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Effect of Antioxidants and Polyamines on Physical Parameters of Sapota [*Manilkara achras* (Mill) Fosberg] cv. Kalipatti

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Abstract

The present investigation was carried out at PG laboratory in College of Horticulture, Rajendranagar during 2016-2017 and 2017-2018. The experiment was carried out in Completely Randomized Design with three replications. The physical parameters like physiological loss in weight (PLW), number of days for ripening, firmness, ripening percentage, shelf life, and spoilage were estimated. PLW, firmness and spoilage were estimated at 3 days interval during ripening. The data on physical parameters showed that there was significant influence of post harvest application of antioxidants and polyamines on shelf-life of sapota. Fruits treated with BA @ 100 ppm (T_2) recorded lower PLW (17.76%), maximum number of days for ripening (8.50 days), and minimum spoilage where as shelf life (12.17 days) and firmness (1.95 kg cm^{-2}), were higher in BA @ 100 ppm (T_2) treated fruits during both the years and in pooled data respectively.

Keywords: Antioxidants, Benzyl Adenine, Physiological loss in weight, Polyamines, Shelf life

Introduction

Sapota [*Manilkara achras* (mill) Fosberg] belongs to the family sapotaceae and is native to Mexico in tropical (central) America. It is one of the most adaptable tropical fruits. Considering the existing plantation and future scope for the cultivation, it is highly essential to study postharvest aspects of this crop, since only scanty work on these is reported so far. Though sapota cultivation has gained area in the past couple of decades, postharvest losses due to spoilage are very high as there is lack of adequate postharvest handling facilities and proper infrastructure. All these lead to economic loss to growers, traders, processors and finally consumers.

High perishability coupled with short storage life are the areas which need lot of attention. Spoilage in sapota fruits in storage is mainly due to damage during harvest, postharvest handling and transport, lack of improved storage facilities in the production areas, fungal infections and fast senescence.

The postharvest losses can be minimized by harvesting fruits at proper maturity, postharvest handling practices. The major aim of postharvest technology is to optimize quality and reduce the losses during unit operations by adopting the emerging technologies which reduces spoilage and increase shelf life of fruits. To meet out the satisfactory results, several researchers applied some technologies to induce shelf life and maximize the quality of fresh fruits. These include postharvest application of antioxidants and polyamines.

Antioxidants are chemicals which prevent the damage of tissues by scavenging free radicals produced during ripening and there by extend the shelf life of fruits (Reddy *et al*., 2014).

Recently it was reviewed that the influence of ascorbic acid application on quality and storage life of fruits with a

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conclusion that ascorbic acid (AA) was helpful in retaining fruit colour and exhibited ultimately light yellow green colour at the end of storage period (Singh and Mirza, 2018). Its application maintained significantly higher firmness, enhancement in consumer acceptability and reduction in post-harvest losses in weight along with satisfactory organoleptic rating, but without significant effect on fruit spoilage. Antioxidants (AOX) at 2% exhibited advanced level of acidity and recorded maximum Vitamin-C content and higher total sugars.

Treated fruits of guava cv. Allahabad safeda with AA 1000 ppm (Gill *et al*., 2014) and fruits treated with AA 1% showed less PLW in Peach (El-Shazy *et al*., 2013), in Ber (Siddiqui and Gupta, 1995). It was observed that the average PLW decreased by boosting the concentration of AA in guava (Gill *et al*., 2014). Treatment with AA 100 ppm at low temperature storage decreased PLW in Ber (Banik *et al*., 1988a).

The application of AA was very effective in reducing fruit weight loss, microbial growth and colour changes in treated fruits of mango (Pythme *et al.*, 2009).

It was reported that AA treatments significantly reduced the post-harvest spoilage of treated fruits and extended shelf life of the guava fruits (Jayachandran *et al*., 2007). AA protected fruits against harmful effects of oxidative processes and biotic stresses, that might prevent softening and rotting of fruits (Poliyanth *et al*., 2008). Ascorbic acid 100 ppm showed least decay in guava (Gill *et al*., 2014). Least spoilage was reported in ber fruits when AA was applied (Siddiqui and Gupta, 1989; Banik *et al*., 1998).

Guava fruits treated with antioxidants like BA 100 ppm recorded lower PLW, highest firmness, maximum TSS, brix to acid ratio and ascorbic acid content, lowest acidity, higher reducing and total sugars compared to untreated fruits (Reddy *et al*., 2014). Jayachandran *et al*. (2007) observed that the guava fruits treated with benzyl adenine (50 ppm) recorded the highest firmness (4.03 kg cm^{-2}) over the control (1.93 kg cm^{-2}), longest shelf life of 14.0 days (50 ppm) and 13.33 days (25 ppm) over control (7 days), highest reducing sugars and minimum acidity over control (0.73%).

Polyamines (PAS are low molecular weight, small aliphatic amines that are produced endogenously in plants (Galston, 1983). The important polyamines are putrescine (PUT), spermidine (SPD and spermine (SPM) (Kakkar and Rai, 1993). Polyamines play important role in many plants physiological process such as cell growth, development and responses to environmental stresses (Ferriera *et al*., 2008). Many studies have shown that polyamines could delay senescence of plant tissues by inhibiting ethylene biosynthesis and there by improved postharvest life of several fruits (Khan *et al*., 2007). Polyamines enhance the shelf life of fruits by reducing respiration rate, ethylene production, release, enhance firmness and quality attributes in fruits (Sharma *et al*., 2017).

