www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; 12(2): 1104-1108

www.thepharmajournal.com
Received: 02-12-2022
Accepted: 09-01-2023

Swarup Anand Dutta
Department of Horticulture,
Assam Agricultural University,
Jorhat, Assam, India

Pritam Coomar Barua
Department of Horticulture,
Assam Agricultural University,
Jorhat, Assam, India

Sanjib Sharma
Department of Horticulture,
Assam Agricultural University,
Jorhat, Assam, India

Prakash Kalita
Department of Crop Physiology
Assam Agricultural University,
Jorhat, Assam, India

Corresponding Author:
Swarup Anand Dutta
Department of Horticulture,
Assam Agricultural University,
Jorhat, Assam, India

Role of active packaging in enhancing the shelf life of strawberry (*Fragaria x ananassa* Duch.)

Swarup Anand Dutta, Pritam Coomar Barua, Sanjib Sharma and Prakash Kalita

Abstract
A lab experiment was conducted in Laboratory, Department of Horticulture, AAU, Jorhat during 2020-21 with a view to enhance the shelf life of strawberry (*Fragaria x ananassa* Duch.) by various treatments under active packaging system. Two packaging system, plastic packaging (P_1) and CFB packaging (P_2) were used. The experiment was laid out in Factorial Randomized Block Design (RBD) with eight treatments *viz.* T_1 (Oxygen absorber + Chlorine dioxide (5ppm), T_2 (T_1 + Moisture Absorber), T_3 (Ethylene absorber + Chlorine dioxide (5ppm), T_4 (Ethylene absorber + Moisture absorber + ClO_2 (5ppm)), T_5 (Chitosan 1% + Lemon essential oil), T_6 (Chitosan 1% + Potassium sorbate (0.3%), T_7 (Hexanol (as vapour), T_0 (Control (Without treatment)) with three replications.
The results revealed that both the packaging materials and the treatments had a significant impact in boosting up the shelf life of strawberry along with the quality parameters. The observations revealed that shelf life was found to be highest in T_4 (8.33 days in T_4P_1 and 8.66 days in T_4P_2), Physiological loss in weight (PLW) was lowest in T_5 (3.80% in T_5P_1 and 3.14% in T_4P_2), Decay incidence was lowest in T_7P_2 (31.33%) and maximum TSS was obtained in T_6P_1 (11.36°Brix). T_4 (Ethylene absorber + Moisture absorber + chlorine dioxide) performed best in boosting up the shelf life and quality of strawberry. CFB packaging performed better than plastic packaging in the entire experiment.

Keywords: Strawberry; active packaging; shelf life; ethylene absorber; moisture absorber

1. Introduction

Strawberry (*Fragaria x ananassa*) is one of the most popular, delicious, nutritious fruit with very vibrant red colour, tantalizing aroma, juicy texture and sweet fruity flavor which makes it one of the most acceptable fruits of the world. It is also one of the most consumed berries of the world. It is one of the noble soft fruits that is very much accepted after grapes. It possesses a very luscious taste with a distinct and pleasant aroma with a delicate flavor which is due to presence of *Ethyle butanoate* and *Ethyle hexanoate*. It is a member of the Rosaceae family and genus *Fragaria.*

A major problem in strawberry cultivation is its extremely short shelf life as the fruits are highly perishable in nature. The shelf life of strawberry is generally 3 to 4 days at ambient room temperature (Gol *et al*., 2013) [10]. The short post harvest life is mainly because the fruits are susceptible towards mechanical injury, physiological deterioration, water loss and microbial decay. It has been found that this fruit has a very limited postharvest life mainly due to its high metabolic activity and vulnerability to decay which gets translated into rapid dehydration, loss of firmness, and tissue degradation, which ultimately makes the fruit susceptible to mechanical injury and leads to color degradation (Baka *et al*., 1999; Bialka and Demirci 2007; Duarte-Molina *et al*., 2016) [4, 5, 8]. This has lead to major economic losses and therefore the industry is constantly seeking postharvest treatments so that its shelf life can be extended and its quality can be retained (Contigiani *et al*., 2018) [7]. This fruit crop has a very demanding post harvest handling requirement.

