Research article
J. Adv. Nutri. Sci. Technol. 1(2): 71-78, 2021 **DOI: http://doi.org/10.15228/2021.v01.i02.p71-78**

Effects of various salt concentrations on shelf life and quality of *Eriobotrya japonica* fruit at ambient temperature

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Abstract
Eriobotrya japonica (Loquat), a subtropical evergreen tree, is a good source of minerals and phytochemicals; its fruit is disbursed in fresh and preserved forms. At the same time, its kernel is rich in protein and carbohydrates. The study was conducted to determine the effects of several salt concentrations in *E. japonica* fruits at ambient conditions. Weight-to-volume ratios were prepared for two concentrations of both KCl and NaCl. Fruit weight, seed weight, and flesh weight were calculated by standard electrical balance. The total number of seeds in the fruit, including the total number of healthy seeds and total no of aborted seeds, was also calculated manually. The result shows that the maximum fruit weight was calculated in fruit treated with 6g NaCl and the minimum fruit weight was calculated in Control. Maximum flesh weight was calculated after 9 days in fruits coated with 6g NaCl, and minimum flesh weight was calculated in uncoated fruits. The maximum total antioxidants and total phenolic compounds (TPC) were measured at 6 days of storage. Total phenolic compounds (TPC) activity was calculated after 9 days in uncoated fruits and coated fruits which were minimum in fruits coated with 6g KCl. It was concluded that the salts might maintain the fruit quality at ambient temperature and preserve maximum fruit quality for 9 days of storage.

Keywords: *Eriobotrya japonica*, concentrations, salts, fruit quality, ambient temperature

Highlights:

- The study explores the quality and shelf life of the *Eriobotrya japonica* fruit under salts concentration and storage periods
- The effects of salts were monitored on the weight of three types of seeds.
- Fruit quality shelf life of *Eriobotrya japonica* at ambient temperature.

1. Introduction

Loquat (*Eriobotrya japonica Lindl*.) is a perpetual tree widely cultivated in the fall and winter season because of its sweet edible fruits (Diwanay et al. 2014). It is highly nectariferous, with a powerful aroma and high honey potential (Yu 1979; Morton 1987; Shaw, 1980; Morton 1987). It has an extensive market value related to its particular nutrients compounds like phenylacetaldehyde, β-ionone, carotenoids, and hexanoic acid. *E. japonica Lindl* fruits regularly grow in some regions of the world (McConnell 1988). Its fruits are consumed in fresh or processed form and use as a part of jam, juice, wine, syrup, or as candied fruits (Brondani et al., 2018). Its seeds are used in wine formulation due to their maximum starch contents (20%), while leaves and fruits are conventionally considered for their medicinal value (Ducos et al.2010; Wee and Hsuan 1992; Chen 1988; Wang 1989; Ichinose 1995). The quality of *E. japonica Lindl* has an optimum quality, depending on the fully ripe and ripening stages. However, in commercial situations where transport and shelf-life are involved, *E. japonica Lindl* is generally harvested at the eating-ripe stage before fully ripe. In most cultivars, a harvest date is determined by skin color changes described for each cultivar.

China and Japan are the top countries in the cultivation of *E. japonica Lindl*, whereas, in China, its sale is higher than citrus and banana in the season, followed by lower than Iongan and litchi similar to the sale of apple and pear(Lin 2006).

E. japonica Lindl fruit is very vulnerable to mechanical impairment in harvesting and management. It can quickly develop a browning spot on the fruit surface and pulp (Lin 2006). Storage at low temperatures is effective in extending the postharvest life of the fruit of the Mogi cultivar. Ding et al. (1998) reported that fruit could be stored at 1 or 5ºC for up to 30 days. However, fruit weight and acidity were progressively lost and, consequently, fruit quality was adversely affected (Hamauzu et al., 1997). Recently, Ding et al. (2002) established that *E. japonica Lindl* fruit might be stored in the modified atmosphere created by low-density polyethylene bags at 5ºC for two months. Due to the relatively high respiration rate of

E. japonica Lindl fruit, low-temperature storage was required to maintain the internal carbon dioxide and oxygen concentration below 5 kPa and 4 kPa, respectively.