Post harvest treatment with polyamines helped to maintain firmness in plum (Khan and Singh, 2008). Exogenous application of polyamines improved shelf life of mango without having deleterious effect on fruit quality (Malik *et al*., 2006).

Polyamines showed best results in extending the shelf life of Kiwi fruits when stored in ambient condition (Jhalegar *et al*., 2012). It was observed that exogenous application of 1 mm putrescine delayed changes in physico-chemical qualities of banana fruit, physiological weight loss, fruit firmness, respiration rate, colour changes, pulp to peel ratio, accumulation of soluble solid content and acidity. Hence, it was suggested to use putrescine to delay ripening, senescence and ultimately to increase its shelf life (Archana *et al*., 2015).

Storage life of mango fruits was extended to 3 weeks in polyamine treated mango fruits, whereas 2 weeks in control under refrigerated condition (Bhat *et al*., 2014).

However, use of polyamines have not been tried for regulating the ripening of sapota fruits which is required. Keeping all this in view, present investigation is designed and proposed to study the effect of post-harvest treatments along with the use of antioxidants, polyamines on physical parameters of sapota fruits.

Materials and Methods

The experiment was carried out in PG lab in College of Horticulture, Rajendranagar during 2016-2017 and 2017-2018. The experiment was laid out in completely randomized design with three replications and seven treatments. The sapota fruits were harvested at mature stage and were dipped in three different antioxidants (Ascorbic acid, Benzyl adenine and sodium benzoate) concentrations, three different polyamine (Putrescine, spermine and spermidine) concentrations as post-harvest treatments *viz*., T_0: Control (without packing), T_1: AA @ 1000 ppm, T_2: BA @ 100 ppm, T_3: SB @ 1000 ppm, T_4: Putrescine @ 1 mM, T_5: Spermine @ 1.5 mM, T_6: Spermidine @ 2 mM. After dipping, fruits were dried at room temperature. The fruits were assessed for PLW, number of days for ripening, firmness, ripening percent. Physiological loss in weight and firmness were assessed at 3rd, 6th, 9th and 12th day of storage. The data obtained were analysed statistically (Panse and Sukhatme, 1985).

Results and Discussion

Observations recorded on every 3rd day.

Physical Parameters

1. Physiological loss in weight (%).
2. Number of days for ripening (days).
3. Fruit firmness (kg cm^{-2}).
4. Ripening (%).
5. Shelf life (days).
6. Spoilage (%).

PLW (%)

The data regarding PLW (%) in fruits of sapota cv. Kalipatti as influenced by different treatments are depicted in table 1. It is observed from the results that there was significant influence of treatments on PLW (%) in both the years (2016-17, 2017-18) and in pooled data.

Table 1: Effect of antioxidants and polyamines on physiological loss in weight (%) of sapota cv. Kalipatti

Treatments	Physiological loss in weight (PLW) (%)											
	3rd day			6th day			9th day			12th day		
	2016-2017	2017-2018	Pooled	2016-2017	2017-2018	Pooled	2016-2017	2017-2018	Pooled	2016-2017	2017-2018	Pooled
T_0: Control (without spray)	8.56	7.44	8.00	11.33	10.40	10.87	14.17	13.53	13.85	*	*	*
T_1: AA @ 1000 ppm	7.24	6.22	6.73	10.52	9.5	10.01	13.33	12.30	12.82	*	*	*
T_2: BA @ 100 ppm	6.12	5.15	5.64	9.23	8.27	8.75	12.37	11.60	11.99	18.25	17.27	17.76
T_3: SB @ 1000 ppm	7.02	5.90	6.47	10.32	9.28	9.80	13.23	12.25	12.74	*	*	*
T_4: Putrescine @ 1 mM	6.23	5.20	5.72	9.72	8.75	9.24	12.85	12.11	12.48	18.89	*	*
T_5: Spermine @ 1.5 mM	7.33	6.31	6.82	10.44	9.46	9.95	13.33	12.46	12.90	*	*	*
T_6: Spermidine @ 2 mM	7.55	6.57	7.06	10.47	9.52	10.00	13.54	12.55	13.05	*	*	*
Mean	7.15	6.11	6.63	10.29	9.31	9.80	13.26	12.40	12.83	-	-	-
SE.m.±	0.01	0.01	0.01	0.03	0.01	0.02	0.05	0.02	0.02	-	-	-
CD at 5%	0.04	0.02	0.03	0.09	0.03	0.05	0.16	0.05	0.06	-	-	-

*Fruits spoiled

On 3rd day of storage, during 2016-2017, significantly lowest PLW (%) was noted with the T_2: BA @ 100 ppm (6.12%). Significantly highest PLW (%) was recorded with T_0: Control (8.56%) and all other treatments recorded intermediate values. Similar trend was observed in 2017-18 and in pooled data. On 3rd day of storage, during 2017-18, significantly lowest PLW (%) was noted with the T_2: BA @ 100 ppm (5.15%). Significantly highest PLW (%) was recorded with T_0: Control (7.44%) and all other treatments recorded intermediate values. On 3rd day of storage, in pooled data, significantly lowest PLW (%) was noted with the T_2: BA @ 100 ppm (5.64%). Significantly highest PLW (%) was recorded with T_0: Control (8.00%) and all other treatments recorded intermediate values.

