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PRE-HARVEST APPLICATION OF ORGANIC EXTRACTS TO MAINTAIN THE QUALITY, ENZYMATIC ACTIVITIES, AND SHELF LIFE OF CHERRY (*PRUNUS AVIUM*)

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Abstract

Prunus avium is a non-climacteric fruit and belongs to the Rosaceae family. This fruit is readily accessible and popular among customers due to its taste, red color, flavor, and health advantages. Natural extracts have traditionally been used to improve the overall appearance and preservation of food. The influence of Moringa leaf extract, Neem leaf extract, and Pomegranate peel extract on the postharvest quality of sweet cherry fruit was evaluated in this study during 8 days' storage period at ambient conditions. The use of extracts significantly enhanced the postharvest quality throughout the storage period and reduced fruit weight loss, fruit decay and maintain ascorbic acid, total flavonoid, total phenolic, antioxidant, anthocyanin, and enzymatic activity (SOD, POD, CAT, MDA, and PPO) of cherry fruit compared to untreated. This study showed that fruits treated with 30% MLE, 20% NLE, and 30%PPE as compared to other treatments have good quality and maximum postharvest life during storage.

Key words: Moringa, Neem, Pomegranate extract, PPO, Antioxidants.

Introduction

Prunus avium is a non-climacteric fruit and belongs to the Rosaceae family. This fruit is readily accessible and popular among consumer due to its taste, red color, mass, flavor, and healthy advantages (Celik *et al.,* 2022). Because have high respiration rates and sensitivity to fungal rots, harvested cherry fruit are highly perishable and frequently fail to meet optimal consumer quality (Petriccione *et al.,* 2015). Sweet cherry characteristics such as skin color, taste, acidity, firmness, and fruit mass are important indicators of customer endorsement (Petriccione *et al.,* 2015).

Sweet cherry fruits have recently become popular for their health-promoting ingredients. This fruit, like others, is high in minerals, vitamins, antioxidants, and bioactive elements, all of which are key nutritional components of a balanced diet. Recent epidemiological research has shown that eating sweet cherries lower the quantity of inflammatory biomarkers in the blood (Kelley *et al.,* 2013;Celik *et al.,* 2022). Changes in these biomarkers show that eating sweet cherries could reduce the risk or severity of inflammatory disorders such as arthritis, diabetes, cardiovascular disease, high blood pressure, and cancer (Kelley *et al.,* 2013).

Cherries are produced worldwide, including in Turkey, Russia, the United States, Italy, Pakistan, and Iran. Cherry cultivation is cultivated in Pakistan's Swat, Chitral, Hunza, Gilgit Baltistan, Zirat, Zhob, Loralai, Quetta, and Nathiagali chilly (hilly) regions (Balbontín *et al.,* 2018: Bal *et al.,* 2022). Turkey grows one of most cherry fruit in the world (417,694 tonnes), followed by the United States (390,000 tonnes), and Italy (125,900 tonnes) (Bal, T. and Cercinli, F. 2013; Gonzalez-Villagra *et al.,* 2024). Cherries are grown in Pakistan in the hilly regions of Baluchistan and Gilgit Baltistan. Pakistan's total cherry production area is 2,500 ha, and the country produces 6,000 tonnes of cherries annually. (Balbontín *et al.,* 2018; Anon., 2017).

Minimizing postharvest losses and extending sweet cherry storage duration are important aims for farmers and dealers. Many chemical and physical treatments, such as Salicylic acid,1-methylcyclopropene, Seaweed extracts, chitosan coating and organic extracts, have been used in recent years to improve sweet cherry postharvest quality (Lara *et al.,* 2015; Petriccione *et al.,* 2015; Gonzalez-Villagra *et al.,* 2024). However, the therapies may pose a danger to fruit storage (Paul & Pandey, 2013).

Edible coatings have traditionally been used to improve the overall appearance and preservation of food. They work as barriers during processing, handling, and storage, and do not only slow food deterioration while improving quality, but they are also safe due to natural biocide activity or the addition of antimicrobial chemicals (Mari *et al.,* 2016). Wax, milk proteins, celluloses, lipids, starch, zein, and alginate have all been employed as edible coatings to reduce commodity weight loss (Pateland & Panigrahi, 2019). Neem also includes several active compounds such as nimbidin, nimbin, and nimbidol with antibacterial and antifungal (Islas *et al.,* 2020). The most reliable and affordable option is the moringa plant, which not only coats fruit but also has antibacterial properties for preservation after harvest. It has been demonstrated that adding moringa extracts to the edible coatings, specifically corn starch and CMC, will reduce citrus fruit mass loss. (Balbontín *et al.,* 2018). Pomegranate peel bioactive components may be used safely as a bio preservative, antibacterial, and food sanitizer (Xi *et al.,* 2017). There is a scant indication of the use of edible coatings in sweet cherry recent literature.

