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Effect of Polyamines, Packaging Materials and Storage conditions on Shelf Life of Banana (*Musa paradisiaca* L.) *cv*. Grand Naine

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ABSTRACT: The present investigation on "Effect of polyamines, packaging materials and storage conditions on shelf life of banana (*Musa paradisiaca* L.) *cv*. Grand Naine" was conducted during June 2021 and November 2021 at the Laboratory of Postharvest Technology, Department of Horticulture, MPKV., Rahuri, Dist. Ahmednagar. The effect of polyamines, packaging materials and storage conditions on shelf life of banana *cv*. Grand Naine was laid out with three polyamine treatments *viz*., A_1 - Putrescine @ 5mM, A_2 - Spermine @5 µM, A_3 - Spermidine@ 4 mM, four packaging materials *viz*., P_1 -Perforated polyethylene bag, P_2- Nano silver based bag, P_3- $KMnO_4$ based ethylene absorber 4g, P_4 - $KMnO_4$ based ethylene absorber6g, two different storage conditions *viz*., S_1 -Ambient temperature and S_2 - Cold storage (13°C+1). During storage, lowest physiological loss in weight (%), ripening (%), spoilage (%) and moisture content (%) recorded in treatment combination $A_2P_4S_2$ *i.e*. spermine @ 5 µM + $KMnO_4$ based ethylene absorber 6 g + cold storage (13^0C+1) at the end of storage life. From concluded that fruits treated with $A_2P_4S_2$ *i.e.* spermine @ 5 µM + $KMnO_4$ based ethylene absorber 6 g + cold storage (13°C+1) was found best treatment for extension of shelf life of banana. Banana is a climacteric fruit, rapid physico-chemical changes after harvest leads to deterioration and senescence. Therefore, there is a need to regulate its ripening so as to improve its shelf life.

Keywords: Banana, polyamines, packaging materials, ethylene absorber, quality and shelf life.

INTRODUCTION

Polyamines are biological compounds of low molecular weight in their free forms which act as anti-senescent agents, delay ethylene production, reduce rate of respiration, increase fruit firmness, induce mechanical resistance, reduce chilling symptoms and retard colour changes. Deterioration of fruit quality physiologically correlates with decrease polyamine (PA) content in the ripening fruits and increase in ethylene production as both polyamine and ethylene have the same precursor S-adenosyl methionine. Much research evidences have shown that exogenous polyamines can inhibit ethylene biosynthesis and so delay the ripening process (Archana and Suresh 2019).

Packaging exhibited great role in extending the shelf life and minimizing the wastage by inhibiting undesirable physiological events, bruising and pathological deterioration during storage, transportation and marketing. The suitable packaging materials provides congenial environment which reduces the ethylene production, undesirable biochemical changes, ripening, slows down the rate of respiration, desiccation and pathological deterioration of fruits. The quality of banana deteriorates and considerable amount is wasted, from harvesting to final consumption. This loss can be kept at minimum by improving postharvest handling techniques through the use of packaging materials (Zerga and Tsegaye 2020).

Several researchers have reported that externally applied polyamines have great potential for lengthening the postharvest life of many fruits Archana and Suresh (2019) in banana, Deepthi *et al*. (2016) in guava, Hanif *et al*. (2020) in papaya, and Singh *et al*. (2019) in pear.

Elamin and Abu-Goukh (2009) revealed that the sealed film liner and $KMnO_4$ in granular form resulted in more delay of fruit ripening and extension of shelf life of banana fruits.

METERIAL AND METHODS

Experiment was carried out at Post-harvest Technology Laboratory, Department of Horticulture, MPKV, Rahuri, during 2021 in the month of June and November consisting of three factors *i.e*.

Factor A: Polyamine treatments (A_1 - Putrescine@ 5 mM, A_2 - Spermine@ 5 µM, A_3 -Spermidine@ 4mM and control).

Factor B: Packaging materials (P_1 -Perforated polyethylene bag, P_2 -Nano silver based bag, P_3- $KMnO_4$ ethylene absorber 4g and P_4 - $KMnO_4$ ethylene absorber 6g).

Factor C: Storage conditions (S_1 - Ambient temperature and S_2 - Cold storage (13°C+1) laid out in Factorial Completely Randomized Design (FCRD) in two replications with twenty four treatment combinations and fruits were analyzed for physicochemical parameters at an interval of two days.

RESULT AND DISCUSSION

Physical parameters

Ripening (%). The data pertaining to the effect of polyamines, packaging materials and storage conditions on ripening of banana have been presented in Table 1. The treatments showed significant influence on ripening of banana. It was observed that, ripening found to be increased in all treatments during storage period.

Ripening showed significant difference with polyamines treatments throughout the storage period. On 12th day of storage, the treatment A_2 *i.e*. spermine 5 µM recorded minimum ripening (69.18 %) whereas the treatment A_1*i.e*. putrescine 5 mM recorded maximum ripening (77.80 %). On 26th day of storage, only fruits treated with A_2 *i.e*. spermine 5 µM could remain in storage and recorded 96.62% ripening.

Packaging materials indicated significant difference on ripening of banana fruits. On 12th day of storage, the treatment P_4 *i.e*. $KMnO_4$ based ethylene absorber 6 g recorded minimum ripening (67.86 %) whereas the treatment P_1*i.e*. perforated polyethylene bag recorded maximum ripening (85.31 %). Fruits treated with P_4*i.e*. $KMnO_4$ based ethylene absorber 6g remained in storage up to 26 days with 96.62% ripening.

Ripening was also significantly influenced by storage conditions. Under ambient conditions fruits showed faster ripening than cold storage conditions. On 20th day of storage, fruits under ambient conditions S_1 recorded 98.51% ripening at the end of storage. On 26th day of storage, fruits under cold storage S_2 increased ripening up to 96.62%.

Effect of polyamines and packaging materials showed significant difference with respect to ripening during storage. On 12th day of storage, the treatment combination of A_2P_4 *i.e*. spermine 5 µM + $KMnO_4$ based ethylene absorber 6 g recorded minimum ripening (65.13 %) followed by the treatment A_2P_3 (65.46 %) whereas the treatment combination A_1P_1*i.e*. putrescine 5 mM + perforated polyethylene bag recorded maximum ripening (90.39 %). On 26th day of storage, interaction A_2P_4 *i.e*. spermine 5 µM + $KMnO_4$ based ethylene absorber 6g were existed in storage with 96.62% ripening.

Effect of polyamines and storage conditions showed significant influence on ripening of banana fruits. On 12th day of storage, the treatment combination of A_2S_2 *i.e*. spermine 5 µM + cold storage was recorded minimum ripening (69.20 %) whereas the treatment combination A_1S_1*i.e*. putrescine 5 mM + ambient temperature recorded maximum ripening (85.73 %). On 26th day of storage, only interaction A_2S_2 *i.e*. spermine 5 µM + cold storage was remained in good condition and recorded 96.62% ripening.

The data on ripening showed significant variation irrespective of packaging materials and storage conditions. On 12th day of storage, the treatment combination P_4S_2 *i.e*. $KMnO_4$ based ethylene absorber 6 g + cold storage was found minimum ripening (65.27 %) followed by P_3S_2 (65.43 %) whereas the treatment combination P_1S_1*i.e*. perforated polyethylene bag + ambient temperature recorded maximum ripening (95.24 %). Fruits treated with P_4S_2 *i.e*. $KMnO_4$ based ethylene absorber 6g + cold storage were existed in storage up to 26th day with 96.62% ripening.

Three factors (polyamines, packaging materials and storage conditions) interaction effect showed significant variation on ripening during storage. Fruits stored in ambient conditions recorded very fast increase in ripening than fruits kept in cold storage irrespective of polyamines, packaging materials and storage conditions. On 12th day of storage, the minimum ripening was recorded in $A_2P_4S_2$ *i.e*. spermine 5 µM + $KMnO_4$ based ethylene absorber 6 g + cold storage (63.05 %) followed by $A_2P_3S_2$ (63.28 %) whereas maximum ripening was recorded in $A_1P_1S_1$ *i.e*. putrescine 5 mM + perforated polyethylene bag + ambient temperature (99.98 %) followed by $A_3P_1S_1$ (99.84 %). On 26th day of storage, it was noticed that, the interaction $A_2P_4S_2$ *i.e*. spermine 5 µM + $KMnO_4$ based ethylene absorber 6g + cold storage revealed slower changes in ripening during storage and retained 96.62% ripening at the end of storage life. The mean ripening in treated fruits increased up to 96.62% at the end of storage life (26th day), whereas it was 99.99% in control at 10th day of storage (at the end of storage life).

Exogenous application of spermine might have increased endogenous free polyamine levels in treated fruits, possibly reduced ethylene production and hence delayed the ripening (Bhagwan *et al*., 2000). Post harvest application of spermine might have inhibited the ethylene biosynthesis and thereby resulting in delay of ripening related processes as reported by Saftner and Baldi (1990).

Ethylene is necessary for ripening of climacteric fruits (Oller *et al.,* 1991). The putrescine and spermine has been reported to inhibit biosynthesis of ethylene as they share the common precursor SAM and are known to exert opposite effects with respect to fruit ripening and senescence. These two polyamines play a crucial role in suppressing the onset of fruit ripening or triggering and promoting this process Valero *et al*. (2002). The effect of polyamines with respect to delaying ripening in climacteric fruits is reported by Serrano *et al.* (2003) in plum, Jawandha *et al*. (2012); Anju *et al*. (2014) in mango and Barbang *et al*. (2002) in banana and papaya, Davarynejad *et al*. (2013) in apricot, Antonio *et al*. (2002) in plum and Nilprapruck *et al*. (2016) in banana. $KMnO_4$ was effective in reducing ethylene levels by oxidizing ethylene to carbon dioxide and water. The reduction in ethylene, low oxygen and increased carbon dioxide inside the polybags affected by addition of potassium permanganate was subsequently found to delay the ripening and extending the fruit firmness period of many climacteric fruits such as banana Elamin and Abu-Goukh (2009) fruits packed in polyethylene bag along $KMnO_4$ sachets was found delay the onset of climacteric peak and to retard ripening of banana. Similar results were observed by Scott *et al*. (1970); Patil and Hulmani (1998); Ghorankhan *et al*. (2012) in banana and Azad *et al*. (2008) in mango.

