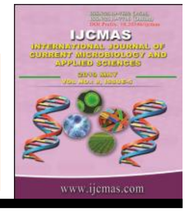
Int.J.Curr.Microbiol.App.Sci (2019) *8*(5): 1542-1550

International Journal of Current Microbiology and Applied Sciences
ISSN: 2319-7706 **Volume 8 Number 05 (2019)**
Journal homepage: http://www.ijcmas.com



Original Research Article https://doi.org/10.20546/ijcmas.2019.805.178

Evaluation of Different Packaging Films on Shelf life and Qualitative Attributes of Pomegranate Fruit cv. *Mridula* under Ambient Environment

Suchismita Jena[1]*, Ramesh K. Goyal[2], Mahesh K. Rana[3], Abhilash Mishra[4], Anuradha Bishnoi[2] and Sagar R. Nayak[5]

[1]Department of Fruit Science, [5]Department of Vegetable Science, Navsari Agricultural University, Navsari 396450 (Gujarat), India
[2]Department of Horticulture, [3]Department of Vegetable Science, Chaudhary Charan Singh Haryana Agricultural University, Hisar 2116443 (Haryana), India
[4]Department of Fruit Science, Dr. Y. S. Parmar University of Horticulture and Forestry, Solan, 173230 (H. P.), India

**Corresponding author*

A B S T R A C T

Keywords

Pomegranate, Shelf life, Quality characteristics, Packaging films

Article Info

Accepted:
15 April 2019
Available Online:
10 May 2019

The experiment aim to evaluate the packaging material for extending the shelf life of pomegranate with retaining better fruit quality attributes. Freshly harvested pomegranate fruits packed in low density polyethylene (LDPE) (25 micron), polypropylene (PP) (25 micron), cling film and cellophane paper film. Among all these packaging materials, the pomegranate fruits packed in LDPE 25 micron film had the least reduction in physiological loss in weight, minimal decay loss and highest ascorbic acid content. The different packaging material had no significant effect on total soluble solids, titratable acidity, pH and anthocyanin contents. However, storage duration had significant influence on these quality attributes and the significantly maximum total soluble solids, anthocyanin content and highest pH was observed on 12th day of storage. The ascorbic acid and titratable acidity were found maximum on the 0^{th} day of storage and subsequently decreased with the prolongation of storage period.

Introduction

Pomegranate ((*Punica granatum* L.) is one of the oldest known edible fruits popularly known as *Anar*. According to De-Candolle (1967), it was originated from Southwest Asia, probably in Iran and some adjoining countries. Pomegranate fruit has high nutritional value and a large number of health benefits as these are an excellent dietary source of organic acids, soluble solids, protein, fat, carbohydrates, tannin, vitamin C and minerals like calcium, iron, phosphorus, and magnesium. Anthocyanins present in the fruit have shown antioxidant activity higher than α-tocopherol, ascorbic acid and β-carotene (Bhowmik *et al.*, 2013) and thus pomegranate fruit juice is highly beneficial for leprosy patients. Pomegranate even being a non-climacteric many seeded berry, it is subjected to continuous physiological and biochemical changes after harvest with severe problems of quality and decay loss during post-harvest handling and storage. The major cause limiting the storage potential of pomegranate is the development of decay, which is often caused due to the presence of fungal infection especially in blossom end of the fruit at harvest. Several post-harvest methods have been evaluated out of which, the modified atmosphere packaging (MAP) is a simple, economical and effective method for delaying post-harvest deterioration, and maintaining quality of pomegranate (Selcuk and Erkan, 2016). In MAP, an atmosphere around the fruit with low in oxygen (O_2) and/or high in carbon dioxide (CO_2) is created to influence the metabolism of the packed produce, which can result in reduction of respiratory activity, delaying softening, ripening, senescence and reducing incidence of physiological disorders and pathogenic infestations. Most commonly packaging films such as LDPE, PP, cling films and cellophane paper are used to create the desired modified atmosphere around the fruits. These packaging materials also play significant role in attracting the consumers and prolonging the storage period of many fruits. In our study, we used these different films to evaluate their potentiality in increasing shelf life and access the quality attributes as influenced by the packing, to identify the best packing film for pomegranate under ambient conditions.