On 6th day of storage, during 2016-17, significantly lowest PLW (%) was noted with the T_2: BA @ 100 ppm (9.23%). Treatment T_5: Spermine @ 1.5 mM (10.44%) was on par with T_1: AA @ 1000 ppm (10.52%) and T_6: Spermidine @ 2 mM (10.47%). Significantly highest PLW (%) was recorded with T_0: Control (11.33%). On 6th day of storage, during 2017-18, significantly lowest PLW (%) was noted with the T_2: BA @ 100 ppm (8.27%). Treatment T_1: AA @ 1000 ppm (9.50%) was on par with T_6: Spermidine @ 2 mM (9.52%). Significantly highest PLW (%) was recorded with T_0: Control (10.40%). On 6th day of storage, in pooled data, significantly lowest PLW (%) was noted with the T_2: BA @ 100 ppm (8.75%). Treatment T_5: Spermine @ 1.5 mM (9.95%) was on par with T_6: Spermidine @ 2 mM (10.00%). Significantly highest PLW (%) was recorded with T_0: control (10.87%) and all other treatments recorded intermediate values.

On 9th day of storage, during 2016-17, significantly lowest PLW (%) was noted with the T_2: BA @ 100 ppm (12.37%). Treatment T_3: SB @ 1000 ppm (13.23%) was on par with T_1: AA @ 1000 ppm (13.33%) and T_5: Spermine @ 1.5 mM (13.33%). Significantly highest PLW (%) was recorded with T_0: Control (14.17%) and all other treatments recorded intermediate values. On 9th day of storage, during 2017-18, significantly lowest PLW (%) was noted with the T_2: BA @ 100 ppm (11.60%). Treatment T_3: SB @ 1000 ppm (12.25%) was on par with T_1: AA @ 1000 ppm (12.30%). Significantly highest PLW (%) was recorded with T_0: Control (13.53%). On 9th day of storage, in pooled data, significantly lowest PLW (%) was noted with the T_2: BA @ 100 ppm (11.99%). Significantly highest PLW (%) was recorded with T_0: control (13.85%) and all other treatments recorded intermediate values.

On 12th day of storage, during 2016-17, except T_2: BA @ 100 ppm (18.25%) and T_4: Putrescine @ 1 mM (18.89%), all other treatments showed end of shelf life. On 12th day of storage, during 2017-18, except T_2: BA @ 100 ppm (17.27%), all other treatments showed end of shelf life. On 12th day of storage, in pooled data, except T_2: BA @ 100 ppm (17.76%), all other treatments showed end of shelf life.

The data presented in the table 1 confirms that the lowest physiological loss in weight (PLW) was recorded with fruits treated with BA @ 100 ppm due to the reason that BA acts as antioxidant and has free radical quenching property which inhibited ethylene biosynthesis resulting in reduced weight loss (Apelbaum, 1981; Jayachandran *et al.*, 2007). The

highest physiological loss in weight (PLW) was recorded with control. The results obtained in the present investigation are in close conformity with those in mandarin cv. Nagpur Santra (Bhardwaj *et al.*, 2005).

Number of Days for Ripening (Days)

The data pertaining to number of days for ripening fruits of sapota cv. Kalipatti as influenced by different treatments are presented in table 2.

Table 2: Effect of antioxidants and polyamines on number of days for ripening (days) of sapota cv. Kalipatti

Treatments	Number of days for ripening (days)		
	2016-2017	2017-2018	Pooled
T_0: Control (without spray)	7.33	7.00	7.17
T_1: AA @ 1000 ppm	8.00	7.33	7.67
T_2: BA @ 100 ppm	9.00	8.00	8.50
T_3: SB @ 1000 ppm	7.67	8.00	7.83
T_4: Putrescine @ 1 mM	7.33	7.67	7.50
T_5: Spermine @ 1.5 mM	8.00	7.33	7.67
T_6: Spermidine @ 2 mM	8.00	7.00	7.50
Mean	7.90	7.48	7.69
SE.m.±	0.22	0.22	0.17
CD at 5%	0.67	0.67	0.51

It is observed from the results that there was significant influence of treatments on number of days for ripening (days) in both the years (2016-17, 2017-18) and in pooled data.