Table 1: Effect of different polyamines, packaging materials and storage conditions on ripening (%) of banana fruit *cv.* Grand Naine during storage.

Treatmt.	Initial days			2 days			4 days			6 days			8 days		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
A_1	0.00	0.00	0.00	18.79	18.70	18.74	24.51	24.41	24.46	35.65	35.56	35.61	48.99	48.90	48.95
A_2	0.00	0.00	0.00	16.16	16.08	16.12	18.80	18.47	18.63	23.19	23.09	23.14	39.30	38.84	39.07
A_3	0.00	0.00	0.00	17.81	17.70	17.75	20.55	20.43	20.49	29.26	29.17	29.21	43.32	43.30	43.31
SEm (±)	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.07	0.01	0.05
CD 1%	0.00	0.00	0.00	0.03	0.03	0.03	0.03	0.04	0.03	0.05	0.03	0.04	0.27	0.03	0.19
P_1	0.00	0.00	0.00	19.67	19.58	19.62	24.67	24.58	24.62	35.65	35.54	35.60	51.89	51.97	51.93
P_2	0.00	0.00	0.00	19.41	19.32	19.36	24.53	24.10	24.32	33.24	33.15	33.19	48.63	48.01	48.32
P_3	0.00	0.00	0.00	15.83	15.73	15.78	18.12	18.00	18.06	24.35	24.27	24.31	37.74	37.57	37.65
P_4	0.00	0.00	0.00	15.44	15.35	15.39	17.82	17.73	17.78	24.22	24.15	24.19	37.23	37.18	37.20
SEm (±)	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.08	0.01	0.06
CD 1%	0.00	0.00	0.00	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.03	0.04	0.32	0.03	0.22
S_1	0.00	0.00	0.00	18.31	18.22	18.26	23.80	23.69	23.74	32.04	31.95	31.99	47.74	47.71	47.73
S_2	0.00	0.00	0.00	16.87	16.76	16.81	18.77	18.52	18.64	26.69	26.61	26.65	40.00	39.65	39.82
SEm (±)	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.06	0.01	0.04
CD 1%	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.03	0.03	0.04	0.02	0.03	0.22	0.02	0.15
A_1P_1	0.00	0.00	0.00	20.52	20.44	20.48	29.92	29.81	29.86	45.56	45.47	45.51	58.78	58.72	58.75
A_1P_2	0.00	0.00	0.00	20.14	20.04	20.09	29.84	29.73	29.78	45.43	45.34	45.38	58.22	58.10	58.16
A_1P_3	0.00	0.00	0.00	17.64	17.57	17.61	19.19	19.10	19.14	25.86	25.78	25.82	39.57	39.47	39.52
A_1P_4	0.00	0.00	0.00	16.86	16.75	16.81	19.09	19.02	19.05	25.76	25.68	25.72	39.42	39.32	39.37
A_2P_1	0.00	0.00	0.00	18.68	18.58	18.63	20.76	20.71	20.73	25.04	24.92	24.98	45.00	44.98	44.99
A_2P_2	0.00	0.00	0.00	18.38	18.30	18.34	20.57	19.46	20.02	23.62	23.54	23.58	40.51	38.89	39.70
A_2P_3	0.00	0.00	0.00	13.89	13.81	13.85	16.98	16.90	16.94	22.09	22.01	22.05	36.43	36.32	36.37
A_2P_4	0.00	0.00	0.00	13.71	13.63	13.67	16.88	16.81	16.84	22.00	21.92	21.96	35.26	35.16	35.21
A_3P_1	0.00	0.00	0.00	19.81	19.72	19.77	23.32	23.23	23.28	36.36	36.25	36.30	51.89	52.21	52.05
A_3P_2	0.00	0.00	0.00	19.71	19.63	19.67	23.20	23.12	23.16	30.67	30.58	30.63	47.15	47.05	47.10
A_3P_3	0.00	0.00	0.00	15.97	15.81	15.89	18.19	18.01	18.10	25.09	25.02	25.05	37.23	36.92	37.07
A_3P_4	0.00	0.00	0.00	15.74	15.66	15.70	17.49	17.38	17.44	24.92	24.85	24.88	37.02	37.05	37.03
SEm(±)	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.02	0.14	0.01	0.10
CD 1%	0.00	0.00	0.00	0.06	0.06	0.05	0.06	0.08	0.07	0.09	0.06	0.07	0.55	0.06	0.38
	Initial days			2 days			4 days			6 days			8 days		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
A_1S_1	0.00	0.00	0.00	19.74	19.64	19.69	29.34	29.25	29.30	39.65	39.57	39.61	57.70	57.60	57.65
A_1S_2	0.00	0.00	0.00	18.36	18.26	18.31	20.46	20.38	20.42	31.24	31.13	31.19	43.01	42.96	42.98
A_2S_1	0.00	0.00	0.00	18.57	18.48	18.52	22.19	22.12	22.15	27.84	27.75	27.80	46.13	46.25	46.19
A_2S_2	0.00	0.00	0.00	16.72	16.63	16.68	18.57	17.98	18.28	25.66	25.56	25.61	40.19	39.36	39.78
A_3S_1	0.00	0.00	0.00	18.58	18.51	18.54	22.45	22.31	22.38	32.19	32.09	32.14	46.29	46.40	46.35
A_3S_2	0.00	0.00	0.00	17.03	16.90	16.97	18.65	18.56	18.60	26.33	26.25	26.29	40.35	40.21	40.28
SEm (±)	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.01	0.01	0.10	0.01	0.07
CD 1%	0.00	0.00	0.00	0.04	0.04	0.04	0.04	0.05	0.05	0.06	0.04	0.05	0.39	0.04	0.27
P_1S_1	0.00	0.00	0.00	20.61	20.51	20.56	28.55	28.47	28.51	38.87	38.78	38.83	58.84	59.05	58.94
P_1S_2	0.00	0.00	0.00	18.73	18.65	18.69	20.78	20.69	20.74	32.43	32.30	32.37	44.94	44.89	44.91
P_2S_1	0.00	0.00	0.00	20.38	20.31	20.35	28.40	28.29	28.35	38.51	38.42	38.47	55.00	54.89	54.95
P_2S_2	0.00	0.00	0.00	18.43	18.33	18.38	20.67	19.91	20.29	27.97	27.88	27.92	42.25	41.13	41.69
P_3S_1	0.00	0.00	0.00	16.43	16.36	16.39	19.34	19.19	19.27	25.46	25.36	25.41	39.01	38.79	38.90
P_3S_2	0.00	0.00	0.00	15.23	15.10	15.17	16.90	16.81	16.86	23.23	23.18	23.21	36.46	36.35	36.41
P_4S_1	0.00	0.00	0.00	15.80	15.72	15.76	18.89	18.82	18.86	25.30	25.23	25.27	38.12	38.11	38.12
P_4S_2	0.00	0.00	0.00	15.07	14.97	15.02	16.74	16.65	16.70	23.14	23.07	23.11	36.34	36.24	36.29
SEm (±)	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.02	0.01	0.02	0.01	0.02	0.11	0.01	0.08
CD 1%	0.00	0.00	0.00	0.05	0.05	0.04	0.05	0.06	0.05	0.07	0.05	0.06	0.45	0.05	0.31
$A_1P_1S_1$	0.00	0.00	0.00	21.11	21.00	21.06	36.97	36.83	36.90	52.61	52.57	52.59	69.85	69.76	69.81
$A_1P_1S_2$	0.00	0.00	0.00	19.93	19.87	19.90	22.86	22.78	22.82	38.50	38.36	38.43	47.71	47.67	47.69
$A_1P_2S_1$	0.00	0.00	0.00	21.03	20.95	20.99	36.85	36.72	36.79	52.54	52.43	52.49	69.78	69.72	69.75
$A_1P_2S_2$	0.00	0.00	0.00	19.24	19.13	19.19	22.82	22.74	22.78	38.32	38.24	38.28	46.65	46.47	46.56
$A_1P_3S_1$	0.00	0.00	0.00	18.38	18.31	18.35	20.74	20.68	20.71	27.45	27.37	27.41	40.61	40.51	40.56
$A_1P_3S_2$	0.00	0.00	0.00	16.90	16.83	16.87	17.63	17.52	17.58	24.27	24.19	24.23	38.52	38.43	38.48
$A_1P_4S_1$	0.00	0.00	0.00	17.05	16.96	17.01	20.74	20.69	20.72	27.33	27.26	27.30	40.48	40.36	40.42
$A_1P_4S_2$	0.00	0.00	0.00	16.67	16.54	16.61	17.44	17.34	17.39	24.18	24.09	24.14	38.35	38.27	38.31