Materials and Methods

The fresh fruits of pomegranate cv. *Mridula* were procured from the Centre of Excellence for Fruits, Mangiana (Haryana). The experiment was carried out in Post-harvest Technology Laboratory of the Department of Horticulture, CCS Haryana Agricultural University, Hisar during 2016-17. The individual fruits were wrapped with different packaging films *viz*., low density polyethylene (LDPE) (25 micron), polypropylene (PP) (25 micron), cling film, cellophane paper and thereafter, wrapped fruits were kept in CFB boxes. The boxes were stored at room temperature with maintaining maximum 29±2°C, minimum 12±2°C and relative humidity 90±5%. Various observations of the stored fruits were recorded periodically at three days interval from the inception of storage. The loss in weight during storage was calculated by subtracting the final weight from the initial weight of the fruits. The decay loss was calculated by subtracting the number of decayed fruit from the total number of fruits. The total soluble solids of fruits were determined at room temperature by using hand refractometer having a range of zero to 32 (ERMA) by putting a drop of pomegranate juice. The refractometer was calibrated with distilled water after every use and the values were expressed in %. pH of freshly extracted pomegranate fruit juice from each sample was determined by using digital pH meter, which was calibrated with buffer solution having pH= 4.0 and 9.2. Acidity and ascorbic acid were determined as per the method suggested by AOAC (1990). The total anthocyanin content was determined according to the pH differential spectroscopic method (Cheng and Breen, 1991; Tonutare *et al.*, 2014). The data were analyzed using completely randomized design (CRD) and critical differences (C.D.) at 5% level of significance with the help of a windows based computer package OPSTAT (Sheoran 2004).

Results and Discussion

Physiological loss in weight (%)

The data presented in Table 1 clearly indicate that the different packaging materials significantly affected the physiological loss in weight of pomegranate fruits. On the 3rd day of storage, the fruits packed in LDPE 25 micron had recorded significantly least loss in weight (0.38%), which was statistically at par with fruits packed in polypropylene 25 micron (1.06%), cling film (0.84%) and cellophane paper (1.11%). On the 6th day, the least loss in weight was observed from fruits packed with LDPE 25 micron (1.36%), which was statistically at par with packaging material polypropylene 25 micron (1.87%).

On 9th and 12th day, the fruits wrapped in LDPE 25 micron illustrated least physiological loss in weight, *i.e.*, 4.19 and 5.17%, respectively as compared to other packaging materials under ambient room conditions. On 6th and 12th day, the treatment cellophane paper and cling film and on 9th day, the treatment polypropylene 25 micron, cellophane paper and cling film were statistically at par with each other.

The unwrapped fruits taken as control had the highest physiological loss in weight, *i.e.*, 5.12, 7.25, 10.31and 12.61% on 3rd, 6th, 9th and 12th day of storage period, respectively. The fruits wrapped with LDPE 25 micron was found best in reducing the physiological loss in weight while fruits retained unwrapped exhibited the highest reduction in physiological loss in weight. Fruits packed in different packaging films recorded lower weight loss, which was obvious due to their role in altering the CO_2 and O_2 concentration inside the packages and thereby, reducing the rate of transpiration/respiration and maintaining higher humidity inside the wrappers (Ben, 1985). These results are in conformity with the findings of Valero *et al.*, (2006) in table grapes, Maniwara *et al.*, (2015) in purple passion fruit, Kumar and Nagpal (1996) in mango,Nielsen and Leufven (2008) in strawberry, Siddiqui and Gupta (1997) in guava and Sonkar and Ladaniya (1998) in Nagpur mandarin.

Decay loss (%)

The perusal of data in Table 2 reveals that the different packaging materials exerted significant effect on decay loss of pomegranate fruits. Under ambient room conditions, no decay loss was found during first eight days of storage of pomegranate fruits, while the minimum decay loss of 3.71 and 10.51% was recorded on 9th and 12th day of storage in fruits wrapped with LDPE 25 micron packaging film and the maximum decay loss of 11.40 and 23.36% was found in unwrapped fruits, respectively in the same period of time. In our experiment, LDPE 25 micron was observed as the best packing materials in terms of controlling decay loss, where least decay loss was observed on9th and 12th days of storage. This might be due to the property of packaging films to retain a higher level of CO_2 inside the package and might exhibited fungi-static effect (Li and Kader, 1989). The results are in line with the findings of Ozkaya *et al.,* (2009) who also reported that the modified atmosphere packaging resulted in lower decay loss in strawberry fruits than the control fruits.