E. japonica Lindl is famous worldwide due to the mild, subacid, vitamins and minerals, phenolic and carotenoids contents, and sweet taste of its fruit (Xu &Chenl 2011) and has been shown to inhibit low-density lipoproteins (Koba et al. 2007). The bioactive components of *E. japonica Lindl* show remarkably high scavenging activity against chemically generated radicals. These bio compounds are flavonoids (founds in peels only), triterpene acids, and carotenoids (Liang et al. 2010; Godoy et al. 1995), making them effective in inhibiting the oxidation of human low-density lipoproteins (Barreto et al. 2009).

The current study investigates the effects of salts concentrations on the quality of *E. japonica Lindl* fruit at ambient temperature. Furthermore, phytochemicals and physiochemical changes are also discussed in the relevant section of the article.

2. Materials and Method

2.1 Collection of fruits and experiment site

The fresh and matured *E. japonica Lindl* fruits were obtained from the Haripur region farm and brought to Horticulture lab UOH after collection. The grading and washing were done on these fruits, and after washing, the fruit was drying and dipped in salts dipping.

2.2 Treatments applications

Following treatment of salt were made per 300 mL of water to apply on fruits viz To Control (untreated fruits), T1: 6g KCl /300ml water, T2:12g KCl/300ml Water, T3: 3g NaCl/300ml Water and T4: 6gNaCl/300ml Water

2.3 Treatment methods and storage days

The fruits were individually dipped in a prepared solution of both salts for 15 minutes. Some fruits were stored for 3,6,9 days of storage and then transferred for their analyses as fresh and stored fruit.

2.4 Physiochemical parameters of E. japonica Lindl fruits

Physicochemical parameters of fruits were recorded, including pH, measured by standard pH meter while fruit, flesh, healthy, and aborted seeds weight of fruits recorded by standard electrical balance.

2.5 Total antioxidant activity by 2, 2-diphenyl-1-picrylhydrazyl stable radicals.

Total antioxidants activities of the fruit juice were assessed by measuring their scavenging abilities to 2, 2-diphenyl-1-picrylhydrazyl stable radicals. The absorbance was read against a blank at 517 nm using a microplate ELISA reader (BioTek, USA). Inhibition of free radical determined by The following formula calculated DPPH in percent (%):

$$I\,\% = (A\ blank - A\ sample / Ablank) \times 100$$

where A blank is the absorbance of the control reaction mixture excluding the fruit sample, and A sample is the absorbance of the test compounds. IC_{50} values, which represented the concentration of fruit extracts that caused 50% neutralization of DPPH radicals, were calculated from the plot of inhibition percentage against concentrations.

2.6 Folin-Ciocalteu for total phenolic compounds

Total phenolic contents (TPC) were calculated by using the Folin-Ciocalteu reagent method. The FC-reagent (10 mL) was dissolved in distilled water to make the solution 100 mL. In each sample (100 mL), FC-reagent (200 µL) was added and vortex thoroughly. The 700 mM Na_2CO_3 (800 µL) was added into each sample and incubated at room temperature for 2 h. Sample (200 µL) was transferred to a transparent 96-well plate, and the absorbance of each well was measured at 765nm. The amount of TPC was calculated using a calibration curve for Gallic acid. The results were expressed as Gallic acid equivalent.

3. Results and Discussion

3.1 Effect of different salt concentrations and storage days on Fruit weight of E. japonica Lindl fruit

The effect of different concentrations of KCl and NaCl on the weight of fruits presented in Fig. 1. Fruits treated with 6g NaCl showed maximum weight as compared to untreated fruits. The maximum fruit weight was reported on the third day of storage due to upheld the moisture contents of the fruit, while in 6 and 9 days of stored fruit, the minor loss of fruits has been seen due to changes in the moisture contents and water contents in fruits. The other days of fruits showed a slight variation of fruit weights while fruit weight was higher and referred to as the fruit quality. The lower loss of fruit weight was observed due to salts coverage in this study.