During 2016-17, significantly lowest number of days taken for ripening was noted with the T_0: control and T_4: Putrescine @ 1 mM (7.33 days) and they were on par with T_3: SB @ 1000 ppm (7.67 days), T_5: Spermine @ 1.5 mM, T_6: Spermidine @ 2 mM, T_1: AA @ 1000 ppm (8.00 days). Significantly highest number of days taken for ripening was recorded with T_2: BA @ 100 ppm (9.00 days). During 2017-18, significantly lowest number of days taken for ripening was noted with the T_0: control and T_6: Spermidine @ 2 mM (7.00 days) which were on par with T_1: AA @ 1000 ppm (7.33 days), T_5: Spermine @ 1.5 mM (7.33 days), T_4: Putrescine @ 1 mM (7.67 days). Significantly highest number of days taken for ripening was noted with T_2: BA @ 100 ppm and T_3: SB @ 1000 ppm (8.00 days). These were on par with T_1: AA @ 1000 ppm, T_5: Spermine @ 1.5 mM, T_4: Putrescine @ 1 mM. In pooled data, significantly lowest number of days taken for ripening was noted with the T_0: Control (7.17 days) which was on par with T_4: Putrescine @ 1 mM and T_6: Spermidine @ 2 mM (7.50 days), T_1: AA @ 1000 ppm and T_5: Spermine @ 1.5 mM (7.67 days). Treatments T_1: AA @ 1000 ppm and T_5: Spermine @ 1.5 mM (7.67 days) were on par with T_3: SB @ 1000 ppm (7.83 days). Significantly highest number of days taken for ripening was recorded with T_2: BA @ 100 ppm (8.50 days).

The data in the table 2 confirms that minimum number of days taken for ripening was reported with control fruits as antioxidant treated fruits showed retardation of fruit ripening due to the scavenging action of antioxidants on free radicals resulting in the lower catalase activity and ethylene synthesis and polyamines act oppositely in ripening and senescence processes (Galston and Sawhney, 1990).

Firmness (kg cm^{-2})

The data pertaining to firmness in fruits of sapota cv. Kalipatti as influenced by different treatments are presented in table 3.

It was observed from the results that there was significant influence of treatments on firmness (kg cm^{-2}) in 2016-17, 2017-18 and in pooled data. On 3rd day of storage, during 2016-17, significantly highest firmness was noted with the T_2: BA @ 100 ppm (7.50 kg cm^{-2}) which was followed by T_5: Spermine @ 1.5 mM (6.59 kg cm^{-2}) and T_5 was on par with

Table 3: Effect of antioxidants and polyamines on firmness (kg cm^{-2}) of sapota cv. Kalipatti

Treatments	Firmness (Kg cm^{-2})											
	3rd day			6th day			9th day			12th day		
	2016-2017	2017-2018	Pooled	2016-2017	2017-2018	Pooled	2016-2017	2017-2018	Pooled	2016-2017	2017-2018	Pooled
T_0	6.73	7.09	6.81	4.23	4.69	4.46	1.92	2.14	2.03	**	**	**
T_1	6.85	7.74	7.24	5.40	5.84	5.62	2.34	2.45	2.40	**	**	**
T_2	7.50	7.90	7.70	5.81	6.11	5.96	3.34	3.61	3.48	2.17	2.06	1.95
T_3	6.80	7.38	7.09	5.42	5.83	5.63	2.46	3.16	2.81	**	**	**
T_4	7.23	7.45	7.35	5.63	5.91	5.77	2.37	2.63	2.50	2.21	**	**
T_5	6.59	7.28	6.94	5.33	5.63	5.48	2.28	2.31	2.30	**	**	**
T_6	6.53	7.76	7.3	5.25	5.44	5.35	2.34	2.36	2.35	**	**	**
Mean	6.89	7.51	7.20	5.30	5.64	5.47	2.44	2.67	2.55	-	-	-
SE.m.±	0.03	0.03	0.02	0.02	0.02	0.01	0.01	0.02	0.01	-	-	-
CD at 5%	0.09	0.08	0.07	0.05	0.05	0.03	0.04	0.06	0.03	-	-	-

**Fruits spoiled

T_6: Spermidine @ 2 mM (6.53 kg cm^{-2}). Treatment T_3: SB @ 1000 ppm (6.80 kg cm^{-2}) was on par with T_1: AA @ 1000 ppm (6.85 kg cm^{-2}). Significantly lowest firmness was recorded with T_6: Spermidine @ 2 mM (6.53 kg cm^{-2}). On 3rd day of storage, during 2017-18, significantly highest firmness was noted with the T_2: BA @ 100 ppm (7.90 kg cm^{-2}) followed by T_6: Spermidine @ 2 mM (7.76 kg cm^{-2}). Treatment T_6 was on par with T_1: AA @ 1000 ppm (7.74 kg cm^{-2}) and T_4: Putrescine @ 1 mM (7.45 kg cm^{-2}) was on par with T_3: SB @ 1000 ppm (7.38 kg cm^{-2}). Significantly lowest firmness was recorded with T_0: control (7.09 kg cm^{-2}). On 3rd day of storage, in pooled data, significantly highest firmness was noted with the T_2: BA @ 100 ppm (7.70 kg cm^{-2}) followed by T_4: Putrescine @ 1 mM (7.35 kg cm^{-2}) and T_4 was on par with T_6: Spermidine @ 2 mM (7.30 kg cm^{-2}). Significantly lowest firmness was recorded with T_0: Control (6.81 kg cm^{-2}).