However, during our search, we were unable to find any studies that examined the influence of Moringa leaf extract (MLE), Neem leaf extract (NLE), and pomegranate peel extract (PPE) on the quality and storage life of cherry fruit stored. The aim of this study is to evaluate the possible effects of different MLE, NLE, and PPE treatment concentrations on the qualitative and quantitative characteristics of cherry fruit while it is being stored. The project aims to offer sustainable methods for maintaining fruit quality and maintain shelf life without depending on artificial chemicals by investigating the usage of these natural extracts.

Material and Methods

Preparation of extracts: The aqueous extracts, viz., Moringa leaves and neem leaves, were made by soaking 1000 g of air-dried Moringa leaves and neem leaves in 10 litres of water for 24 hours, then filtering and diluting with water to 10%, 20%, and 30% concentrations. The pomegranate peel was separated and blended into powder form. The 100 g was added to 1 litre of purified water at 40°C and agitated at ambient temperature for 24 hours. To remove peel particles, the pomegranate peel extract was sieved through filter paper. Finally, the extract was refrigerated at 4 degrees Celsius until further use.

Experimental design and treatment: This experiment was designed in a randomised complete block design (RCBD) in Kalam Research Station, Swat, Khyber Pakhtunkhwa, Pakistan, in April 2022. The treatments of the current study consisted of leaf extracts of Moringa, Neem, and Pomegranate plants. For this purpose, the leaves were collected from thirty healthy trees and applied in three different concentrations (10%, 20%, and 30% of each plant's extract), along with a control. The cherries were applied with foliar application of moringa leaf extract (MLE; 10%, 20% and 30%), neem leaf extract (NLE; 10%, 20% and 30%), and pomegranate peel extract (PPE; 10%, 20% and 30%) before 30 days of the commercial harvesting date. The fruits were harvested carefully, packed in boxes, and shifted to the lab for further study.

Fruit weight loss: Weight loss (WL) was estimated by subtracting the initial weight from the weight after each interval after 2, 4, 6, and 8 days of storage, using the following equation. The outcome is expressed as a percentage.

$$\text{Weight loss} = [Wi\text{-}Wf / Wi] \times 100$$

Fruit decay percentage: The percentage of decayed fruits includes all ruined fruits caused by microbes and pathogens. The defects were determined as follows:

$$\text{Decay} = \frac{\text{No of decay fruit}}{\text{Total no of fruit storage}} \times 100$$

Total soluble solid (TSS): The fruit juice was extracted using a professional juicer and then filtered using a filter made by the USA for TSS. TSS was calculated as a percentage (Brix%) using a refractometer (Atago, Japan). Distilled water was used to calibrate the refractometer.

Total Titratable acidity (TTA): Fruit juice was extracted using a professional juicer and then filtered for TTA. TTA was determined by titrating 10 ml of fruit juice to pH 7.4 with 0.1 M NaOH solution, and results were recorded in terms of malic acid percentage (g of malic acid equivalent per 100 g fresh weight).

Ascorbic acid content (AAC): The ascorbic acid concentration was expressed as mg per 100 g of FW using the 2, 6-dichloroindophenol titration method (Parsa *et al.,* 2021).

Total sugar content (TSC): Total sugars were calculated and reported as a percentage using the method described by Khan *et al.,* (2009).

Total phenolic content (TPC): The total phenolic content (TPC) was evaluated using spectrophotometry and gallic acid as a standard, as published by Singleton *et al.,* (1999). In short, 2 mL of the diluted sample extract was put in tubes with 10 mL of a 1/10 dilution of Folin-Ciocalteu's reagent in water. After 10 minutes, the sample was treated with 0.8 mL of a 7.5% w/v sodium carbonate solution. After 30 minutes of standing at room temperature, the absorbance at 743 nm was measured. TPC was calculated as the number of gallic acid equivalents (GAE) per 100 mL of cherry fruit juice.

Total anthocyanin compound (TAC): Lee *et al.,* (2010) described a method that was modified to cherry tissue. Two grams of fruit tissue were homogenised in 4 mL of methanol and stored at -18°C for 1 hour. At 4°C, the extracts were centrifuged at 15,000 rpm for 15 minutes. The supernatant was placed onto a C18 Sep-Pak cartridge that had been previously conditioned with 5 mL of methanol, 5 mL of clean water, and 5 mL of 0.01 N HCl. After washing the cartridge with 5 mL of pure water, it was eluted with acidified MeOH (0.01% HCl). At 530 nm, the absorbance of the collected fraction was measured. Total anthocyanin contents expressed as mg 100 g^{-1}.