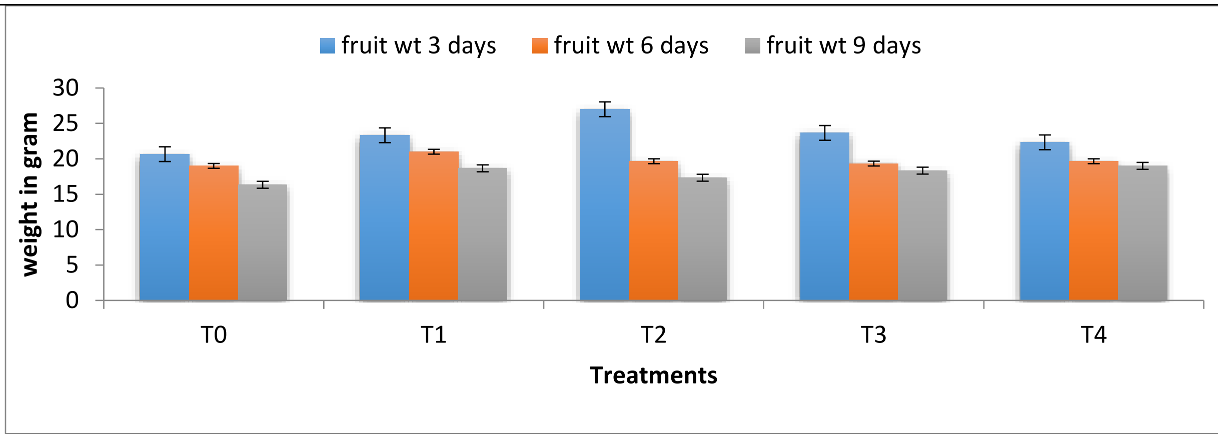

Fig1. Fruit weight of E. japonica Lindl affected by different concentration of treatment of KCl and NaCl

3. 2 Effect of different salt concentrations on number of healthy and Aborted seeds of E. japonica Lindl fruits and storage periods

The effects of different concentrations of KCl and NaCl treatments on a number of seeds of *E. japonica Lindl* are presented in Fig. 2. No significant differences in healthy seeds were found among the treatments and storage days of fruits (Fig. 2), followed by no substantial variances in the number of seeds of *E. japonica Lindl* fruits (Fig.3). In contrast, some lower healthy seeds were observed in 9 days of storage (Fig 4). The concepts of the seed changes have significant enhancements due to its early development of fruit structure. Later, the quality changes have been maintained, and no morphological and structural changes of fruits were reported (Diwanay et al., 2014).

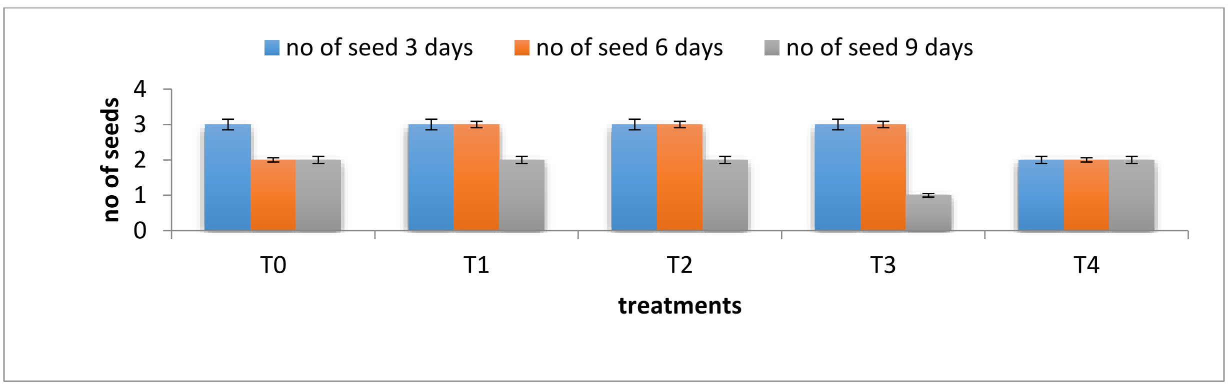

Fig. 2. No of seeds of E. japonica Lindl affected by different concentration of treatment of KCl and NaCl