On 6th day of storage, during 2016-17, significantly highest firmness was noted with the T_2: BA @ 100 ppm (5.81 kg cm^{-2}). Significantly lowest firmness was recorded with T_0: control (4.23 kg cm^{-2}) and remaining all treatments recorded intermediate values. On 6th day of storage, during 2017-18, significantly highest firmness was noted with the T_2: BA @ 100 ppm (6.11 kg cm^{-2}) followed by T_1: AA @ 1000 ppm (5.84 kg cm^{-2}) and T_1 was on par with T_3: SB @ 1000 ppm (5.83 kg cm^{-2}). Significantly lowest firmness was recorded with T_0: Control (4.69 kg cm^{-2}). On 6th day of storage, in pooled data, significantly highest firmness was noted with the T_2: BA @ 100 ppm (5.96 kg cm^{-2}) followed by T_1: AA @ 1000 ppm (5.62 kg cm^{-2}) and T_1 was on par with T_3: SB @ 1000 ppm (5.63 kg cm^{-2}). Significantly lowest firmness was recorded with T_0: Control (4.46 kg cm^{-2}).

On 9th day of storage, during 2016-17, significantly highest firmness was noted with the T_2: BA @ 100 ppm (3.34 kg cm^{-2}) followed by T_4: Putrescine @ 1 mM (2.37 kg cm^{-2}) and T_4 was on par with T_1: AA @ 1000 ppm and T_6: Spermidine @ 2 mM (2.34 kg cm^{-2}). Significantly lowest firmness was recorded with T_0: Control (1.92 kg cm^{-2}). On 9th day of storage, during 2017-18, significantly highest firmness was noted with the T_2: BA @ 100 ppm (3.61 kg cm^{-2}) followed by T_6: Spermidine @ 2 mM (2.36 kg cm^{-2}) and T_6 was on par with T_5: Spermine @ 1.5 mM (2.31 kg cm^{-2}). Significantly lowest firmness was recorded with T_0: control (2.14 kg cm^{-2}). On 9th day of storage, in pooled data, significantly highest firmness was noted with the T_2: BA @ 100 ppm (3.48 kg cm^{-2}). Significantly lowest firmness was recorded with T_0: control (2.03 kg cm^{-2}) and all other treatments recorded intermediate values.

On 12th day of storage, during 2016-17, except T_2: BA @ 100 ppm (2.17 kg cm^{-2}), T_4: Putrescine @ 1 mM (2.21 kg cm^{-2}) all other treatments showed end of shelf life. On 12th day of storage, during 2017-18, except T_2: BA @ 100 ppm (2.06 kg cm^{-2}) all other treatments showed end of shelf life. On 12th day of storage, in pooled data, except T_2: BA @ 100 ppm (1.95 kg cm^{-2}) all other treatments showed end of shelf life.

The data in the table 3 confirms that as the storage period increased, the firmness decreased irrespective of treatments. Among all the treatments BA @ 100 ppm recorded maximum firmness followed by fruits treated with polyamines. This may be attributed to the retarded nature of ripening as a result of antioxidant treatment (Jayachandran *et al*., 2007). Similar results were also reported with BA @ 100 ppm in guava (Reddy *et al*., 2014).

Ripening Percent (%)

The data pertaining to ripening percent (%) in fruits of Sapota cv. Kalipatti as influenced by different treatments are presented in Table 4.

It is observed from the results that there was significant influence of treatments on ripening percent (%) in 2016-17, 2017-18 and in pooled data. During 2016-17, significantly highest ripening (%) was noted with the T_0: Control (72.50%) and this was on par with T_2: BA @ 100 ppm (72.10%). Treatment T_2 was on par with T_5: Spermine @ 1.5 mM (71.75%), T_3: SB @ 1000 ppm (71.72%) and T_1: AA @ 1000 ppm (71.71%). Treatment T_1 was on par with T_6: Spermidine @ 2 mM (71.09%). Significantly lowest ripening (%) was recorded with T_4: Putrescine @ 1 mM (70.64%) and this was on par with T_6. During 2017-18, significantly highest ripening (%) was noted with the T_0: Control (73.13%) and this was followed by T_3: SB @ 1000 ppm (72.33%). Treatment T_3 was on par with T_2: BA @ 100 ppm (72.27%), T_5: Spermine @ 1.5 mM (72.06%), T_6: Spermidine @ 2 mM (71.93%) and T_4: Putrescine @ 1 mM (71.59%). Significantly lowest ripening (%) was noted with T_1: AA @ 1000 ppm (71.50%) and this was on par with T_4: Putrescine @ 1 mM (71.59%).

In pooled data, significantly highest ripening was noted with the T_0: control (72.82%) and this was followed by T_2: BA @ 100 ppm (72.18%). Treatment T_2 was on par with T_3: SB @ 1000 ppm (72.03%), T_5: Spermidine @ 1.5 mM (71.91%). Treatment T_5 was on par with T_1: AA @ 1000 ppm (71.60%) and T_6: Spermidine @ 2 mM (71.51%). Significantly lowest ripening (%) was recorded with T_4: Putrescine @ 1 mM (71.12%) this was on par with T_6: Spermidine @ 2 mM (71.51%).