	Initial days			2 days			4 days			6 days			8 days		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
$A_2P_1S_1$	0.00	0.00	0.00	19.76	19.65	19.71	22.81	22.76	22.79	26.10	26.00	26.05	50.68	50.54	50.61
$A_2P_1S_2$	0.00	0.00	0.00	17.60	17.51	17.56	18.71	18.65	18.68	23.97	23.83	23.90	39.31	39.42	39.37
$A_2P_2S_1$	0.00	0.00	0.00	19.31	19.24	19.28	22.64	22.53	22.59	25.25	25.18	25.22	41.55	41.43	41.49
$A_2P_2S_2$	0.00	0.00	0.00	17.44	17.35	17.40	18.50	16.39	17.45	21.98	21.89	21.94	39.47	36.34	37.91
$A_2P_3S_1$	0.00	0.00	0.00	14.46	14.38	14.42	17.56	17.47	17.52	22.27	22.14	22.21	38.49	38.40	38.45
$A_2P_3S_2$	0.00	0.00	0.00	13.31	13.24	13.28	16.40	16.32	16.36	21.91	21.87	21.89	34.36	34.24	34.30
$A_2P_4S_1$	0.00	0.00	0.00	14.24	14.17	14.21	17.44	17.37	17.41	22.12	22.04	22.08	36.31	36.20	36.26
$A_2P_4S_2$	0.00	0.00	0.00	13.18	13.09	13.14	16.31	16.24	16.28	21.88	21.80	21.84	34.20	34.12	34.16
$A_3P_1S_1$	0.00	0.00	0.00	20.95	20.87	20.91	25.87	25.81	25.84	37.90	37.77	37.84	55.99	56.84	56.42
$A_3P_1S_2$	0.00	0.00	0.00	18.67	18.57	18.62	20.77	20.65	20.71	34.81	34.72	34.77	47.79	47.57	47.68
$A_3P_2S_1$	0.00	0.00	0.00	20.81	20.74	20.78	25.71	25.62	25.67	37.74	37.65	37.70	53.67	53.52	53.60
$A_3P_2S_2$	0.00	0.00	0.00	18.61	18.52	18.57	20.68	20.61	20.65	23.60	23.51	23.56	40.63	40.57	40.60
$A_3P_3S_1$	0.00	0.00	0.00	16.45	16.38	16.42	19.71	19.43	19.57	26.65	26.56	26.61	37.94	37.46	37.70
$A_3P_3S_2$	0.00	0.00	0.00	15.49	15.23	15.36	16.67	16.59	16.63	23.52	23.47	23.50	36.51	36.37	36.44
$A_3P_4S_1$	0.00	0.00	0.00	16.11	16.04	16.08	18.50	18.39	18.45	26.46	26.38	26.42	37.57	37.78	37.68
$A_3P_4S_2$	0.00	0.00	0.00	15.36	15.27	15.32	16.48	16.37	16.43	23.37	23.31	23.34	36.46	36.32	36.39
SEm (±)	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.02	0.03	0.20	0.02	0.14
CD 1%	0.00	0.00	0.00	0.08	0.08	0.08	0.08	0.11	0.09	0.13	0.08	0.10	0.78	0.08	0.53
Treated	0.00	0.00	0.00	17.59	17.49	17.54	21.28	21.10	21.19	29.36	29.28	29.32	43.87	43.68	43.77
Control	0.00	0.00	0.00	34.19	34.07	34.13	42.37	42.30	42.34	55.90	55.78	55.84	73.01	72.89	72.95
SEm (±)	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.03	0.02	0.03	0.02	0.03	0.20	0.02	0.14
CD 1%	0.00	0.00	0.00	0.06	0.06	0.05	0.06	0.08	0.07	0.09	0.06	0.07	0.56	0.06	0.38

	10 days			12 days			14 days			16 days			18 days		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
A_1	63.80	63.81	63.80	77.81	77.79	77.80	87.40	87.31	87.36	93.75	93.66	93.70	96.88	96.80	96.84
A_2	52.70	52.74	52.72	69.22	69.14	69.18	80.13	80.01	80.07	87.89	87.76	87.83	91.05	90.90	90.98
A_3	59.63	59.55	59.59	75.74	75.67	75.71	85.45	85.35	85.40	90.32	90.22	90.27	93.59	93.46	93.53
SEm (±)	0.01	0.01	0.01	0.01	0.01	0.01	-	-	-	-	-	-	-	-	-
CD 1%	0.03	0.03	0.03	0.03	0.03	0.03	-	-	-	-	-	-	-	-	-
P_1	70.98	71.08	71.03	85.35	85.27	85.31	93.75	93.65	93.70	97.07	96.91	96.99	-	-	-
P_2	63.41	63.48	63.45	75.63	75.54	75.59	86.36	86.26	86.31	95.50	95.39	95.45	97.00	97.85	97.43
P_3	50.34	50.23	50.28	68.19	68.13	68.16	80.01	79.91	79.96	89.25	89.14	89.19	93.01	92.86	92.93
P_4	50.10	50.02	50.06	67.87	67.85	67.86	79.63	79.51	79.57	86.83	86.73	86.78	92.15	91.84	92.00
SEm (±)	0.01	0.01	0.01	0.01	0.01	0.01	-	-	-	-	-	-	-	-	-
CD 1%	0.03	0.03	0.03	0.03	0.03	0.03	-	-	-	-	-	-	-	-	-
S_1	63.70	63.61	63.65	79.17	79.07	79.12	87.43	87.32	87.37	93.70	93.58	93.64	96.16	95.73	95.94
S_2	53.72	53.79	53.76	69.35	69.32	69.34	81.40	81.29	81.34	87.97	87.86	87.92	91.61	91.62	91.62
SEm (±)	0.01	0.01	0.01	0.01	0.01	0.01	-	-	-	-	-	-	-	-	-
CD 1%	0.02	0.02	0.02	0.02	0.02	0.02	-	-	-	-	-	-	-	-	-
A_1P_1	77.23	77.15	77.19	90.43	90.36	90.39	97.87	97.78	97.83	-	-	-	-	-	-
A_1P_2	70.80	71.12	70.96	78.84	78.74	78.79	90.77	90.69	90.73	97.85	97.76	97.81	-	-	-
A_1P_3	53.64	53.53	53.58	71.11	71.03	71.07	83.16	83.07	83.11	92.82	92.74	92.78	96.91	96.84	96.88
A_1P_4	53.53	53.45	53.49	70.89	71.01	70.95	83.06	82.94	83.00	92.64	92.53	92.58	96.84	96.76	96.80
A_2P_1	64.14	64.56	64.35	77.30	77.20	77.25	89.88	89.78	89.83	97.07	96.91	96.99	-	-	-
A_2P_2	51.96	51.88	51.92	68.93	68.84	68.89	77.47	77.31	77.39	93.51	93.40	93.45	97.00	97.85	97.43
A_2P_3	47.40	47.32	47.36	65.50	65.43	65.46	76.95	76.82	76.88	83.85	83.72	83.79	91.96	91.81	91.88
A_2P_4	47.31	47.23	47.27	65.17	65.08	65.13	76.24	76.13	76.18	81.72	81.61	81.66	87.17	86.53	86.85
A_3P_1	71.57	71.53	71.55	88.32	88.24	88.28	97.39	97.27	97.33	-	-	-	-	-	-
A_3P_2	67.49	67.45	67.47	79.13	79.04	79.08	90.86	90.79	90.83	97.14	97.00	97.07	-	-	-
A_3P_3	50.00	49.84	49.92	67.98	67.94	67.96	79.93	79.83	79.88	91.08	90.97	91.02	91.19	91.00	91.10
A_3P_4	49.47	49.38	49.42	67.55	67.47	67.51	79.59	79.47	79.53	86.15	86.07	86.11	94.79	94.69	94.74
SEm(±)	0.01	0.01	0.01	0.01	0.01	0.01	-	-	-	-	-	-	-	-	-
CD1%	0.06	0.06	0.05	0.05	0.05	0.05	-	-	-	-	-	-	-	-	-

	10 days			12 days			14 days			16 days			18 days		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
A_1S_1	73.26	73.17	73.22	85.78	85.68	85.73	95.93	95.85	95.89	98.80	98.69	98.75	-	-	-
A_1S_2	59.59	59.97	59.78	72.94	72.97	72.96	84.37	84.26	84.31	93.80	93.68	93.74	96.84	96.76	96.80
A_2S_1	65.08	65.00	65.04	80.61	80.52	80.57	84.28	84.16	84.22	91.33	91.22	91.27	91.15	90.02	90.59
A_2S_2	52.41	52.60	52.50	69.25	69.16	69.20	82.93	82.80	82.87	88.29	88.16	88.23	90.09	90.45	90.27
A_3S_1	65.59	65.49	65.54	81.95	81.86	81.90	88.52	88.44	88.48	94.17	94.08	94.13	98.70	98.62	98.66
A_3S_2	53.67	53.61	53.64	69.54	69.49	69.51	83.15	83.04	83.09	87.75	87.64	87.70	91.04	90.88	90.96
SEm (±)	0.01	0.01	0.01	0.01	0.01	0.01	-	-	-	-	-	-	-	-	-
CD 1%	0.04	0.04	0.04	0.04	0.04	0.04	-	-	-	-	-	-	-	-	-
P_1S_1	80.91	80.82	80.87	95.28	95.19	95.24	99.62	99.56	99.59	-	-	-	-	-	-
P_1S_2	61.04	61.34	61.19	75.41	75.34	75.38	91.80	91.68	91.74	97.07	96.91	96.99	-	-	-
P_2S_1	68.35	68.27	68.31	79.96	79.84	79.90	91.64	91.53	91.59	99.54	99.43	99.49	-	-	-
P_2S_2	58.47	58.69	58.58	71.31	71.24	71.27	81.09	80.99	81.04	94.16	94.04	94.10	97.00	97.85	97.43
P_3S_1	52.93	52.83	52.88	70.94	70.85	70.90	83.60	83.48	83.54	94.94	94.83	94.89	98.63	98.54	98.59
P_3S_2	47.75	47.62	47.69	65.45	65.41	65.43	76.43	76.33	76.38	83.55	83.46	83.50	91.13	90.97	91.05
P_4S_1	52.58	52.52	52.55	70.50	70.41	70.45	82.98	82.87	82.92	90.50	90.39	90.45	94.93	94.32	94.62
P_4S_2	47.61	47.51	47.56	65.24	65.30	65.27	76.28	76.15	76.22	83.17	83.07	83.12	90.30	90.19	90.24
SEm (±)	0.01	0.01	0.01	0.01	0.01	0.01	-	-	-	-	-	-	-	-	-
CD 1%	0.05	0.05	0.04	0.04	0.04	0.04	-	-	-	-	-	-	-	-	-