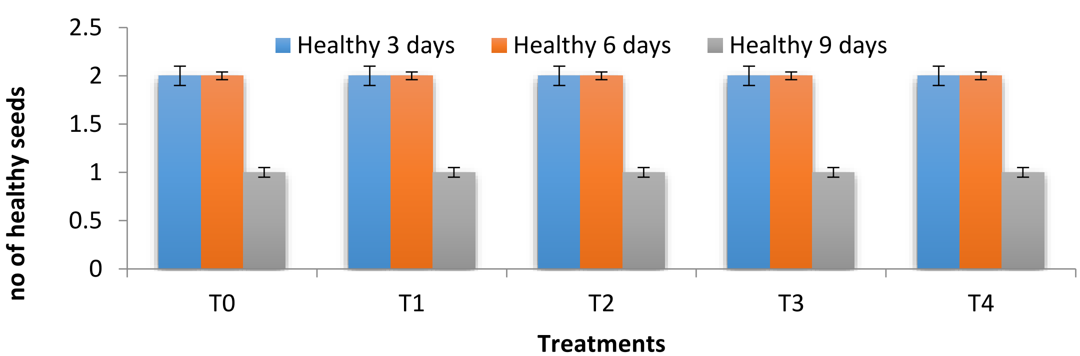

Fig. 3. No of healthy seeds of E. japonica Lindl affected by different concentration of treatment of KCl and NaCl

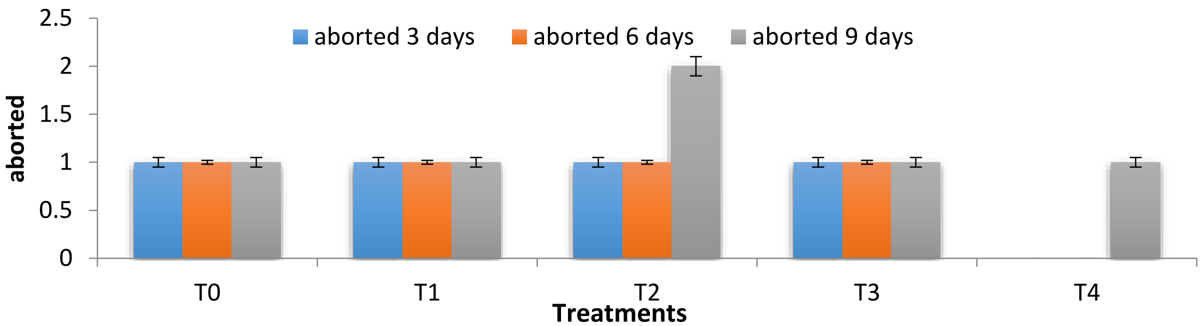

Fig. 4. No of aborted seeds of E. japonica Lindl affected by different concentration of treatment of KCl and NaCl

3.3 Effect of different salt concentrations on Seed, Flesh weight

The effects of storage period and treatments of salts of NaCl and KCl on the weight of seeds of *E. japonica Lindl* fruits are presented in Fig.5. The higher weight of seed was reported in untreated fruit as compared to treated fruits. The 3 g NaCl/300ml Water showed less seed weight (1.33 g). Significant differences were found in storage days and treatments on flesh weight (Fig 6). The flesh weight of *E. japonica Lindl* was higher in treated fruits as compared to untreated fruits. Fruits treated with 6g NaCl showed maximum flesh weight compared to untreated fruits. The salts improve the quality of the flesh and improve the enzymatic activities, and lower water losses in the internal structure of fruits which was similar to the earlier reported work of Baskaran et al.(2006).