The data in the Table 4 shows that maximum ripening percent was found in control (T_0) fruits than treated fruits

Table 4: Effect of antioxidants and polyamines on ripening (%) of sapota cv. Kalipatti

Treatments	Ripening (%)		
	2016-2017	2017-2018	Pooled
T_0: Control (without spray)	72.50	73.13	72.82
T_1: AA @ 1000 ppm	71.71	71.50	71.60
T_2: BA @ 100 ppm	72.10	72.27	72.18
T_3: SB @ 1000 ppm	71.72	72.33	72.03
T_4: Putrescine @ 1 mM	70.64	71.59	71.12
T_5: Spermine @ 1.5 mM	71.75	72.06	71.91
T_6: Spermidine @ 2 mM	71.09	71.93	71.51
Mean	71.64	72.12	71.88
SE.m.±	0.21	0.24	0.13
CD at 5%	0.65	0.75	0.41

due to the fact that antioxidants reduces senescence, rate of respiration, ethylene production and ripening of fruits and also polyamines act oppositely in ripening.

Shelf Life (Days)

The data related to shelf life in fruits of sapota cv. Kalipatti as influenced by different treatments are presented in table 5.

During 2016-17, significantly highest shelf life was noted with the T_2: BA @ 100 ppm (12.33 days) and it was on par with T_4: Putrescine @ 1 mM (12.00 days). Treatment T_4: Putrescine @ 1 mM was on par with T_3: SB @ 1000 ppm (11.33 days). Treatment T_3: SB @ 1000 ppm was on par with T_1: AA @ 1000 ppm (11.00 days). Significantly lowest shelf life was recorded with T_0: control (9.67 days) and this was on par with T_6: Spermidine @ 2 mM (10.00 days) and T_5: Spermine @ 1.5 mM (10.33 days).

During 2017-18, significantly highest shelf life was noted with the T_2: BA @ 100 ppm (12.00 days) and this was on par with T_4: Putrescine @ 1 mM (11.33 days). Treatment T_4 was on par with T_3: SB @ 1000 ppm (11.00 days). Treatments T_1: AA @ 1000 ppm and T_5: Spermine @ 1.5 mM (10.00 days) were on par with T_6: Spermidine @ 2 mM (9.67 days). Significantly lowest shelf life was recorded with T_0: Control (9.00 days).

In the pooled data, significantly highest shelf life was noted with the T_2: BA @ 100 ppm (12.17 days) which was on par with T_4: Putrescine @ 1 mM (11.67 days) and T_4: Putrescine @ 1 mM was on par with T_3: SB @ 1000 ppm (11.17 days). Treatment T_3 was on par with T_1: AA @ 1000 ppm (10.50 days). Treatment T_1: AA @ 1000 ppm was on par with T_5: Spermine @ 1.5 mM (10.17 days), T_6: Spermidine @ 2 mM (9.83 days). Significantly lowest shelf life was recorded with T_0: control (9.33 days) which was on par with T_6.

The data presented in the table 5 confirms that maximum shelf life was recorded with fruits treated with BA @ 100 ppm, which might be due to reason that antioxidants extend the shelf life of fruits by minimizing the onset of ripening and ethylene production which is mediated by lipid peroxidation reactions (Reddy *et al*., 2014). The minimum shelf life was recorded with control. Similar results were obtained when guava fruits were treated with BA 50 ppm (Jayachandran *et al*., 2007).

Table 5: Effect of antioxidants and polyamines on shelf life (days) of sapota cv. Kalipatti

Treatments	Shelf life (days)		
	2016-2017	2017-2018	Pooled
T_0: Control (without spray)	09.67	09.00	09.33
T_1: AA @ 1000 ppm	11.00	10.00	10.50
T_2: BA @ 100 ppm	12.33	12.00	12.17
T_3: SB @ 1000 ppm	11.33	11.00	11.17
T_4: Putrescine @ 1 mM	12.00	11.33	11.67
T_5: Spermine @ 1.5 mM	10.33	10.00	10.17
T_6: Spermidine @ 2 mM	10.00	09.67	09.83
Mean	10.95	10.43	10.69
SE.m.±	0.25	0.28	0.22
CD at 5%	0.77	0.86	0.67

Spoilage (%)

The data pertaining to spoilage (%) in fruits of sapota cv. Kalipatti as effected by different treatments are depicted in table 6.

On 3rd day of storage, during 2016-2017, significantly lowest spoilage (1.12%) was noted with the T_2: BA @ 100 ppm and it was on par with all other treatments. Significantly highest spoilage was recorded with T_0: control (3.53%). Similar trend was observed during 2017-18 and in pooled data. On 3rd day of storage, during 2017-2018, significantly lowest spoilage was noted with the T_4: Putrescine @ 1 mM (1.12%) and it was on par with all other treatments. Significantly highest spoilage was recorded with T_0: control (4.20%). On 3rd day of storage, in pooled data, significantly lowest spoilage (1.13%) was noted with the T_2: BA @ 100 ppm and it was on par with all other treatments. Significantly highest spoilage was recorded with T_0: control (3.87%).

On 6th day of storage, during 2016-2017, significantly lowest spoilage was recorded with the T_2: BA @ 100 ppm (15.32%). Significantly highest spoilage was recorded with T_0: Control (30.36%) and all other treatments recorded intermediate values. Similar trend was observed during 2017-18 and in pooled data. On 6th day of storage, during 2017-2018, significantly lowest spoilage was recorded with the T_2: BA @ 100 ppm (15.24%). Significantly highest spoilage was recorded with T_0: Control (32.25%) and all other treatments recorded intermediate values. On 6th day of storage, in pooled data, significantly lowest spoilage was recorded with the T_2: BA @ 100 ppm (15.29%). Significantly highest spoilage was recorded with T_0: control (31.31%) and all other treatments recorded intermediate values.