Therefore, Active packaging can be a very beneficial tool for increasing the shelf life of strawberries by controlling various parameters like ethylene, oxygen, and moisture level by the use of ethylene absorbers, oxygen scavengers and moisture absorbers. Presently, oxygen scavengers, moisture absorbers, ethylene absorbers and barrier packaging are the technologies which dominate more than 80% of the market (Robinson and Morrison, 2010) [18]. Active packaging takes into consideration various aspects of the fruit such as physiological processes (respiration of fresh fruit and vegetables), chemical processes (lipid oxidation), physical processes (dehydration) and also microbiological aspects (spoilage by microorganisms) that may be helpful in determining the shelf life of packaged fruits (Bodbodak and Rafiee, 2016) [6].

2. Materials and Methods

2.1 Fruit sample: Fresh strawberry fruits (*Fragaria* × *ananassa*) of the variety Sweet Charlie were harvested at commercial stage (75% of fruits surface with red color) from a private farm named 'Iswari Dairy Farms' located in Lality Chapari, Jorhat, Assam (latitude 26.7951◦ N, longitude 94.0504◦ E).

2.2 Packages: Plastic punnets (P_1) of size 17cm x 11cm x 3.5 cm of 100g capacity and CFB box (P_2) of 100g capacity in size 19cm x 9.5cm x 7.5cm have been used in this experiment.

2.3 Treatment: The experiment is laid out in Factorial Randomized Block Design consisting of eight treatments and three replications with two packaging material. Treatment details in the experiment are: T_1- Oxygen absorber + Chlorine dioxide (5ppm)**,** T_2- T_1 + Moisture Absorber, T_3- Ethylene absorber + Chlorine dioxide (5ppm), T_4- Ethylene absorber + Moisture absorber + ClO_2 (5ppm)**,** T_5- Chitosan 1% + Lemon essential oil, T_6- Chitosan 1% + Potassium sorbate (0.3%), T_7- Hexanol (as vapour)**,** T_0: Control (Without treatment).

2.4 Shelf life: Fruits were accessed for shelf life based on visual appearance during the time of storage. The number of days was counted up to which the fruits remained in a good condition.

2.5 Physiological loss in weight (PLW) (%): Weight of the packages containing fruits in each treatment was recorded individually before storage till storable days and final loss in weight was recorded and the results were expressed in percentage using following formula:

$$\text{PLW (\%)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{FinalWeight}} \text{X100}$$

2.6 Decay incidence (%)

Fruit decay was determined visually by counting the diseased and healthy strawberries in each treatment at every interval and expressed as percentage.

$$\text{Decay loss (\%)} = \frac{\text{Weight of decayed fruit}}{\text{Weight of fruit (initial)}} \text{X100}$$

2.7 Total Soluble Solids (°B)

Zeiss hand juice brix refractometer is used to ascertain total soluble solids of the ripe fruits. The refractometer is first calibrated with distilled water before use and further readings are noted by putting a few drops of juice on the prism. The total soluble solid values are expressed in degrees Brix (°B) at 200 °C (Ranganna, 1977) [17]. TSS of the stored samples are estimated every second, fourth and sixth day of packaging.

3. Results

3.1 Shelf life (days)

The observations related to influence of plastic packaging and CFB packaging on shelf life of strawberry are depicted in Fig. 1.

The highest shelf life under Plastic packaging (P_1) was obtained (8.33 days) in T_4 and lowest (3 days) was obtained in T_0. Among the various treatments under the influence of CFB box (P_2), it was observed that the highest shelf life was in T_4 (8.66 days) and lowest was observed in T_0 (3.33 days). The differences were found to be significant.

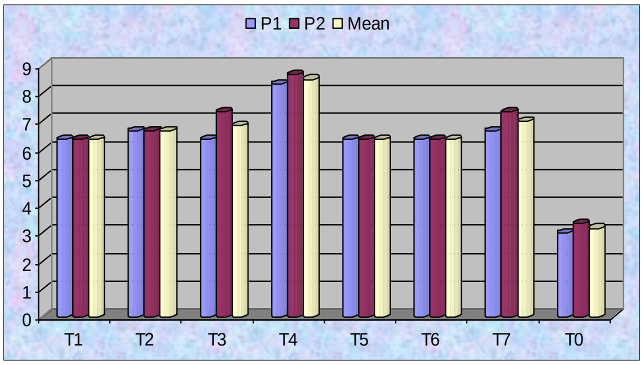

Fig 1: Influence of traditional packaging (plastic) and Corrugated fibre board (CFB) box on the shelf life (days) of strawberry (*Fragaria x ananassa* Duch.)