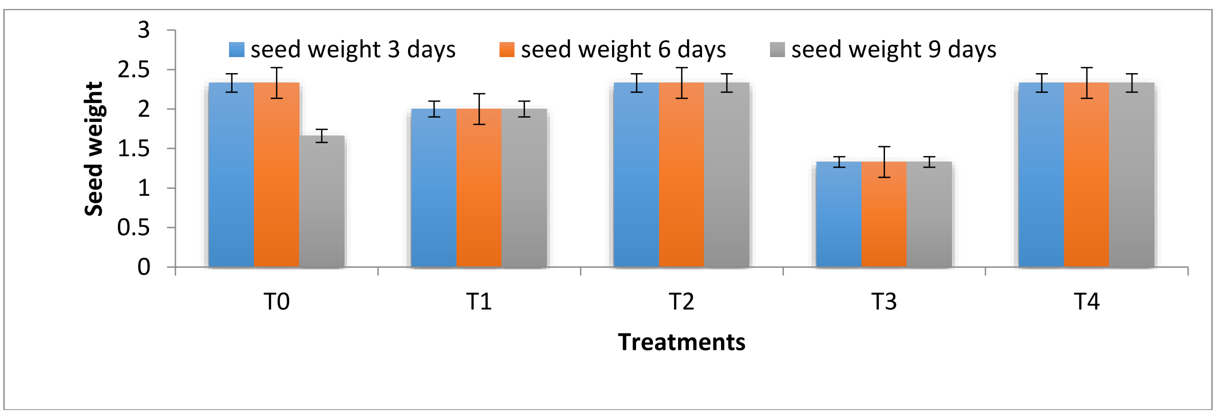

Fig.5. Seed weight of E. japonica Lindl affected by different concentration of treatment of KCl and NaCl

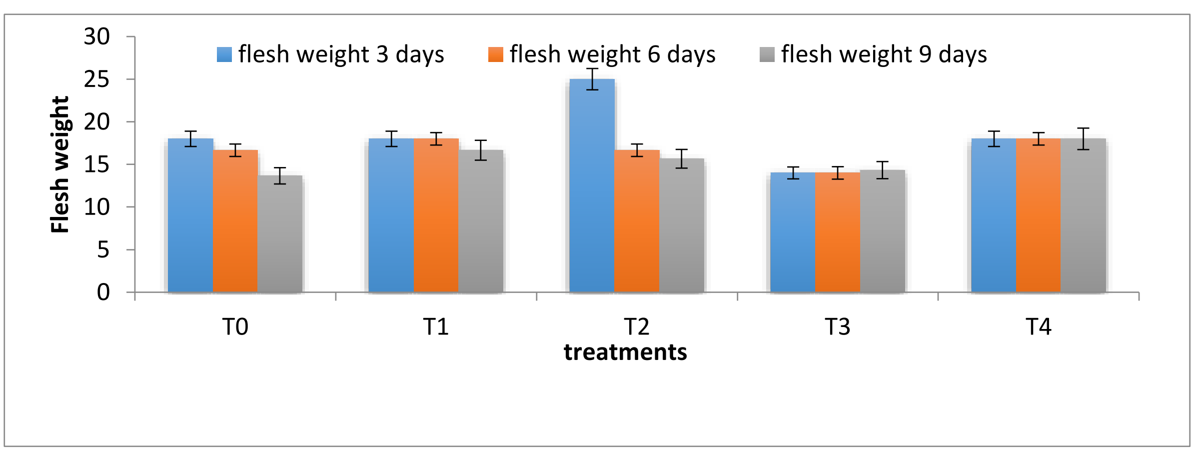

Fig 6. flesh weight of E. japonica Lindl affected by different concentration of treatment of KCl and NaCl