On 9th day of storage, during 2016-2017, significantly lowest spoilage was noted with the T_4: Putrescine @ 1 mM (33.69%). Significantly highest spoilage was recorded with T_0: Control (65.67%) and all other treatments recorded intermediate values. Similar trend was observed during 2017-18 and in pooled data. On 9th day of storage, during 2017-2018, significantly lowest spoilage was noted with the T_4: Putrescine @ 1 mM (33.43%). Significantly highest spoilage was recorded with T_6: Spermidine @ 2 mM (54.57%) and all other treatments recorded intermediate values. On 9th day of storage, in pooled data, significantly lowest spoilage was recorded with the T_4: Putrescine @ 1 mM (33.56%). Significantly highest spoilage was recorded with T_0: control (58.05%) and all other treatments recorded intermediate values.

On 12th day of storage, during 2016-2017, except treatments T_2: BA @ 100 ppm (70.26%), T_4: Putrescine @ 1 mM (72.79%), all other treatments showed end of shelf life. On 12th day of storage, during 2017-2018, except treatments T_2: BA @ 100 ppm (69.07%) all other treatments showed end of shelf life. On 12th day of storage, in pooled data, except treatments T_2: BA @ 100 ppm (69.67%) all other treatments showed

Table 6: Effect of antioxidants and polyamines on spoilage (%) of sapota cv. Kalipatti

Treatments	Spoilage (%)											
	3rd day			6th day			9th day			12th day		
	2016-2017	2017-2018	Pooled	2016-2017	2017-2018	Pooled	2016-2017	2017-2018	Pooled	2016-2017	2017-2018	Pooled
T_0	3.53	4.20	3.87	30.36	32.25	31.31	65.67	50.43	58.05	***	***	***
T_1	1.14	1.20	1.17	20.49	22.16	21.33	40.71	39.90	40.31	***	***	***
T_2	1.12	1.13	1.13	15.32	15.24	15.29	35.63	35.10	35.37	70.26	69.07	69.67
T_3	1.19	1.23	1.21	25.69	25.72	25.71	50.39	51.43	50.91	***	***	***
T_4	1.15	1.12	1.14	17.84	18.04	17.94	33.69	33.43	33.56	72.79	***	***
T_5	1.15	1.16	1.16	28.36	29.42	28.89	55.51	53.37	54.44	***	***	***
T_6	1.18	1.20	1.19	27.40	28.24	27.82	55.18	54.57	55.32	***	***	***
Mean	1.49	1.61	1.55	23.64	24.44	24.04	48.11	45.46	46.85	-	-	-
SE.m.±	0.11	0.04	0.08	0.04	0.19	0.11	0.08	0.20	0.11	-	-	-
CD at 5%	0.34	0.14	0.24	0.12	0.59	0.33	0.25	0.61	0.33	-	-	-

***Fruits spoiled

end of shelf life.

The data presented in the table 6 confirms that the rate of spoilage increased with the progressive increase in ripening and days to storage. Spoilage of fruits was directly related to the rate of respiration of fruits, which leads to deterioration of fruits. Minimum spoilage was recorded with BA @ 100 ppm due to the reason that antioxidant compounds extend the shelf life of fruits by minimizing the spoilage of fruits. Similar results were obtained in Guava (Reddy *et al*., 2014).

Conclusion

Fruits treated with BA @ 100 ppm (T_2) showed lower PLW, maximum number of days for ripening and spoilage where as shelf life and firmness were higher in BA @ 100 ppm (T_2) treated fruits during both the years and in pooled data respectively. Post-harvest treatment of sapota fruits with BA @ 100 ppm increased shelf life. Further research on sapota is still needed to understand the overall effect of postharvest treatments on shelf life of sapota for the exploitation of sapota fruit on to national and international markets.

References

Apelbaum, A., Burgoon, A.C., Anderson, J.D., Salomos, T., Lieberman, M., 1981. Some characteristics of the system converting ACC to ethylene. *Plant Physiology* 67(1), 80-84. DOI: 10.1104/pp.67.1.80.

Bhat, A., Kaul, R.K., Reshi, M., Gupta, N., 2014. Effect of polyamines on shelf life and chilling injury of mango cv. Dashehari. *The Bioscan* 9(3), 1097-1100.

Archana, T.J., Suresh, G.J., Swamy, G.S.K., 2015. Influence of exogenic application of putrescince on ripening changes in banana cv. Grand Naine. *International Journal of Food and Fermentation Technology* 5(1), 53-58. DOI: 10.5958/2277-9396.2015.00007.0.

Banik, D., Dhua, R.S. Ghosh, S.K., Sen, S.K., 1988a. Studies on extension of storage of Sapota (*Achras sapota* L.). *Indian Journal of Horticulture* 45(3&4), 241-245.