A₁P₁S₁	84.82	84.73	84.78	100.00	99.95	99.98	-	-	-	-	-	-	-	-	-
A₁P₁S₂	69.64	69.57	69.61	80.85	80.77	80.81	97.87	97.78	97.83	-	-	-	-	-	-
A₁P₂S₁	74.51	74.38	74.45	82.76	82.63	82.70	99.93	99.86	99.90	-	-	-	-	-	-
A₁P₂S₂	67.08	67.86	67.47	74.91	74.85	74.88	81.60	81.52	81.56	97.85	97.76	97.81	-	-	-
A₁P₃S₁	57.35	57.27	57.31	74.79	74.70	74.75	88.39	88.31	88.35	98.82	98.74	98.78	-	-	-
A₁P₃S₂	49.92	49.78	49.85	67.42	67.36	67.39	77.92	77.83	77.88	86.81	86.73	86.77	96.91	96.84	96.88
A₁P₄S₁	57.20	57.14	57.17	74.41	74.32	74.37	88.24	88.13	88.19	98.80	98.69	98.75	-	-	-
A₁P₄S₂	49.85	49.75	49.80	67.37	67.70	67.54	77.87	77.74	77.81	86.47	86.36	86.42	96.84	96.76	96.80

	10 days			12 days			14 days			16 days			18 days		
	Trial I	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**
A₂P₁S₁	76.51	76.43	76.47	85.96	85.83	85.90	99.62	99.56	99.59	-	-	-	-	-	-
A₂P₁S₂	51.77	52.69	52.23	68.63	68.56	68.60	80.13	80.00	80.07	97.07	96.91	96.99	-	-	-
A₂P₂S₁	53.24	53.17	53.21	69.37	69.28	69.33	75.18	75.02	75.10	99.54	99.43	99.49	-	-	-
A₂P₂S₂	50.67	50.58	50.63	68.49	68.40	68.45	79.75	79.60	79.68	87.48	87.36	87.42	97.00	97.85	97.43
A₂P₃S₁	49.23	49.16	49.20	67.71	67.58	67.65	79.29	79.10	79.20	87.26	87.07	87.17	98.63	98.54	98.59
A₂P₃S₂	45.56	45.47	45.52	63.29	63.27	63.28	74.61	74.53	74.57	80.44	80.37	80.41	85.29	85.07	85.18
A₂P₄S₁	49.14	49.09	49.12	67.24	67.16	67.20	78.04	77.91	77.98	83.11	83.00	83.06	91.15	90.02	90.59
A₂P₄S₂	45.47	45.36	45.42	63.10	63.00	63.05	74.44	74.34	74.39	80.32	80.21	80.27	83.18	83.04	83.11
A₃P₁S₁	81.41	81.29	81.35	99.88	99.80	99.84	-	-	-	-	-	-	-	-	-
A₃P₁S₂	61.72	61.76	61.74	76.76	76.68	76.72	97.39	97.27	97.33	-	-	-	-	-	-
A₃P₂S₁	77.31	77.25	77.28	87.74	87.61	87.68	99.80	99.72	99.76	-	-	-	-	-	-
A₃P₂S₂	57.67	57.64	57.66	70.52	70.46	70.49	81.92	81.86	81.89	97.14	97.00	97.07	-	-	-
A₃P₃S₁	52.21	52.07	52.14	70.32	70.27	70.30	83.11	83.03	83.07	98.75	98.67	98.71	-	-	-
A₃P₃S₂	47.78	47.61	47.70	65.63	65.61	65.62	76.75	76.63	76.69	83.40	83.27	83.34	91.19	91.00	91.10
A₃P₄S₁	51.41	51.33	51.37	69.85	69.74	69.80	82.65	82.56	82.61	89.59	89.49	89.54	98.70	98.62	98.66
A₃P₄S₂	47.52	47.43	47.48	65.24	65.19	65.22	76.52	76.38	76.45	82.71	82.65	82.68	90.88	90.76	90.82
SEm (±)	0.02	0.02	0.02	0.02	0.02	0.02	-	-	-	-	-	-	-	-	-
CD 1%	0.08	0.08	0.08	0.07	0.08	0.07	-	-	-	-	-	-	-	-	-
Treated	58.71	58.70	58.70	74.26	74.20	74.23	84.14	84.03	84.08	90.33	90.22	90.27	92.98	92.85	92.91
Control	100.00	99.98	99.99	-	-	-	-	-	-	-	-	-	-	-	-
SEm (±)	0.02	0.02	0.02	-	-	-	-	-	-	-	-	-	-	-	-
CD 1%	0.06	0.06	0.05	-	-	-	-	-	-	-	-	-	-	-	-

	20 days			22 days			24 days			26 days		
	Trial I	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**
A₁	-	-	-	-	-	-	-	-	-	-	-	-
A₂	91.77	91.68	91.72	93.41	93.28	93.34	95.64	95.56	95.60	96.68	96.56	96.62
A₃	94.97	94.84	94.90	96.74	96.61	96.68	-	-	-	-	-	-
SEm (±)	-	-	-	-	-	-	-	-	-	-	-	-
CD 1%	-	-	-	-	-	-	-	-	-	-	-	-
P₁	-	-	-	-	-	-	-	-	-	-	-	-
P₂	-	-	-	-	-	-	-	-	-	-	-	-
P₃	94.36	94.24	94.30	94.72	94.64	94.68	96.72	96.65	96.69	-	-	-
P₄	92.17	92.08	92.13	94.42	94.26	94.34	94.55	94.47	94.51	96.68	96.56	96.62
SEm (±)	-	-	-	-	-	-	-	-	-	-	-	-
CD 1%	-	-	-	-	-	-	-	-	-	-	-	-
S₁	98.57	98.45	98.51	-	-	-	-	-	-	-	-	-
S₂	91.67	91.57	91.62	94.52	94.39	94.45	95.64	95.56	95.60	96.68	96.56	96.62
SEm (±)	-	-	-	-	-	-	-	-	-	-	-	-
CD 1%	-	-	-	-	-	-	-	-	-	-	-	-
A₁P₁	-	-	-	-	-	-	-	-	-	-	-	-
A₁P₂	-	-	-	-	-	-	-	-	-	-	-	-
A₁P₃	-	-	-	-	-	-	-	-	-			
A₁P₄	-	-	-	-	-	-	-	-	-	-	-	-
A₂P₁	-	-	-	-	-	-	-	-	-	-	-	-
A₂P₂	-	-	-	-	-	-	-	-	-	-	-	-
A₂P₃	91.91	91.83	91.87	94.72	94.64	94.68	96.72	96.65	96.69	-	-	-
A₂P₄	91.70	91.61	91.65	92.10	91.91	92.01	94.55	94.47	94.51	96.68	96.56	96.62
A₃P₁	-	-	-	-	-	-	-	-	-	-	-	-
A₃P₂	-	-	-	-	-	-	-	-	-	-	-	-
A₃P₃	96.80	96.65	96.73	-	-	-	-	-	-	-	-	-
A₃P₄	93.13	93.02	93.08	96.74	96.61	96.68	-	-	-	-	-	-
SEm(±)	-	-	-	-	-	-	-	-	-	-	-	-
CD1%	-	-	-	-	-	-	-	-	-	-	-	-

	20 days			22 days			24 days			26 days		
	Trial I	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**
A₁S₁	-	-	-	-	-	-	-	-	-	-	-	-
A₁S₂	-	-	-	-	-	-	-	-	-	-	-	-
A₂S₁	98.57	98.45	98.51	-	-	-	-	-	-	-	-	-
A₂S₂	84.82	84.76	84.79	92.10	91.91	92.01	94.55	94.47	94.51	96.68	96.56	96.62
A₃S₁	-	-	-	-	-	-	-	-	-	-	-	-
A₃S₂	94.97	94.84	94.90	96.74	96.61	96.68	-	-	-	-	-	-
SEm (±)	-	-	-	-	-	-	-	-	-	-	-	-
CD 1%	-	-	-	-	-	-	-	-	-	-	-	-
P₁S₁	-	-	-	-	-	-	-	-	-	-	-	-
P₁S₂	-	-	-	-	-	-	-	-	-	-	-	-
P₂S₁	-	-	-	-	-	-	-	-	-	-	-	-
P₂S₂	-	-	-	-	-	-	-	-	-	-	-	-
P₃S₁	-	-	-	-	-	-	-	-	-	-	-	-
P₃S₂	94.36	94.24	94.30	94.72	94.64	94.68	96.72	96.65	96.69	-	-	-