3.2 Physiological loss in weight (PLW)

The observations related to influence of Plastic packaging and CFB packaging on the PLW (%) of strawberry are depicted in Fig 2.

Among all the treatments studied in the present research, the lowest PLW under Plastic packaging (P_1) was observed in T_5 (3.80%) and the highest PLW was observed in T_0 (9.13%). The differences were found to be significant. The influence of Corrugated Fibre Board Packaging (P_2) on Physiological loss in weight (%) was found to be significant. The lowest PLW was found in T_5 (3.14%) and highest PLW was observed in T_0 (8.46%).

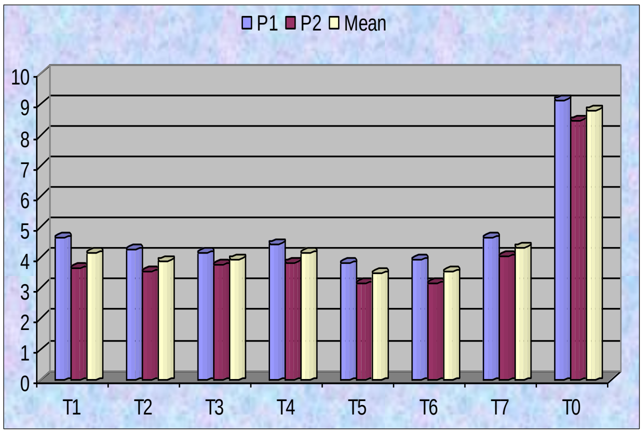

Fig 2: Influence of traditional packaging (plastic) and corrugated fibre board (CFB) box on the Physiological loss in weight (%) of strawberry (*Fragaria x ananassa* Duch.)

3.3 Decay incidence (%)

The observations related to influence of Plastic packaging and CFB packaging on the Decay incidence (%) of strawberry are depicted in Fig 3.

Under Plastic Packaging (P1) it was observed that lowest decay incidence was in T_7 (36.66%) and highest decay incidence was in T_0 (96.66%). Among all the treatments under CFB Packaging (P_2) it was observed that lowest decay incidence was in T_7 (31.33%) and highest was in T_0 (98.33%). The differences were found to be significant.

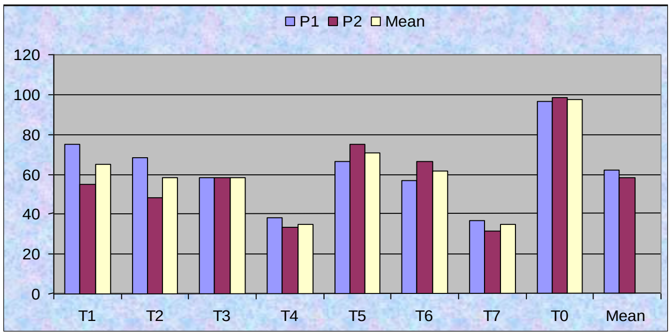

Fig 3: Influence of traditional packaging (plastic) and Corrugated fibre board (CFB) box on the Decay incidence (%) of strawberry (*Fragaria x ananassa* Duch.)

3.4. Total Soluble Solids (^{0}Brix)

The observations related to influence of Plastic packaging and CFB packaging in TSS are tabulated in Table 1.

Under plastic packaging, the highest TSS on the second day was found in T_6 (11.36^0 Brix) and lowest TSS was found in T_1 (8.93^{0}Brix). The differences were found to be significant. The influence of CFB packaging on TSS was found to be non significant on the 2nd day of packaging.

On Fourth day, under Plastic packaging the highest TSS was found in T_6 (11.90^0 Brix) and lowest TSS was found in T_1 (9.80^{0}Brix). The differences were found to be significant. The influence of CFB packaging on TSS was also found to be significant on the 4th day of packaging. The highest TSS was observed in T_4 (12.0^o Brix) and lowest TSS was observed in T_1 (9.26^{O}Brix).

TSS significantly increased on the fourth day as compared to second day under both packages.