Total soluble solids (%)

The total soluble solids as observed from pomegranate fruits packed in different packaging materials is represented in Table 3 and the mean data exhibited statistically significant variation with respect to the period of storage but the packaging films and the interaction between packaging materials and storage duration had showed no significant effect on total soluble solids of fruits. Under ambient room conditions, the minimum total soluble solids were found on zero day (13.37%), which was statistically at par with TSS of 3rd day of storage (13.46%) and the maximum TSS was found on 12th day (14.24%) of storage. The increase in TSS during storage period could be attributed to the water loss and hydrolysis of starch and conversation of other polysaccharides to soluble form of sugar (Wills *et al.,* 1980). The gradual increase in TSS took a longer period of time in film wrapped fruits was possibly due to retarded ripening and senescence processes, which simultaneously delayed the conversion of starch into sugars (Pongener *et al.,* 2011). The results of present study was corroborate with the findings of O'Grady *et al.,* (2014).

Titratable acidity (%)

The analysis of variance of the titratable acidity of stored pomegranate fruits packed with different packaging films was presented in Table 4 and it showed a significant variation over the storage period. However, no significant variation was recorded for the effect of different packaging films and the interaction between the packaging films with the period of storage. The titratable acidity of the fruits went on decreasing with the advancement of storage period. The titratable acidity was observed maximum on zero day (0.43%) and minimum on 12th (0.40%) day of storage, whereas, the titratable acidity on 6th (0.41%) and 9th day (0.41%) was found statistically at par with each other under ambient room conditions. Most of the polyethylene bags retained higher acidity content of fruits as compared to control fruits. This might be due to the development of modified atmospheric condition around the fruits which might have slow down various metabolic processes, resulting in lower utilization of acids in respiration (Wavlah and Athale, 1988). Variability in titratable acidity could be attributed to the effect of increased solubility of CO_2 inside the packages (Caleb *et al.,* 2013). Similar results were also reported by O'Grady *et al.,* (2014) in pomegranate arils, McCollum *et al.,* (1992) in mango and Nielsen and Leufven (2008) in strawberry fruits.

pH

The data in Table 5 reveal statistically non-significant effect of different packaging films on pH of stored pomegranate fruits. However, storage period significantly influenced the pH of fruits. Under ambient room conditions, the minimum pH was recorded on zero days (3.48), which was statistically at par with pH of 3rd day of storage (3.57) while maximum was recorded on 12th day (3.71) of storage, which was statistically at par with pH of 9th day (3.67) of storage.

The pH of fruit increased with the increasing in storage period and this might be attributed to reduction of titratable acidity and increase in TSS of fruits and also the effect of increased CO_2 solubility inside the packages (Caleb *et al.,* 2013). The results of present study are in line with the findings of O'Grady *et al.,* (2014) in pomegranate.

Ascorbic acid (mg/100 g)

The data pertaining to ascorbic acid content of pomegranate fruits are presented in Table 6. The perusal of data reveals that the ascorbic acid content of pomegranate fruits varied significantly due to different packaging films and the period of storage. However, the interaction between the packaging materials and storage period was found statistically non-significant.

With the advancement of storage period, the ascorbic acid content of fruits decreased significantly. It was recorded maximum on zero day of storage (13.08 mg/100 g) and the minimum on 12th day (11.48 mg/100 g) of storage. Under ambient room conditions, the maximum ascorbic acid was observed in fruits packed with LDPE 25 micron packaging film (12.79 mg/100 g) and the minimum (12.03 mg/100 g) in fruits kept unwrapped, whereas, the treatment cling film

(12.38 mg/100 g) and cellophane paper (12.27 mg/100 g) were statistically at par with each other. The effect of films may be due to modification of the atmosphere inside the package by reducing O_2 concentration, which concomitantly decreased the enzymatic oxidation of ascorbic acid (Agrahari *et al.*, 2001). Over the prolongation of storage period, the ascorbic acid content showed a decreasing trend. This might be due to the oxidation and irreversible conversion of ascorbic acid to dehydro-ascorbic acid in the presence of enzyme ascorbinase. Similar results were also obtained by Sood *et al.*, (2012) in strawberry.