P_4S_1	98.57	98.45	98.51	-	-	-	-	-	-	-	-	-
P_4S_2	88.98	88.89	88.93	94.42	94.26	94.34	94.55	94.47	94.51	96.68	96.56	96.62
SEm (±)	-	-	-	-	-	-	-	-	-	-	-	-
CD 1%	-	-	-	-	-	-	-	-	-	-	-	-
$A_1P_1S_1$	-	-	-	-	-	-	-	-	-	-	-	-
$A_1P_1S_2$	-	-	-	-	-	-	-	-	-	-	-	-
$A_1P_2S_1$	-	-	-	-	-	-	-	-	-	-	-	-
$A_1P_2S_2$	-	-	-	-	-	-	-	-	-	-	-	-
$A_1P_3S_1$	-	-	-	-	-	-	-	-	-	-	-	-
$A_1P_3S_2$	-	-	-	-	-	-	-	-	-	-	-	-
$A_1P_4S_1$	-	-	-	-	-	-	-	-	-	-	-	-
$A_1P_4S_2$	-	-	-	-	-	-	-	-	-	-	-	-
$A_2P_1S_1$	-	-	-	-	-	-	-	-	-	-	-	-
$A_2P_1S_2$	-	-	-	-	-	-	-	-	-	-	-	-
$A_2P_2S_1$	-	-	-	-	-	-	-	-	-	-	-	-
$A_2P_2S_2$	-	-	-	-	-	-	-	-	-	-	-	-
$A_2P_3S_1$	-	-	-	-	-	-	-	-	-	-	-	-

	20 days			**22 days**			**24 days**			**26 days**		
	Trial I	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**
$A_2P_2S_2$	-	-	-	-	-	-	-	-	-	-	-	-
$A_2P_3S_1$	-	-	-	-	-	-	-	-	-	-	-	-
$A_2P_3S_2$	91.91	91.83	91.87	94.72	94.64	94.68	96.72	96.65	96.69	-	-	-
$A_2P_4S_1$	98.57	98.45	98.51	-	-	-	-	-	-	-	-	-
$A_2P_4S_2$	84.82	84.76	84.79	92.10	91.91	92.01	94.55	94.47	94.51	96.68	96.56	96.62
$A_3P_1S_1$	-	-	-	-	-	-	-	-	-	-	-	-
$A_3P_1S_2$	-	-	-	-	-	-	-	-	-	-	-	-
$A_3P_2S_1$	-	-	-	-	-	-	-	-	-	-	-	-
$A_3P_2S_2$	-	-	-	-	-	-	-	-	-	-	-	-
$A_3P_3S_1$	-	-	-	-	-	-	-	-	-	-	-	-
$A_3P_3S_2$	96.80	96.65	96.73	-	-	-	-	-	-	-	-	-
$A_3P_4S_1$	-	-	-	-	-	-	-	-	-	-	-	-
$A_3P_4S_2$	93.13	93.02	93.08	96.74	96.61	96.68	-	-	-	-	-	-
SEm (±)	-	-	-	-	-	-	-	-	-	-	-	-
CD 1%	-	-	-	-	-	-	-	-	-	-	-	-
Treated	93.05	92.94	92.99	94.52	94.39	94.45	95.64	95.56	95.60	96.68	96.56	96.62
Control	-	-	-	-	-	-	-	-	-	-	-	-
SEm (±)	-	-	-	-	-	-	-	-	-	-	-	-
CD 1%	-	-	-	-	-	-	-	-	-	-	-	-

A_1: Putrescine (5mM) A_2: Spermine (5µM) P_1: Perforated polyethylene bag P_2: Nano silver based bag S_1: Ambient temperature
A_3: Spermidine (4mM) P_3: $KMnO_4$ ethylene absorber (4g) P_4: $KMnO_4$ ethylene absorber (6g) S_2 : Cold storage (13^0C +1)

Spoilage (%). The data regarding spoilage of banana fruits as influenced by different polyamines, packaging materials and storage conditions have been presented in Table 2. It was observed that, spoilage found to be increased during storage period. The spoilage of banana fruits of any treatment reached up to 50%, it is considered as the end of storage life and such treatments were discarded.

The individual effect of polyamines showed significant influence on spoilage of banana fruits. On 12th day of storage, the treatment A_2 *i.e.* spermine 5 µM recorded minimum spoilage (17.15 %) whereas the treatment A_1*i.e.* putrescine 5 mM recorded maximum spoilage (34.33 %). On 26th day of storage, only one treatment A_2*i.e.* spermine 5 µM remained in storage which was spoilage of 47.21%.

The data regarding spoilage was found significant influence irrespective of packaging materials. On 12th day of storage, the treatment P_4*i.e.* $KMnO_4$ based ethylene absorber 6 g recorded minimum spoilage (16.52 %) whereas the treatment P_1 *i.e.* perforated polyethylene bag recorded maximum spoilage (39.11 %). On 26th day of storage, fruits treated with P_4*i.e.* $KMnO_4$ based ethylene absorber 6g recorded 47.21% spoilage at the end of storage.

The data on spoilage varied significantly among different storage conditions. Fruits stored under ambient conditions recorded faster increased in spoilage than cold storage. On 20th day of storage, fruits under ambient conditions S_1 recorded spoilage of 50.33%. On 26th day of storage, the fruits kept under cold storage S_2 recorded the spoilage of 47.21%.

The data on spoilage indicated significant influence due to polyamines and packaging materials. On 12th day of storage, the treatment combination A_2P_4 *i.e.* spermine 5 µM + $KMnO_4$ based ethylene absorber 6 g recorded minimum spoilage (7.37 %) followed by the treatment A_2P_3 (7.65) whereas the treatment combination A_1P_1*i.e.* putrescine 5 mM + perforated polyethylene bag recorded maximum spoilage (44.38 %). On 26th day of storage, only fruits treated with A_2P_4 *i.e.* spermine 5 µM + $KMnO_4$ based ethylene absorber 6g remained in storage which had recorded the spoilage of 47.21% spoilage.

Effect of polyamines and storage conditions showed significant influenced on spoilage. On 12th day of storage, the treatment combination of A_2S_2 *i.e.* spermine 5 µM + cold storage recorded minimum spoilage (17.33 %) whereas the treatment combination A_1S_1*i.e.* putrescine 5 mM + ambient temperature recorded maximum spoilage (43.12 %). Fruits treated with A_2S_2 *i.e.* spermine 5 µM + cold storage remained in storage up to 26th day with 47.21% spoilage.

Effect of packaging materials and storage conditions showed significant influenced on spoilage. On 12th day of storage, the treatment combination P_4S_2 *i.e.* $KMnO_4$ based ethylene absorber 6g + cold storage recorded minimum spoilage (8.34 %) while the treatment combination P_1S_1 *i.e.* perforated polyethylene bag + ambient temperature observed maximum spoilage

(46.91 %). On 26th day of spoilage, fruits treated with P_4S_2 *i.e*. $KMnO_4$ based ethylene absorber 6g + cold storage recorded spoilage of 47.21%.

The interaction effect of polyamines, packaging materials and storage conditions showed significant influenced on spoilage of banana fruits. The fruits under ambient conditions rate of increase in spoilage was very fast than cold storage. On 12th day of storage, the treatment combination of $A_2P_4S_2$ *i.e*. spermine 5 µM + $KMnO_4$ based ethylene absorber 6 g + cold storage was recorded minimum spoilage (0.00 %) whereas maximum spoilage was recorded in $A_1P_1S_1$ *i.e*. putrescine 5 mM + perforated polyethylene bag + ambient temperature (51.74 %) statistically followed by $A_3P_1S_1$ (51.58 %). On 26th day of storage, it was noted that, interaction of $A_2P_4S_2$ *i.e*. spermine 5 µM + $KMnO_4$ based ethylene absorber 6g + cold storage revealed slower increase in spoilage and recorded the spoilage of 47.21%. The mean spoilage in treated fruits were 47.21% at the end of storage life whereas, fruits in control treatment showed 76.16% spoilage at 10th day of storage under ambient conditions.

The reduced spoilage in polyamine treated fruits could be mainly attributed to the retarded fruit ripening, because susceptibility to pathogens increases with ripeness. Similar findings were reported in mango by Malik and Singh (2003).

The combined effect of packaging material and ethylene absorbers in producing minimum attributed to partly to the moisture conservation by the polyethylene bags around the produce to reduce moisture loss and shriveling of banana fruit, to cut off the concentration of ethylene and enzymatic activity and consequently slowing down the rate of respiration (Zewter *et al*., 2012). The lower spoilage in fruits packed in LDPE may also be due to the accumulation of CO_2 within the polyethylene bags and its preservative effects (Hardenburg, 1956). The reduced spoilage by using active packaging technology has earlier been reported by Szczerbanik *et al*. (2005) in Japanese pear, Bhutia *et al*. (2011) in sapota, Lal and Dayal (2014) in date palm, Mir *et al*. (2018) in peach and Sarkar *et al*. (2017) in banana.

Table 2: Effect of different polyamines, packaging materials and storage conditions on spoilage (%) of banana fruit *cv.* Grand Naine during storage.