Under Plastic Packaging (P_1) the highest TSS on the sixth day was found in T_6 (11.6^0 Brix) and lowest TSS was found in T_1 (9.3^{0}Brix). The differences were found to be significant. The influence of CFB packaging (P_2) on TSS was also found to be significant on the 6th day of packaging. The highest TSS was observed in T_4 (11.76.0^o Brix) and lowest TSS was observed in T_1 (8.86^{O}Brix). On the sixth day, TSS of both packages decreased significantly.

Table 1: Influence of traditional packaging (plastic) and corrugated fibre board (CFB) box on the Total Soluble Solids of strawberry (*Fragaria x ananassa* Duch.)

	DAY 2			DAY 4			DAY 6		
	P_1	P_2	Mean	P_1	P_2	Mean	P_1	P_2	Mean
T_1	8.933	8.667	8.800	9.800	9.267	9.533	9.300	8.867	9.083
T_2	10.200	9.767	9.983	10.967	10.200	10.583	10.400	9.500	9.950
T_3	9.500	10.033	9.767	10.367	10.900	10.633	9.900	10.467	10.183
T_4	10.967	11.133	11.050	11.767	12.000	11.883	10.967	11.767	11.367
T_5	9.767	10.000	9.883	10.500	10.867	10.683	10.067	10.267	10.167
T_6	11.367	10.400	10.883	11.900	11.033	11.467	11.600	10.700	11.150
T_7	11.267	10.933	11.100	11.700	11.533	11.617	11.000	10.567	10.783
T_0	9.833	10.333	10.083	0.000	0.000	0.000	0.000	0.000	0.000
Mean	10.229	10.158		9.625	9.475		9.154	9.017	

	2nd Day			4th Day			6th Day		
	Result	S.Ed±	CD@5%	Result	S.Ed±	CD@5%	Result	S.Ed±	CD@5%
Plastic packaging (P_1)	SIG	0.142	0.292	SIG	0.082	0.167	SIG	0.099	0.202
CFB packaging (P_2)	NS	0.171	N/A	SIG	0.041	0.084	SIG	0.049	0.101

Plate 1: Pictures showing Active packaging of Strawberry (1st Day)

4. Discussion

4.1 Shelf life

Significant variations in shelf life were found in response to various treatments under both plastic packaging (P_1) and CFB packaging (P_2) (Fig.1). The highest shelf life under P_1 was found in T_4 (8.33 days) and lowest shelf life was in control T_0 (3 days). The highest shelf life under P_2 was also found in T_4 (8.66 days) and lowest shelf life was in control T_0 (3.33 days). This might be due to the influence of Ethylene absorber, moisture absorber and chlorine dioxide in both the packages of T_4 as clear difference has been observed in control where no treatment led to a shelf life of 3 days only. Similar results have been obtained by Picon *et al.* (1993) [15], Aharoni & Barkai-Golan (1987) [2] in use of ethylene absorber under polyethylene packaging in strawberry. Also, results have been similar with Aday & Caner (2011) [1] in use of moisture absorber, ethylene absorber and chlorine dioxide packed in polyethylene trays. Results have been similar with Umme Seema *et al.* (2021) [21] in sapota and Ramesh & Pal (2006) [19] in litchi for CFB packaging.

4.2 Physiological loss in weight (PLW %)

Physiological loss in weight showed significant variations under both plastic packaging (P_1) and CFB packaging (P_2) (Fig. 2). The lowest PLW under P_1 was observed in T_5 (3.80%) and highest was in control T_0 (9.13%). The lowest PLW under P_2 was also observed in T_5 (3.14%) and highest was in control T_0 (8.46%). This might be due to influence of chitosan coating in T_5 under both the packages as edible coatings may act as barrier which restricts water transfer and protects fruit skin from mechanical injuries. It may also seal small wounds and delay dehydration. Results were similar to that obtained by Hernandez-Munoz *et al*. (2008) [11], Hernandez-Munoz *et al*. (2006) [12] and Petriccione *et al.* (2015) [16] in strawberry under chitosan treatment.

4.3 Decay incidence (%)

Significant variations in decay incidence were found in response to various treatments under both Plastic packaging (P_1) and CFB packaging (P_2) (Fig. 3). The lowest decay incidence under P_1 was observed in T_7 (36.66%) and highest was in control T_0 (96.66%). The lowest decay incidence under P_2 was also observed in T_7 (31.33%) and highest was in control T_0 (98.33%). The lowest decay incidence in T_7 under both the packages may be due to the effect of hexanal as it is known to have antifungal properties and are very effective in enhancing the shelf life of many fruits. Similar results have been obtained by Song *et al.* (2007) [20] in Raspberry and Peach.