Anthocyanin content (mg/100 g)

The experimental results pertaining to anthocyanin content of pomegranate fruits packed in different packaging films was presented in Table 7. The storage period exhibited significant effect on the anthocyanin content of fruits, though statistically non-significant effect was found for packaging films and their interaction with storage period.

The minimum anthocyanin content was recorded on zero day or prior to storage (13.86 mg/100 g) and the maximum on 12th day of storage (14.44 mg/100 g), which was statistically at par with anthocyanin content of 9th day (14.26 mg/100 g) of storage under ambient room conditions.

This is in close agreement with the findings of Nielsen and Leufven (2008) in strawberry fruits, where the packaged strawberries maintained their colour and lustre much better than the unpackaged samples.

Table.1 Effect of different packaging materials on physiological loss in weight (%) of pomegranate cv. Mridula

Treatments	Storage period (days)			
	3	6	9	12
LDPE 25 micron	0.38	1.36	4.19	5.17
Polypropylene 25 micron	1.06	1.87	5.97	7.33
Cling film	0.84	2.21	6.61	8.39
Cellophane paper	1.11	2.26	6.83	8.96
Control	5.12	7.25	10.31	12.61
C.D. at p= 0.05(Treatments)	**0.83**	**0.74**	**1.09**	**1.02**

Table.2 Effect of different packaging materials on decay loss (%) of pomegranate cv. Mridula

Treatments	Storage period (days)	
	9	12
LDPE 25 micron	3.71	10.51
Polypropylene 25 micron	4.43	11.22
Cling film	9.95	18.82
Cellophane paper	7.17	16.80
Control	11.40	23.36
C.D. at p = 0.05 (Treatments)	**0.61**	**0.54**

Table.3 Effect of different packaging materials on total soluble solids (%) of pomegranate cv. Mridula

Treatments	Storage period (days)					Mean
	0	3	6	9	12	
LDPE 25 micron	13.37	13.41	13.52	13.67	13.96	**13.59**
Polypropylene 25 micron	13.37	13.41	13.53	13.84	14.11	**13.65**
Cling film	13.37	13.44	13.6	13.87	14.25	**13.71**
Cellophane paper	13.37	13.48	13.67	13.91	14.4	**13.77**
Control	13.37	13.54	13.83	14.22	14.47	**13.89**
Mean	**13.37**	**13.46**	**13.63**	**13.90**	**14.24**	
C.D. at p=0.05	Treatments (T) = NS Storage period (S) = 0.15 Treatments × storage period = NS					

Table.4 Effect of different packaging materials on titratable acidity (%) of pomegranate cv. Mridula

Treatments	Storage period (days)					Mean
	0	3	6	9	12	
LDPE 25 micron	0.43	0.43	0.42	0.41	0.41	**0.42**
Polypropylene 25 micron	0.43	0.42	0.42	0.41	0.40	**0.42**
Cling film	0.43	0.42	0.41	0.41	0.39	**0.41**
Cellophane paper	0.43	0.42	0.41	0.40	0.39	**0.41**
Control	0.43	0.41	0.41	0.40	0.39	**0.41**
Mean	**0.43**	**0.42**	**0.41**	**0.41**	**0.40**	
C.D. at p=0.05	Treatments (T) = NS Storage period (S) = 0.01 Treatments × storage period = NS					

Table.5 Effect of different packaging materials on pH of pomegranate cv. Mridula

Treatments	Storage period (days)					Mean
	0	3	6	9	12	
LDPE 25 micron	3.48	3.52	3.56	3.62	3.65	**3.57**
Polypropylene 25 micron	3.48	3.55	3.58	3.65	3.68	**3.59**
Cling film	3.48	3.58	3.61	3.67	3.73	**3.61**
Cellophane paper	3.48	3.59	3.62	3.69	3.74	**3.62**
Control	3.48	3.61	3.64	3.71	3.76	**3.64**
Mean	**3.48**	**3.57**	**3.60**	**3.67**	**3.71**	
C.D. at p =0.05	Treatments (T) = NS Storage period (S) = 0.10 Treatments × storage period = NS					

Table.6 Effect of different packaging materials on ascorbic acid (mg/100 g) of pomegranate cv. Mridula