3.4 Phenolic compounds, total Antioxidant, and pH of fruits under treatment

Substantial alterations were observed in the treatments and the storage days of *E. japonica Lindl* (Fig 7) regarding TPC and TA, where a relationship was observed in total phenolic and antioxidants with the storage period. The effects of salts concentration showed significant improvement of TPC on the 6th day of storage. At the same time, it was lower from the initial to 3rd day. Fruits treated with 3g NaCl showed maximum TPC as compared to untreated fruits. Fruits treated with 6g NaCl showed maximum TA compared to fruits that were left untreated. The improved TPC during the storage period is related to the activation of several enzymes, as Baranek et al. (2006) reported in their study. The variations of antioxidants activity against the storage days and treatments are represented in Fig.8. The higher values of antioxidants were measured at six days of storage period while a little variation of TA was observed in 9 days of storage. The higher activity of TA was observed in 6 g of NaCl treated fruit, while lower activity was found in untreated. The antioxidants were increased or decreed from the ripening of fruits. Storage conditions for control fruits reduced the antioxidants activity in untreated fruit, a similar investigation reported by Baranek et al. (2006) in peach fruit. The significant differences in pH were found in storage days and treatments of *E. japonica Lindl* fruits shown in Fig 9. The maximum pH values were found in treated fruits of 6 g of NaCl, while lower values were found in untreated fruit.

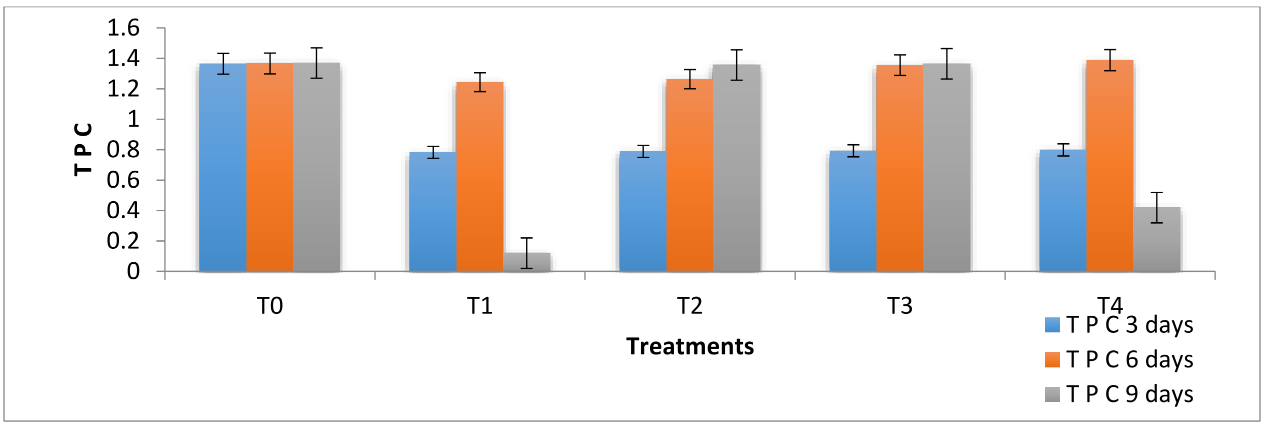

Fig 7. TPC of E. japonica Lindl affected by different concentration of treatment of KCl and NaCl

