25 days) as compared to no spray treatment under ambient storage condition. It might be due to the calcium plays number of roles such as an increase the fruit firmness which leads benefits like slower ripening and increased the shelf-life. The present investigation is in conformity with the results reported by Karemera and Habimana (2014) in mango.

The interaction effect between different varieties and preharvest application of various chemicals and plant growth regulators were found non-significant on fruit weight, fruit volume, fruit diameter, fruit firmness, physiological loss in weight, pulp weight per fruit, peel weight per fruit, seed weight per fruit, shelf-life of fruits, marketable fruits (%) and spoilage (%) under ambient storage condition.

On the basis of finding of the present investigation, it can be concluded that among the different varieties, Balanagar whereas, among various preharvest treatments of chemicals and PGRs, GA_3 @ 50 mg/l treatment found significantly highest the fruit weight, fruit volume, fruit diameter, pulp weight per fruit of custard apple. While, $CaCl_2$ @ 2 % was effective and found promising for increasing fruit firmness, shelf-life and marketable fruits by the reducing physiological loss in weight and spoilage of fruits.

Acknowledgment:

The authors extended thanks to Head, Department of Horticulture, B.A. College of Agriculture, Anand Agricultural University, Anand for providing necessary facilities for conducting the research work.

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