Banik, D., Hore, J.K., Sen, S.K., 1988b. Studies on storage life of Ber (*Zizyphus mauritiana* Lamk). *Haryana Journal of Horticulture Science* 17(1-2), 49-55.

Bhardwaj, R.L., Sen, N.L., Mukherjee, S., 2005. Effect of benzyladenine on physico-chemical characteristics and shelf life of mandarin cv. Nagpur orange. *Indian J. Hort.* 62(2), 181-183.

El-shazy, S.M., Elisa, A.M., Moatamed, A.M.H., Kotb, H.R.M., 2013. Effect of some agro chemicals and pre harvest foliar application on yield and fruit quality of 'swelling' peach trees. *Alexandria Journal of Agriculture Research* 58(3), 219-229.

Ferriera, M.D., Sarget, S.A., Brecht, J.K., Kellman, C., 2008. Strawberry fruit resistance to simulated handling. *Scientia Agriculture* 65, 490-495. DOI: 10.1590/S0103-90162008000500007.

Gill, K.B.S., Dhaliwal, H.S., Maharajan, B.V.C., 2014. Effect of post harvest treatments of ascorbic acid on shelf life and quality of guava (*Pisidium guajava* L.) cv. Allahabad safeda. *International Journal of Agriculture Science & Veterinary Medicine* 2(1), 130-141.

Galston, A.W., 1983. Polyamines on modulations of plant development. *Bioscience* 33, 382-388. DOI: 10.2307/1309107.

Galston, A.W., Sawhney, K., 1990. Polyamine and Plant physiology. *Plant Physiology* 94 (2), 406-410. DOI: 10.1104/pp.94.2.406.

Jayachandran, K.S., Sri Hari, D., Reddy, Y.N., 2007. Post harvest application of selected antioxidants to improve the shelf life of guava fruit. *Acta Horticulturae* 735, 627-632. DOI: 10.17660/ActaHortic.2007.735.81.

Jhalegar, M.J., Sharma, R.R., Pal, R.K., Rana, V., 2012. Effect of post harvest treatments with polyamines on physiological and biochemical attributes of Kiwi fruit (*Actinidia deliciosa*) cv. Allison. *Fruits* 67, 13-22. DOI: 10.1051/fruits/2011062.

Kakkar, R.K., Rai, V.K., 1993. Plant polyamines in flowering

and fruit ripening. *Phytochemistry* 33, 1281-1288. DOI: 10.1016/0031-9422(93)85076-4.

Khan, A.S., Singh, Z., 2008. Influence of pre and post harvest applications of putrescine on ethylene production, storage life and quality of 'Angelino' plum. *Acta Horticulturae* 768, 125-133. DOI: 10.17660/ActaHortic.2008.768.14.

Khan, A.S., Singh, Z., Abbasi, N.A., 2007. Pre storage putrescine application suppresses ethylene biosynthesis and retards fruit softening during low temperature storage in 'Angelino' plum. *Post harvest biology and technology* 46, 36-46. DOI: 10.1016/j.postharvbio.2007.03.018.

Malik, A.U., Singh, Z., Tan, S.C., 2006. Exogenous application of polyamines improves shelf life and fruit quality of mango. *Acta Horticulturae* 699, 291-296. DOI: 10.17660/ActaHortic.2006.699.34.

Panse, V.G., Sukhtme, P.V., 1985. *Statistical Methods for Agricultural Workers.* Indian Council of Agricultural Research, New Delhi, pp. 187-202.

Poliyanth, G., Phospholipase, D., Subramanian, J., 2008. Inhibition technology for enhancing shelf life and quality. In: *Post Harvest Biology and Technology of Fruits, Vegetables and Flowers*. 1st edition, (Eds.) Paliyath, G., Murr, D.P., Honda, A.K. and Lurie, S. Wiley-Blackwell, USA, pp. 195-239.

Pythme, T., Bonyyarithongchai, P., Kanlayanarat, S., 2009. Effect of ascorbic acid on shelf life and quality of fresh cut 'Mahachanok' mango. In: South east symposium on quality and safety of fresh and fresh cut produce. *Acta Hortic* 875, 223-226. DOI: 10.17660/ActaHortic.2010.875.27 875, 223-226.

Reddy, T.S., Babu, J.D., Polaiah, A.C., 2014. Effect of antioxidants on shelf life of guava (*Psidium guajava* L.). *Plant Archives* 14(1), 575-578.

Sharma, S., Pareek, S.I.D., Sagar, N.A., Valero, D., Serrano, M., 2017. Modulatory Effects of Exogenously Applied Polyamines on Postharvest Physiology, Antioxidant System and Shelf Life of Fruits: A Review. *Int. J. Mol. Sci*. 18, 1789. DOI: 10.3390/ijms18081789.

Siddiqui, S., Gupta, O.P., 1995. Effect of post harvest application of some chemicals on shelf life of Ber (*Zizyphus mauritiana* Lamk) fruits. *Haryana Journal of Horticulture Science* 24(4), 19-23.

Singh, J., Mirza, A., 2018. Influence of Ascorbic acid application on quality and storage life of fruits. *International Journal of Current Microbiology and Applied Sciences* 7(7), 4319-4328. DOI: 10.20546/ijcmas.2018.707.503.