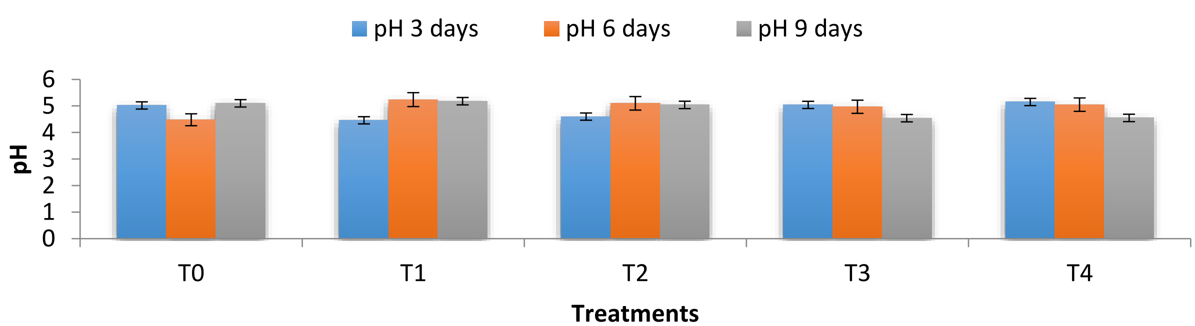

Fig 9. pH of E. japonica Lindl affected by different concentration of treatment of KCl and NaCl

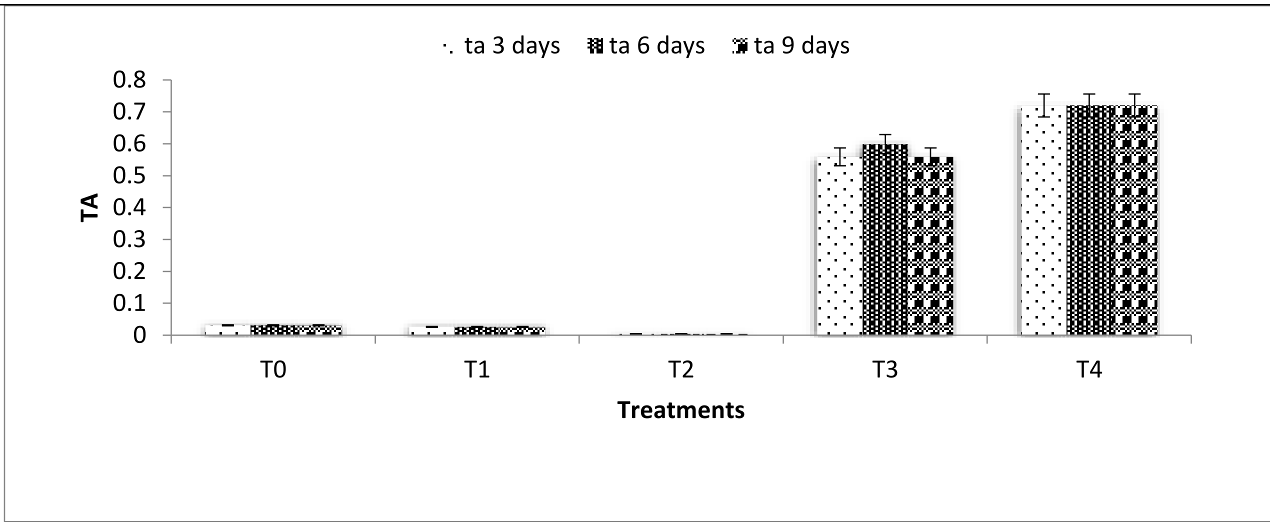

Fig 8. TA of E. japonica Lindl affected by different concentration of treatment of KCl and NaCl

4. Conclusion

it was concluded that the average life of the *E. japonica Lindl* fruits could be enhanced by the treatment of salts from 2 days to six days, while the salts' treatments were significantly improved the fruit quality shelf life at storage periods of 6 and 9 days. The effect of salt concentration did not alter the fruit quality and found adequate to maintain nutritional contents; both salts of NaCl and KCl. The treatments had a beneficial effect on reducing postharvest losses of *E. japonica Lindl* fruit. However, treatments with KCl proved to be the best among all treatments and can be used commercially to reduce postharvest losses of *E. japonica Lindl* fruit. It is recommended that the farmers use these salts to preserve *E. japonica Lindl* through an essay and friendly method.

Acknowledgments.
The authors highly appreciate the Department of Horticulture, The University of Haripur, to complete this project

Conflict of interest
It is declared that there is no conflict of interest among the authors.

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Received: 10th March, 2021 **Accepted: 4h April, 2021**