4.4 TSS (^{0}Brix)

On the second day, significant differences in TSS were obtained in various treatments under plastic packaging (P_1) (Table 1.). The highest TSS under P_1 was observed in T_6 (11.36^{0}Brix) and the lowest TSS was observed in T_1 (8.93^{0}Brix). This may be due to prevention of hydrolysis of sucrose by chitosan coating. Similar results have been obtained by Duran *et al.* (2016) [9] and Jiang *et al.* (2019) [13] in strawberry. However, non significant results have been obtained for CFB packaging (P_2).

On the fourth day, significant differences in TSS were obtained in various treatments under plastic packaging (P_1) and CFB packaging (P_2) (Table 1). The highest TSS under P_1 was observed in T_6 (11.90^{0}Brix) and the lowest TSS was observed in T_1 (9.8^{0}Brix). The highest TSS under P_2 however was observed in T_4 (12.0^{0}Brix) and the lowest TSS was observed in T_1 (9.26^{0}Brix). In T_6P_1 higher TSS may be due to prevention of hydrolysis of sucrose by chitosan coating. Similar results have been obtained by Duran *et al.* (2016) [9] and Jiang *et al.* (2019) [13] in strawberry. In T_4P_2, higher TSS may be because of presence of ethylene and moisture absorber which is preventing hydrolysis of sucrose. Similar results have been obtained by Aday & Caner (2011) [1] in strawberry and Syahidah *et al*. (2014) in *Cucumis Melo.*

It has also been observed that there is a significant increase in TSS in all the treatments of both the packages in day four as compared to day two. This may be due to the completion of ripening process of the unripe fruits (since 75% ripe fruits were taken in this experiment). Similar results have been obtained by Panda *et al.* (2016) [14] in strawberry. This may also be associated with water loss, leading to an increase in TSS (Jiang *et al.* (2019) [13] in strawberry).

On the sixth day, significant differences in TSS were obtained in various treatments under plastic packaging (P_1) and CFB packaging (P_2). The highest TSS under P_1 was observed in T_6 (11.6^{0}Brix) and the lowest TSS was observed in T_1 (9.3^{0}Brix). The highest TSS under P_2 however was observed in T_4 (11.76^{0}Brix) and the lowest TSS was observed in T_1 (8.86^{0}Brix). In T_6P_1 higher TSS may be due to prevention of hydrolysis of sucrose by chitosan coating. Similar results have been obtained by Duran *et al.* (2016) [9] and Jiang *et al.* (2019) [13]in strawberry. In T_4P_2, higher TSS may be because of presence of ethylene and moisture absorber which is preventing hydrolysis of sucrose. Similar results have been obtained by Aday & Caner (2011) [1] in strawberry.

It has also been observed that there is a significant decrease in TSS in all the treatments of both the packages in day six as compared to day four. The reduction of TSS during storage may be due to hydrolysis and the utilization of the reducing sugars and acids. Similar results have been obtained by Aday and Caner (2011) [1], Zheng *et al.* (2008) [22] and Almenar *et al.* (2009) [3] in active packaging of strawberry.

5. Acknowledgements

We thank the Director of Post Graduate studies and Department of Horticulture, Assam Agricultural University, Jorhat for all the support during the study period