Treatmt.	Initial days			2 days			4 days			6 days			8 days		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
A_1	0.00	0.00	0.00	3.51	3.42	3.46	9.11	9.05	9.08	14.31	14.24	14.28	20.77	20.67	20.72
A_2	0.00	0.00	0.00	0.71	0.68	0.70	2.00	1.98	1.99	6.69	6.62	6.66	9.16	9.07	9.12
A_3	0.00	0.00	0.00	2.26	2.21	2.23	6.69	6.61	6.65	12.60	12.54	12.57	17.39	17.32	17.35
SEm (±)	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CD 1%	0.00	0.00	0.00	0.04	0.04	0.04	0.04	0.05	0.04	0.05	0.05	0.05	0.05	0.06	0.05
P_1	0.00	0.00	0.00	2.74	2.66	2.70	9.64	9.58	9.61	19.25	19.14	19.20	25.63	25.52	25.58
P_2	0.00	0.00	0.00	2.17	2.10	2.13	8.40	8.34	8.37	15.78	15.67	15.72	23.07	22.96	23.01
P_3	0.00	0.00	0.00	2.47	2.42	2.44	3.49	3.45	3.47	5.90	5.87	5.88	9.18	9.09	9.14
P_4	0.00	0.00	0.00	1.25	1.23	1.24	2.19	2.15	2.17	3.89	3.86	3.87	5.22	5.17	5.19
SEm (±)	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.02	0.02	0.02	0.01	0.02	0.02
CD 1%	0.00	0.00	0.00	0.04	0.04	0.04	0.05	0.05	0.05	0.06	0.06	0.06	0.05	0.07	0.06
S_1	0.00	0.00	0.00	3.87	3.77	3.82	8.81	8.73	8.77	16.89	16.80	16.84	22.62	22.50	22.56
S_2	0.00	0.00	0.00	0.45	0.43	0.44	3.06	3.03	3.04	5.52	5.47	5.49	8.93	8.87	8.90
SEm (±)	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CD 1%	0.00	0.00	0.00	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.04	0.04	0.04	0.05	0.04
A_1P_1	0.00	0.00	0.00	4.63	4.49	4.56	13.36	13.28	13.32	23.68	23.57	23.62	29.22	29.14	29.18
A_1P_2	0.00	0.00	0.00	1.22	1.15	1.19	12.06	12.00	12.03	17.78	17.68	17.73	29.16	29.04	29.10
A_1P_3	0.00	0.00	0.00	4.43	4.35	4.39	5.88	5.84	5.86	8.87	8.84	8.85	15.01	14.91	14.96
A_1P_4	0.00	0.00	0.00	3.76	3.69	3.72	5.13	5.09	5.11	6.94	6.89	6.91	9.69	9.61	9.65
A_2P_1	0.00	0.00	0.00	1.76	1.73	1.75	4.45	4.41	4.43	13.76	13.64	13.70	17.71	17.57	17.64
A_2P_2	0.00	0.00	0.00	1.07	1.00	1.04	3.54	3.50	3.52	10.95	10.83	10.89	15.01	14.88	14.94
A_2P_3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.06	2.02	2.04	3.93	3.85	3.89
A_2P_4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
A_3P_1	0.00	0.00	0.00	1.84	1.78	1.81	11.12	11.06	11.09	20.31	20.23	20.27	29.98	29.87	29.92
A_3P_2	0.00	0.00	0.00	4.21	4.15	4.18	9.62	9.53	9.57	18.61	18.50	18.55	25.05	24.96	25.00
A_3P_3	0.00	0.00	0.00	2.99	2.91	2.95	4.59	4.50	4.55	6.77	6.74	6.75	8.60	8.53	8.56
A_3P_4	0.00	0.00	0.00	0.00	0.00	0.00	1.43	1.37	1.40	4.72	4.69	4.71	5.96	5.92	5.94
SEm(±)	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03	0.03	0.02	0.03	0.03
CD1%	0.00	0.00	0.00	0.08	0.07	0.07	0.08	0.09	0.09	0.11	0.11	0.10	0.09	0.11	0.10
	Initial days			2 days			4 days			6 days			8 days		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
A_1S_1	0.00	0.00	0.00	4.34	4.22	4.28	12.63	12.56	12.59	21.81	21.70	21.75	30.23	30.11	30.17
A_1S_2	0.00	0.00	0.00	1.34	1.30	1.32	4.87	4.83	4.85	9.27	9.19	9.23	12.66	12.57	12.62
A_2S_1	0.00	0.00	0.00	2.33	2.25	2.29	7.10	7.04	7.07	17.06	16.98	17.02	22.40	22.29	22.34
A_2S_2	0.00	0.00	0.00	0.00	0.00	0.00	2.45	2.44	2.45	5.45	5.37	5.41	8.95	8.87	8.91
A_3S_1	0.00	0.00	0.00	4.51	4.42	4.46	9.08	8.97	9.02	18.86	18.77	18.81	23.70	23.58	23.64
A_3S_2	0.00	0.00	0.00	0.00	0.00	0.00	4.30	4.26	4.28	6.35	6.31	6.33	11.09	11.05	11.07
SEm (±)	0.00	0.00	0.00	0.01	0.01	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
CD 1%	0.00	0.00	0.00	0.05	0.05	0.05	0.06	0.07	0.06	0.08	0.08	0.07	0.06	0.08	0.07
P_1S_1	0.00	0.00	0.00	3.69	3.59	3.64	12.92	12.84	12.88	26.67	26.54	26.60	33.71	33.61	33.66
P_1S_2	0.00	0.00	0.00	1.79	1.74	1.76	6.36	6.31	6.34	11.83	11.75	11.79	17.55	17.44	17.50
P_2S_1	0.00	0.00	0.00	4.33	4.20	4.26	10.95	10.88	10.92	21.31	21.21	21.26	30.25	30.11	30.18
P_2S_2	0.00	0.00	0.00	0.00	0.00	0.00	5.86	5.80	5.83	10.24	10.12	10.18	15.89	15.80	15.85
P_3S_1	0.00	0.00	0.00	4.94	4.84	4.89	6.98	6.89	6.94	11.80	11.73	11.76	16.07	15.94	16.01
P_3S_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	2.28	2.24	2.26
P_4S_1	0.00	0.00	0.00	2.50	2.46	2.48	4.37	4.30	4.34	7.77	7.72	7.75	10.43	10.35	10.39
P_4S_2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

SEm (±)	0.00	0.00	0.00	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
CD 1%	0.00	0.00	0.00	0.06	0.06	0.06	0.07	0.08	0.07	0.09	0.09	0.08	0.07	0.09	0.08
$A_1P_1S_1$	0.00	0.00	0.00	3.89	3.76	3.83	17.44	17.38	17.41	29.89	29.76	29.83	36.24	36.17	36.21
$A_1P_1S_2$	0.00	0.00	0.00	5.37	5.21	5.29	9.28	9.17	9.23	17.46	17.38	17.42	22.20	22.10	22.15
$A_1P_2S_1$	0.00	0.00	0.00	2.44	2.30	2.37	13.93	13.86	13.90	20.84	20.76	20.80	35.89	35.78	35.84
$A_1P_2S_2$	0.00	0.00	0.00	0.00	0.00	0.00	10.19	10.13	10.16	14.71	14.59	14.65	22.43	22.30	22.37
$A_1P_3S_1$	0.00	0.00	0.00	8.85	8.69	8.77	11.76	11.67	11.72	17.74	17.67	17.71	23.17	23.09	23.13
$A_1P_3S_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.85	6.73	6.79
$A_1P_4S_1$	0.00	0.00	0.00	7.51	7.37	7.44	10.25	10.17	10.21	13.87	13.78	13.83	19.38	19.21	19.30
$A_1P_4S_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

	Initial days			**2 days**			**4 days**			**6 days**			**8 days**		
	Trial I	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**
$A_2P_1S_1$	0.00	0.00	0.00	3.52	3.46	3.49	8.90	8.81	8.86	22.62	22.49	22.56	29.40	29.26	29.33
$A_2P_1S_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.90	4.78	4.84	6.01	5.88	5.95
$A_2P_2S_1$	0.00	0.00	0.00	2.14	2.00	2.07	7.07	7.00	7.04	18.13	18.04	18.09	24.68	24.51	24.60
$A_2P_2S_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	3.76	3.61	3.69	5.33	5.24	5.29
$A_2P_3S_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	4.12	4.04	4.08	7.85	7.69	7.77
$A_2P_3S_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$A_2P_4S_1$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$A_2P_4S_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$A_3P_1S_1$	0.00	0.00	0.00	3.67	3.55	3.61	12.42	12.34	12.38	27.49	27.37	27.43	35.50	35.39	35.45
$A_3P_1S_2$	0.00	0.00	0.00	0.00	0.00	0.00	9.81	9.77	9.79	13.13	13.08	13.11	24.45	24.34	24.40
$A_3P_2S_1$	0.00	0.00	0.00	8.41	8.29	8.35	11.85	11.78	11.82	24.97	24.83	24.90	30.18	30.05	30.12
$A_3P_2S_2$	0.00	0.00	0.00	0.00	0.00	0.00	7.38	7.27	7.33	12.25	12.16	12.21	19.91	19.87	19.89
$A_3P_3S_1$	0.00	0.00	0.00	5.97	5.82	5.90	9.18	9.00	9.09	13.53	13.48	13.51	17.19	17.05	17.12
$A_3P_3S_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
$A_3P_4S_1$	0.00	0.00	0.00	0.00	0.00	0.00	2.86	2.74	2.80	9.44	9.38	9.41	11.91	11.83	11.87
$A_3P_4S_2$	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SEm (±)	0.00	0.00	0.00	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.04	0.03	0.04	0.04
CD 1%	0.00	0.00	0.00	0.11	0.10	0.10	0.12	0.13	0.12	0.15	0.15	0.15	0.13	0.16	0.14
Treated	0.00	0.00	0.00	2.16	2.10	2.13	5.93	5.88	5.90	11.20	11.13	11.17	15.77	15.69	15.73
Control	0.00	0.00	0.00	5.26	5.13	5.20	19.90	19.76	19.83	36.76	36.61	36.69	47.49	47.37	47.43
SEm (±)	0.00	0.00	0.00	0.03	0.03	0.03	0.04	0.03	0.04	0.04	0.04	0.04	0.03	0.04	0.04
CD 1%	0.00	0.00	0.00	0.08	0.08	0.07	0.10	0.10	0.10	0.11	0.11	0.11	0.09	0.12	0.10