Treatments	Storage period (days)					Mean
	0	3	6	9	12	
LDPE 25 micron	13.08	12.94	12.81	12.67	12.45	**12.79**
Polypropylene 25 micron	13.08	12.90	12.71	12.45	11.74	**12.57**
Cling film	13.08	12.83	12.41	12.24	11.35	**12.38**
Cellophane paper	13.08	12.81	12.33	11.96	11.15	**12.27**
Control	13.08	12.84	12.09	11.43	10.70	**12.03**
Mean	**13.08**	**12.86**	**12.47**	**12.15**	**11.48**	
C.D. at p=0.05	Treatments (T) = 0.16 Storage period (S) = 0.16 Treatments × storage period = NS					

Table.7 Effect of different packaging materials on anthocyanin content (mg/100 g) of pomegranate cv. Mridula

Treatments	Storage period (days)					Mean
	0	3	6	9	12	
LDPE 25 micron	13.86	13.93	13.97	14.03	14.27	**14.01**
Polypropylene 25 micron	13.86	13.96	14.06	14.10	14.30	**14.05**
Cling film	13.86	13.73	14.23	14.27	14.41	**14.10**
Cellophane paper	13.86	13.87	14.19	14.37	14.53	**14.16**
Control	13.86	14.00	14.36	14.51	14.72	**14.29**
Mean	**13.86**	**13.90**	**14.16**	**14.26**	**14.44**	
C.D. at p=0.05	Treatments (T) = NS Storage period (S) = 0.19 Treatments × storage period = NS					

In conclusion, the loss in weight, decay loss and ascorbic acid content of pomegranate fruits were affected by the different packaging materials and LDPE 25 micron packaging film proved to the best in controlling physiological loss in weight, least decay loss and highest ascorbic acid content of fruit. The total soluble solids, titratable acidity, pH and anthocyanin contents of fruits were not affected by different packaging material, on the other hand, storage period had significant effect on them and the significantly maximum total soluble solids and anthocyanin content and pH was observed on 12th day of storage, whereas, the ascorbic acid and titratable acidity were found maximum on the very first day. From the study, it is concluded that LDPE 25 micron was the best packaging material for the packaging of pomegranate fruits as they alter surrounding atmosphere of fruits.

Acknowledgement

The author SJ sincerely acknowledges the financial assistance received from the Indian Council of Agricultural Research (National Talent Fellowship) for her course of study and also acknowledges the CCSHAU, Hisar, for providing lab and instrumental facilities.

References

A.O.A.C., 1990. *Official Methods of Analysis*. 15th Edn. Association of Official Analytical Chemist, Washington, D.C.

Agrahari, P.R., Thakur, K.S., Sharma, R.M., Tripathi, V.K. and Singh, R.R., 2001. Effects of various packaging treatments and storage atmosphere on storage quality of Chandler strawberry (*Fragaria* × *ananassa* Duch.). *Scientia Horticulturae*, 7:63-74.

Ben, Y., 1985. Individual seal packaging of fruits and vegetables in plastic films- a new post-harvest technique. *HortScience*, 94: 524-528.

Bhowmik, D., Gopinath, H., Kumar, B.P., Duraive, S., Aravind, G. and Kumar, S.K.P., 2013. Medicinal Uses of *Punica granatum* and Its Health Benefits. *Journal of Pharmacognosy and Phytochemistry*, 1(5): 28-35.

Caleb, O.J., Opara, U.L., Mahajan, P.V., Manley, M., Mokwena, L., Andreas, G.J. and Tredoux, A.G.J., 2013. Effect of modified atmosphere packaging and storage temperature on volatile composition and post-harvest life of minimally-processed pomegranate arils cvs. Acco and Herskawitz. *Postharvest Biology and Technology*, 79: 54-61.

Caleb, O.J., Opara, U.L., Mahajan, P.V., Manley, M., Mokwena, L., Andreas, G.J. and Tredoux, A.G.J., 2013. Effect of modified atmosphere packaging and storage temperature on volatile composition and post-harvest life of minimally-processed pomegranate arils cvs. Acco and Herskawitz. *Postharvest Biology and Technology*, 79: 54-61.

Cheng, G.W. and Breen, B.J., 1991. Activity of phenyl alanylammonialyase (PAL) and concentrations of anthocyanins and phenolics in developping strawberry fruit. *Journal of American Society of Horticultural Science*, 116: 865-868.