6. References

1. Aday MS, Caner C. The applications of ‘active packaging and chlorine dioxide’ for extended shelf life of fresh strawberries. Packaging Technology and Science. 2011;24(3):123-136.
2. Aharoni Y, Barkai-Golan R. Pre-harvest fungicide sprays and polyvinyl wraps to control Botrytis rot and prolong the postharvest storage life of strawberries. J Hort Sci. 1987;62:177-81.
3. Almenar E, Catala R, Hernandez-Munoz P, Gavara R. Optimization of an active package for wild strawberries based on the release of. Lebensmittel-Wissenschaft und Technologie. 2009;42:587-593.
4. Baka M, Mercier J, Corcuff R, Castaigne F, Arul J. Photochemical treatment to improve storability of fresh strawberries. Journal of Food Science. 1999;64(6):1068-1072.
5. Bialka K, Demirci A. Efficacy of aqueous ozone for the decontamination of Escherichia coli O157:H7 and Salmonella on raspberries and strawberries. Journal of Food Protection. 2007;70(5):1088-1092.
6. Bodbodak S, Rafiee Z. Recent trends in active packaging in fruits and vegetables. In Eco-friendly Technology for Postharvest Produce Quality. 2016, 77-125.
7. Contigiani EV, Jaramillo-Sánchez G, Castro MA, Gómez PL, Alzamora SM. Postharvest quality of strawberry fruit (*Fragaria x Ananassa* Duch cv. Albion) as affected by ozone washing: fungal spoilage, mechanical properties, and structure. Food and Bioprocess Technology. 2018;11(9):1639-1650.
8. Duarte-Molina F, Gómez PL, Castro MA, Alzamora SM. Storage quality of strawberry fruit treated by pulsed light: Fungal decay, water loss and mechanical properties. Innovative Food Science and Emerging Technologies. 2016;34:267-274.
9. Duran M, Aday MS, Zorba NND, Temizkan R, Büyükcan MB, Caner C. Potential of antimicrobial active packaging ‘containing natamycin, nisin, pomegranate and grape seed extract in chitosan coating’ to extend shelf life of fresh strawberry. Food and Bioproducts Processing. 2016;98:354-363.
10. Gol NB, Patel PR, Rao TR. Improvement of quality and shelf-life of strawberries with edible coatings enriched with chitosan. Postharvest Biology and Technology. 2013;85:185-195.
11. Hernández-Muñoz P, Almenar E, Del Valle V, Velez D, Gavara R. Effect of chitosan coating combined with postharvest calcium treatment on strawberry (*Fragaria×ananassa*) quality during refrigerated storage. Food Chemistry. 2008;110(2):428-435.

12. Hernández-Muñoz P, Almenar E, Ocio MJ, Gavara R. Effect of calcium dips and chitosan coatings on postharvest life of strawberries (*Fragaria x ananassa*). Postharvest Biology and Technology. 2006;39(3):247-253.
13. Jiang Y, Yu L, Hu Y, Zhu Z, Zhuang C, Zhao Y, Zhong Y. Electrostatic spraying of chitosan coating with different deacetylation degree for strawberry preservation. International journal of biological macromolecules. 2019;139:1232-1238.
14. Panda AK, Goyal RK, Godara AK, Sharma VK. Effect of packaging materials on the shelf-life of strawberry cv. Sweet Charlie under room temperature storage. Journal of Applied and Natural Science. 2016;8(3):1290-1294.
15. Picón A, Martínez-Jávega JM, Cuquerella J, Del Río MA, Navarro P. Effects of precooling, packaging film, modified atmosphere and ethylene absorber on the quality of refrigerated Chandler and Douglas strawberries. Food Chemistry. 1993;48(2):189-193.
16. Petriccione M, Mastrobuoni F, Pasquariello MS, Zampella L, Nobis E, Capriolo G, *et al*. Effect of chitosan coating on the postharvest quality and antioxidant enzyme system response of strawberry fruit during cold storage. Foods. 2015;4(4):501-523.
17. Ranganna S. Handbook of analysis and quality control for fruits and vegetable products. New Delhi: Tata McGraw Hill Publishing Co. Ltd. 1977. p. 4-125.
18. Robinson DKR, Morrison MJ. Nanotechnologies for food packaging: reporting the science and technology research trends. Report for Observatory NANO; c2010.
19. Ramesh C, Pal RK. Influence of active cushioning materials in packaging on shelf-life of litchi fruits. Indian Journal of Horticulture. 2006;63(1):31-35.
20. Song J, Hildebrand PD, Fan L, Forney CF, Renderos WE, Campbell-Palmer L, *et al*. Effect of hexanal vapor on the growth of postharvest pathogens and fruit decay. Journal of Food Science. 2007;72(4):108-112.
21. Umme Seema N, Jhalegar MJ, Jagadeesh SL, Bhuvaneshwari G, Awati MG, Ahmed T. Effect of potassium permanganate and salicylic acid chemicals on the shelf life and quality of sapota (*Manilkara achras*) fruits. Journal of Pharmacognosy and Phytochemistry. 2021;10(3):281-287.
22. Zheng Y, Zhenfeng Y, Xuehong C. Effect of high oxygen atmospheres on fruit decay and quality in Chinese bayberries, strawberries and blueberries. Food Control. 2008;19:470-474.