	10 days			**12 days**			**14 days**			**16 days**			**18 days**		
	Trial I	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**
A_1	28.10	27.98	28.04	34.39	34.28	34.33	39.29	39.17	39.23	41.87	41.78	41.83	47.91	47.82	47.86
A_2	13.57	13.48	13.52	17.20	17.11	17.15	26.01	25.89	25.95	29.15	29.03	29.09	30.61	30.50	30.56
A_3	23.43	23.29	23.36	30.47	30.38	30.42	35.61	35.50	35.55	37.44	37.34	37.39	39.47	39.36	39.42
SEm (±)	0.01	0.01	0.01	0.01	0.01	0.01	-	-	-	-	-	-	-	-	-
CD 1%	0.03	0.03	0.03	0.04	0.04	0.04	-	-	-	-	-	-	-	-	-
P_1	33.01	32.87	32.94	39.17	39.05	39.11	45.25	45.15	45.20	48.70	48.58	48.64	-	-	-
P_2	29.13	29.02	29.08	34.56	34.47	34.52	41.34	41.20	41.27	45.03	44.93	44.98	48.67	48.51	48.59
P_3	14.00	13.87	13.93	19.11	19.02	19.06	27.93	27.83	27.88	33.81	33.70	33.75	36.45	36.37	36.41
P_4	10.67	10.57	10.62	16.57	16.48	16.52	22.62	22.50	22.56	28.16	28.06	28.11	34.56	34.45	34.50
SEm (±)	0.01	0.01	0.01	0.01	0.01	0.01	-	-	-	-	-	-	-	-	-
CD 1%	0.04	0.06	0.05	0.04	0.04	0.04	-	-	-	-	-	-	-	-	-
S_1	28.30	28.19	28.24	35.61	35.50	35.56	40.14	40.03	40.08	42.70	42.59	42.64	44.42	44.31	44.37
S_2	15.10	14.98	15.04	19.09	19.00	19.05	27.58	27.46	27.52	30.17	30.07	30.12	33.43	33.33	33.38
SEm (±)	0.01	0.01	0.01	0.01	0.01	0.01	-	-	-	-	-	-	-	-	-
CD 1%	0.03	0.04	0.03	0.03	0.03	0.03	-	-	-	-	-	-	-	-	-
A_1P_1	37.56	37.42	37.49	44.46	44.31	44.38	48.80	48.71	48.76	-	-	-	-	-	-
A_1P_2	36.65	36.54	36.59	42.79	42.72	42.75	46.57	46.42	46.49	48.76	48.69	48.73	-	-	-
A_1P_3	21.57	21.42	21.50	26.19	26.09	26.14	33.54	33.46	33.50	40.94	40.86	40.90	48.00	47.91	47.96
A_1P_4	16.64	16.55	16.59	24.11	24.00	24.05	33.00	32.88	32.94	39.37	39.25	39.31	47.81	47.72	47.77
A_2P_1	25.50	25.41	25.45	28.96	28.85	28.90	41.73	41.64	41.69	48.70	48.58	48.64	-	-	-
A_2P_2	19.71	19.60	19.65	24.75	24.63	24.69	34.50	34.35	34.42	41.33	41.20	41.26	48.67	48.51	48.59
A_2P_3	5.73	5.64	5.68	7.69	7.61	7.65	16.67	16.57	16.62	21.32	21.20	21.26	30.81	30.71	30.76
A_2P_4	3.33	3.26	3.30	7.41	7.34	7.37	11.16	11.02	11.09	15.05	14.92	14.98	21.40	21.28	21.34
A_3P_1	35.97	35.77	35.87	44.09	44.01	44.05	48.74	48.61	48.68	-	-	-	-	-	-
A_3P_2	31.04	30.94	30.99	36.16	36.05	36.11	42.96	42.85	42.90	48.71	48.63	48.67	-	-	-
A_3P_3	14.69	14.55	14.62	23.45	23.35	23.40	33.58	33.48	33.53	39.17	39.04	39.10	36.20	36.13	36.17
A_3P_4	12.04	11.91	11.97	18.20	18.10	18.15	23.72	23.61	23.66	30.08	30.01	30.04	41.11	40.98	41.04
SEm(±)	0.02	0.03	0.02	0.02	0.02	0.02	-	-	-	-	-	-	-	-	-
CD1%	0.07	0.10	0.08	0.08	0.08	0.07	-	-	-	-	-	-	-	-	-

	10 days			**12 days**			**14 days**			**16 days**			**18 days**		
	Trial I	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**
A_1S_1	36.26	36.18	36.22	43.18	43.06	43.12	48.23	48.10	48.16	51.07	50.91	50.99	-	-	-
A_1S_2	21.91	21.77	21.84	26.98	26.87	26.92	36.68	36.57	36.62	41.71	41.62	41.66	47.81	47.72	47.77
A_2S_1	28.67	28.53	28.60	35.23	35.12	35.18	37.61	37.47	37.54	37.52	37.39	37.46	31.90	31.79	31.85
A_2S_2	13.58	13.49	13.53	17.36	17.29	17.33	27.67	27.56	27.61	28.80	28.68	28.74	29.78	29.64	29.71
A_3S_1	28.90	28.75	28.82	38.20	38.12	38.16	41.53	41.44	41.49	43.10	43.00	43.05	50.76	50.64	50.70
A_3S_2	17.97	17.84	17.90	22.75	22.64	22.69	31.16	31.04	31.10	33.33	33.24	33.29	33.83	33.72	33.77
SEm (±)	0.01	0.02	0.02	0.01	0.01	0.01	-	-	-	-	-	-	-	-	-
CD 1%	0.05	0.07	0.06	0.05	0.05	0.05	-	-	-	-	-	-	-	-	-
P_1S_1	39.96	39.82	39.89	46.96	46.86	46.91	51.56	51.45	51.51	-	-	-	-	-	-
P_1S_2	26.06	25.91	25.99	31.37	31.24	31.31	43.15	43.05	43.10	48.70	48.58	48.64	-	-	-

P_2S_1	36.77	36.69	36.73	42.92	42.80	42.86	48.80	48.68	48.74	51.31	51.19	51.25	-	-	-
P_2S_2	21.49	21.36	21.42	26.21	26.13	26.17	33.88	33.72	33.80	42.94	42.84	42.89	48.67	48.51	48.59
P_3S_1	20.45	20.33	20.39	27.79	27.70	27.75	37.95	37.85	37.90	45.83	45.73	45.78	50.61	50.49	50.55
P_3S_2	7.54	7.41	7.48	10.42	10.33	10.37	17.91	17.82	17.86	21.45	21.33	21.39	31.73	31.66	31.70
P_4S_1	16.02	15.90	15.96	24.76	24.64	24.70	29.88	29.74	29.81	36.70	36.58	36.64	41.33	41.22	41.27
P_4S_2	5.32	5.24	5.28	8.38	8.31	8.34	15.37	15.26	15.32	19.62	19.53	19.58	30.05	29.93	29.99
SEm (±)	0.01	0.02	0.02	0.02	0.02	0.02	-	-	-	-	-	-	-	-	-
CD 1%	0.06	0.08	0.07	0.06	0.06	0.06	-	-	-	-	-	-	-	-	-
$A_1P_1S_1$	43.47	43.38	43.43	51.81	51.67	51.74	-	-	-	-	-	-	-	-	-
$A_1P_1S_2$	31.65	31.46	31.56	37.11	36.94	37.03	48.80	48.71	48.76	-	-	-	-	-	-
$A_1P_2S_1$	42.40	42.32	42.36	48.85	48.78	48.82	51.69	51.53	51.61	-	-	-	-	-	-
$A_1P_2S_2$	30.89	30.75	30.82	36.72	36.66	36.69	41.44	41.30	41.37	48.76	48.69	48.73	-	-	-
$A_1P_3S_1$	29.25	29.17	29.21	34.60	34.53	34.57	42.25	42.17	42.21	51.15	51.05	51.10	-	-	-
$A_1P_3S_2$	13.89	13.67	13.78	17.78	17.64	17.71	24.83	24.74	24.79	30.73	30.66	30.70	48.00	47.91	47.96
$A_1P_4S_1$	24.43	24.36	24.40	34.57	34.42	34.50	41.43	41.32	41.38	51.07	50.91	50.99	-	-	-
$A_1P_4S_2$	8.85	8.73	8.79	13.64	13.57	13.61	24.56	24.44	24.50	27.66	27.58	27.62	47.81	47.72	47.77

	10 days			12 days			14 days			16 days			18 days		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
$A_2P_1S_1$	34.75	34.67	34.71	37.47	37.38	37.43	51.56	51.45	51.51	-	-	-	-	-	-
$A_2P_1S_2$	16.25	16.14	16.20	20.44	20.31	20.38	31.90	31.83	31.87	48.70	48.58	48.64	-	-	-
$A_2P_2S_1$	31.61	31.52	31.57	37.04	36.90	36.97	43.18	43.05	43.12	51.31	51.19	51.25	-	-	-
$A_2P_2S_2$	7.80	7.67	7.74	12.45	12.36	12.41	25.81	25.64	25.73	31.34	31.21	31.28	48.67	48.51	48.59
$A_2P_3S_1$	11.45	11.28	11.37	15.37	15.22	15.30	28.63	28.50	28.57	35.45	35.37	35.41	50.61	50.49	50.55
$A_2P_3S_2$	0.00	0.00	0.00	0.00	0.00	0.00	4.70	4.63	4.67	7.18	7.03	7.11	11.00	10.93	10.97
$A_2P_4S_1$	6.66	6.52	6.59	14.81	14.67	14.74	18.09	17.90	18.00	23.73	23.59	23.66	31.90	31.79	31.85
$A_2P_4S_2$	0.00	0.00	0.00	0.00	0.00	0.00	4.22	4.14	4.18	6.37	6.24	6.31	10.89	10.77	10.83
$A_3P_1S_1$	41.66	41.41	41.54	51.61	51.54	51.58	-	-	-	-	-	-	-	-	-
$A_3P_1S_2$	30.28	30.13	30.21	36.56	36.48	36.52	48.74	48.61	48.68	-	-	-	-	-	-
$A_3P_2S_1$	36.31	36.23	36.27	42.87	42.73	42.80	51.52	51.46	51.49	-	-	-	-	-	-
$A_3P_2S_2$	25.77	25.65	25.71	29.45	29.37	29.41	34.39	34.23	34.31	48.71	48.63	48.67	-	-	-
$A_3P_3S_1$	20.65	20.54	20.60	33.41	33.36	33.39	42.96	42.87	42.92	50.89	50.76	50.83	-	-	-
$A_3P_3S_2$	8.73	8.56	8.65	13.48	13.34	13.41	24.19	24.09	24.14	26.45	26.31	26.38	36.20	36.13	36.17
$A_3P_4S_1$	16.96	16.82	16.89	24.90	24.83	24.87	30.11	30.00	30.06	35.31	35.23	35.27	50.76	50.64	50.70
$A_3P_4S_2$	7.11	7.00	7.06	11.49	11.36	11.43	17.33	17.21	17.27	24.84	24.78	24.81	31.45	31.31	31.38
SEm (±)	0.03	0.04	0.03	0.03	0.03	0.03	-	-	-	-	-	-	-	-	-
CD 1%	0.10	0.14	0.12	0.11	0.11	0.10	-	-	-	-	-	-	-	-	-
Treated	21.70	21.58	21.64	27.35	27.25	27.30	33.29	33.17	33.23	35.27	35.17	35.22	36.73	36.62	36.67
Control	76.21	76.10	76.16	-	-	-	-	-	-	-	-	-	-	-	-
SEm (±)	0.03	0.04	0.03	-	-	-	-	-	-	-	-	-	-	-	-
CD 1%	0.07	0.10	0.09	-	-	-	-	-	-	-	-	-	-	-	-