De-Candolle, A., 1967. *Origin of Cultivated Plants*.Hafner Publication, Co. New York, USA, pp: 237-240

Kumar, R. and Nagpal, R., 1996. Effect of post-harvest treatment on the storage behaviour of mango cv. Dusehri. *Haryana Journal of Horticultural Sciences*, 25: 101-108.

Li, C., and Kader, A.A., 1989. Residual effects of controlled atmospheres on post-harvest physiology and quality of strawberries. *Journal of the American Society for Horticultural Sciences*, 114: 629-634.

Maniwara, P., Boonyakiat, D., Poonlarp, P.B., Natwichai, J. and Nakano, K. 2015. Changes of post-harvest quality in passion fruit (*Passiflora edulis* Sims) under modified atmosphere packaging conditions. *International Food Research Journal*, 22(4): 1596-1606.

McCollum, T.G., Aquino, S., Miller, W.R. and McDonald, R.F., 1992. Individual shrink film wrapping of mangoes. Proceeding of the Florida State Horticulture Society, 105: 103-105.

Nielsen, T. and Leufve, A., 2008. The effect of modified atmosphere packaging on the quality of Honeoye and Korona strawberries. *Food Chemistry*, 107: 1053-1063.

O'Grady, L., Sigge, G., Caleb, O.J. and Opara, U.L., 2014. Effects of storage temperature and duration on chemical properties, proximate composition and selected bioactive components of pomegranate (*Punica granatum*L.) arils. LWT- *Food Science and Technology*, 57(2): 508-515.

Ozkaya, O., Dundar, O., Scovazzo, G.C. and Volpe, G., 2009. Evaluation of quality parameters of strawberry fruits in modified atmospheric packaging during storage. *African Journal of Biotechnology*, 8(5): 789-793.

Pongener, A., Mahajan, B.V.C. and Singh, H., 2011. Effect of different packaging film on storage life and quality of peach fruits under cold storage conditions. *Indian Journal of Horticulture*, 68(2): 240-245.

Selcuk, N. and Erkan, M., 2016. Impact of passive modified atmosphere packaging on physic-chemical properties, bioactive compounds, and quality attributes of sweet pomegranates. *Turkish Journal of Agriculture and Forestry*, 40: 475-488.

Sheoran OP. Statistical package for agricultural research workers. CCS HAU, Hisar. http://hau.ernet.in, 2004.

Siddiqui, S. and Gupta, O.P., 1997. Effect of individual fruit wrapping by different materials on the shelf life of guava cv. Allahabad Safeda. *Haryana Journal of Horticultural Sciences*, 26(1-2): 101-104.

Sonkar, R.K. and Ladaniya, M.S., 1998. Effect of tray over wrapping by heat shrinkable and stretchable films on Nagpur mandarin fruits. *Indian Food Packer*, 52(5): 22-26.

Sood, M., Kaul, R. K. and Sood, P., 2012. Improving strawberry fruit storability by application of post-harvest chemical treatments. *Applied Biological Research*,14(2): 125-130.

Tonutare, T., Moor, U. and Szajdak, L., 2014. Strawberry anthocyanin determination by pH differential spectroscopic method – how to get true results? *Acta Scientiarum* Polonorum, Hortorum Cultus, 13(3): 35-47.

Valero, D., Valverde, J.M., Martinez-Romero, D., Guillen, F., Castillo, S. and Serrano, M., 2006. The combination of modified atmosphere packaging with eugenol or thymol to maintain quality, safety and functional properties of table grapes. *Postharvest Biology and Technology*, 41: 317-327.

Wavlah, K.M. and Athale, P.W., 1988. Studies to prolong shelf life of mango fruits. *Acta Horticulturae*, 231: 771-775.

Wills, R.B.H., Cambridge, P.A. and Scott, K.J. 1980. Use of flesh firmness and other objective tests to determine consumer acceptability of delicious apples. *Australian Journal of Experimental Agriculture and Animal Husbandry*, 20: 252-256.

How to cite this article:

Suchismita Jena, Ramesh K. Goyal, Mahesh K. Rana, Abhilash Mishra, Anuradha Bishnoi and Sagar R. Nayak. 2019. Evaluation of Different Packaging Films on Shelf life and Qualitative Attributes of Pomegranate Fruit cv. *Mridula* under Ambient Environment. *Int.J.Curr.Microbiol.App.Sci.* 8(05): 1542-1550. doi: https://doi.org/10.20546/ijcmas.2019.805.178