	20 days			22 days			24 days			26 days		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
A_1	-	-	-	-	-	-	-	-	-	-	-	-
A_2	40.41	40.26	40.34	43.72	43.42	43.57	46.26	46.15	46.20	47.24	47.17	47.21
A_3	45.37	45.22	45.29	47.65	47.50	47.58	-	-	-	-	-	-
SEm (±)	-	-	-	-	-	-	-	-	-	-	-	-
CD 1%	-	-	-	-	-	-	-	-	-	-	-	-
P_1	-	-	-	-	-	-	-	-	-	-	-	-
P_2	-	-	-	-	-	-	-	-	-	-	-	-
P_3	44.19	44.03	44.11	45.57	45.09	45.33	47.41	47.29	47.35	-	-	-
P_4	41.20	41.05	41.13	44.76	44.62	44.69	45.10	45.00	45.05	47.24	47.17	47.21
SEm (±)	-	-	-	-	-	-	-	-	-	-	-	-
CD 1%	-	-	-	-	-	-	-	-	-	-	-	-
S_1	50.39	50.26	50.33	-	-	-	-	-	-	-	-	-
S_2	40.40	40.24	40.32	45.03	44.78	44.90	46.26	46.15	46.20	47.24	47.17	47.21
SEm (±)	-	-	-	-	-	-	-	-	-	-	-	-
CD 1%	-	-	-	-	-	-	-	-	-	-	-	-
A_1P_1	-	-	-	-	-	-	-	-	-	-	-	-
A_1P_2	-	-	-	-	-	-	-	-	-	-	-	-
A_1P_3	-	-	-	-	-	-	-	-	-	-	-	-
A_1P_4	-	-	-	-	-	-	-	-	-	-	-	-
A_2P_1	-	-	-	-	-	-	-	-	-	-	-	-
A_2P_2	-	-	-	-	-	-	-	-	-	-	-	-
A_2P_3	40.67	40.51	40.59	45.57	45.09	45.33	47.41	47.29	47.35	-	-	-
A_2P_4	40.29	40.13	40.21	41.86	41.74	41.80	45.10	45.00	45.05	47.24	47.17	47.21
A_3P_1	-	-	-	-	-	-	-	-	-	-	-	-
A_3P_2	-	-	-	-	-	-	-	-	-	-	-	-
A_3P_3	47.70	47.54	47.62	-	-	-	-	-	-	-	-	-
A_3P_4	43.04	42.89	42.97	47.65	47.50	47.58	-	-	-	-	-	-
SEm (±)	-	-	-	-	-	-	-	-	-	-	-	-
	20 days			22 days			24 days			26 days		
	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled	Trial I	Trial II	Pooled
CD 1%	-	-	-	-	-	-	-	-	-	-	-	-
A_1S_1	-	-	-	-	-	-	-	-	-	-	-	-
A_1S_2	-	-	-	-	-	-	-	-	-	-	-	-
A_2S_1	50.39	50.26	50.33	-	-	-	-	-	-	-	-	-
A_2S_2	30.18	30.00	30.09	41.86	41.74	41.80	45.10	45.00	45.05	47.24	47.17	47.21
A_3S_1	-	-	-	-	-	-	-	-	-	-	-	-
A_3S_2	45.37	45.22	45.29	47.65	47.50	47.58	-	-	-	-	-	-
SEm (±)	-	-	-	-	-	-	-	-	-	-	-	-

CD 1%	-	-	-	-	-	-	-	-	-	-	-	-
P_1S_1	-	-	-	-	-	-	-	-	-	-	-	-
P_1S_2	-	-	-	-	-	-	-	-	-	-	-	-
P_2S_1	-	-	-	-	-	-	-	-	-	-	-	-
P_2S_2	-	-	-	-	-	-	-	-	-	-	-	-
P_3S_1	-	-	-	-	-	-	-	-	-	-	-	-
P_3S_2	44.19	44.03	44.11	45.57	45.09	45.33	47.41	47.29	47.35	-	-	-
P_4S_1	50.39	50.26	50.33	-	-	-	-	-	-	-	-	-
P_4S_2	36.61	36.45	36.53	44.76	44.62	44.69	45.10	45.00	45.05	47.24	47.17	47.21
SEm (±)	-	-	-	-	-	-	-	-	-	-	-	-
CD 1%	-	-	-	-	-	-	-	-	-	-	-	-
$A_1P_1S_1$	-	-	-	-	-	-	-	-	-	-	-	-
$A_1P_1S_2$	-	-	-	-	-	-	-	-	-	-	-	-
$A_1P_2S_1$	-	-	-	-	-	-	-	-	-	-	-	-
$A_1P_2S_2$	-	-	-	-	-	-	-	-	-	-	-	-
$A_1P_3S_1$	-	-	-	-	-	-	-	-	-	-	-	-
$A_1P_3S_2$	-	-	-	-	-	-	-	-	-	-	-	-
$A_1P_4S_1$	-	-	-	-	-	-	-	-	-	-	-	-
$A_2P_1S_1$	-	-	-	-	-	-	-	-	-	-	-	-
$A_2P_1S_2$	-	-	-	-	-	-	-	-	-	-	-	-

	20 days			**22 days**			**24 days**			**26 days**		
	Trial I	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**	**Trial I**	**Trial II**	**Pooled**
$A_2P_2S_1$	-	-	-	-	-	-	-	-	-	-	-	-
$A_2P_2S_2$	-	-	-	-	-	-	-	-	-	-	-	-
$A_2P_3S_1$	-	-	-	-	-	-	-	-	-	-	-	-
$A_2P_3S_2$	40.67	40.51	40.59	45.57	45.09	45.33	47.41	47.29	47.35	-	-	-
$A_2P_4S_1$	50.39	50.26	50.33	-	-	-	-	-	-	-	-	-
$A_2P_4S_2$	30.18	30.00	30.09	41.86	41.74	41.80	45.10	45.00	45.05	47.24	47.17	47.21
$A_3P_1S_1$	-	-	-	-	-	-	-	-	-	-	-	-
$A_3P_1S_2$	-	-	-	-	-	-	-	-	-	-	-	-
$A_3P_2S_1$	-	-	-	-	-	-	-	-	-	-	-	-
$A_3P_2S_2$	-	-	-	-	-	-	-	-	-	-	-	-
$A_3P_3S_1$	-	-	-	-	-	-	-	-	-	-	-	-
$A_3P_3S_2$	47.70	47.54	47.62	-	-	-	-	-	-	-	-	-
$A_3P_4S_1$	-	-	-	-	-	-	-	-	-	-	-	-
$A_3P_4S_2$	43.04	42.89	42.97	47.65	47.50	47.58	-	-	-	-	-	-
SEm (±)	-	-	-	-	-	-	-	-	-	-	-	-
CD 1%	-	-	-	-	-	-	-	-	-	-	-	-
Treated	42.40	42.24	42.32	45.03	44.78	44.90	46.26	46.15	46.20	47.24	47.17	47.21
Control	-	-	-	-	-	-	-	-	-	-	-	-
SEm (±)	-	-	-	-	-	-	-	-	-	-	-	-
CD 1%	-	-	-	-	-	-	-	-	-	-	-	-

A_1: Putrescine (5mM) **A_2: Spermine (5µM)** **P_1: Perforated polyethylene bag** **P_2: Nano silver based bag** **S_1: Ambient temperature**
A_3: Spermidine (4mM) **P_3: $KMnO_4$ ethylene absorber (4g)** **P_4: $KMnO_4$ ethylene absorber (6g)** **S_2 : Cold storage (13°C+1)**

CONCLUSION AND FUTURE SCOPE

From the experiment it can be concluded that polyamines, packaging materials and storage conditions improve the shelf life of banana fruits. Considering physical parameters *viz*., physiological loss in weight (%), ripening (%), spoilage (%) and moisture content (%) the treatment, spermine 5 µM + $KMnO_4$ based ethylene absorber 6g + cold storage (13°C+1) was found to be best recorded highest shelf life up to 20 days in banana *cv*. Grand Naine at ambient conditions and 26 days under cold storage. Effect of polyamines on the health of humans can be studied before recommendation.

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Conflict of Interest. None.

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