Total flavonoid compound (TFC): The flavonoid compound was determined by the method developed by Zhishen *et al.,* (1999). 50 ml methanol was used to extract 5 g of a substance. One millilitre of sample extract was mixed with four millilitres of distilled water and three millilitres of 5% $NaNO_2$. The mixes were allowed to stand at room temperature for 5 minutes. The solution was then treated with 0.3 ml of 10% $AlCl_3$. After 6 minutes, 2 cc of 1 M NaOH was added to the aforesaid mixture. By purified water, the final volume was increased up to 10 mL. A spectrophotometer (UV-1602, BMS, Canada) was used to test absorbance at 510 nm against a prepared blank. Methanol and reagents make up a blank sample.

Total antioxidant activity (TAA): TAA was graded using the Ismail *et al.,* (2012) approach. In brief, 100 mg of cherry pulp was extracted with 10 mL of 85% methanol. In methanol, 1 ml of this extract was combined with 2 ml of 0.15 mM (1,1-diphenyl-2-picrylhydrazyl). The mixes were briskly mixed and allowed to stand for 30 minutes (in the dark). The control was made by combining 2 ml of DPPH with 1 ml of methanol. A spectrophotometer was used at 517 nm absorbance to measure TTA. The antioxidant activity is given as a percentage of free radical scavenging.

Super peroxidase (SOD): 100 mL of enzyme extract was mixed with 500 mL of phosphate buffer, 200 mL of methionine, 200 mL of Triton X, and 100 mL of nitro blue tetrazolium (NBT). The mixture was supplemented with 800 millilitres of distilled water. The mixture was exposed to UV light for around 15 minutes immediately before the addition of 100 mL of riboflavin. A spectrophotometer was used to detect absorbance at 560 nm. Each sample's absorbance was measured three times (Tareen *et al.,* 2012).

Peroxidase (POD): The activities of peroxidase (POD) were determined by the method described by Yu *et al.,* (2014). 5 mL of sodium phosphate buffer (100 mM, pH 7.5) was combined with a fresh fruit peel. The findings were presented in units (U) per gram of fresh mass. At 470 nm, absorbance was measured by using a spectrophotometer.

CAT activity: Catalase levels in cherry juice samples were determined using a modified version of the method described by Li *et al.,* (2009). To begin the enzyme response, 100 L of enzyme extract was dissolved in 5.9 mM 100 L H_2O_2.

Malondialdehyde (MDA): Girotti *et al.,* (1991) developed a method for assessing MDA levels. Homogenised samples were subjected to incubation for five minutes at 100 degrees Celsius with 0.375% thiobarbituric acid (TBA), fifteen percent trichloroacetic acid, and 0.25 mol per litre hydrochloric acid to allow MDA to react with TBA to produce a red outcome. After cooling on ice, samples were centrifuged, and absorbance was measured by the spectrometer at 535 wavelengths.

Polyphenoloxidase (PPO): The activities of polyphenol oxidase (PPO) were determined using the method described by Zhou *et al.,* (2019). 5 mL of ice-cold sodium phosphate buffer was combined with a fresh fruit peel. The findings were presented in units (U) per gram of fresh weight (FW).

Results and Discussion

Effect of organic extracts on fruit weight loss: The result indicates the effects of treatments on the weight loss of delicious cherry fruits depicted in Table 1. Fruit weight loss rose substantially in all fruit samples during 8 days of storage. MLE, NLE, and PPE clearly reduced the weight loss % of cherry compared to untreated, and change increased during the storage period. As shown in Table 1, the 30% Moringa leaf extract, 20% Neem leaf extract, and 30% Pomegranate peel extract (0.36%, 0.36%, 0.43% on the 8th day) and control (1.75% at day) treatments had the lowest and maximum weight loss during storage, respectively.

Fruit weight loss is linked to an increase in water loss due to evaporating from the outermost layer of tissue during storage (Zhao *et al.,* 2019). As a result, a slight element that reduces the rate of respiration can indirectly affect weight loss (Nasirzadeh, 2010; Gonzalez-Villagra *et al.,* 2024).

Effect of organic extracts on fruit decay: Cherry fruit decay percentage significantly increased during the storage period in both treated and untreated fruits. The MLE, NLE, and PPE treatments clearly decreased the decay % of fruits as compared to untreated at 8 days in the storage period. Fruit treated with 30% moringa leaf extract, 20% neem leaf extract, and 30% pomegranate peel extract showed the lowest decay percentage as compared to others, respectively (Table 1).

One of the most important elements influencing the shelf life of fresh horticultural products is decay. Harvested fruits have a high concentration of nutrients and H_2O; they are extremely sensitive to microbial deterioration (Valero & Serrano, 2010). The anti-microbial and anti-fungal properties of pomegranate, moringa and contain highly phenolic content, so it appears that fruit treated with PPE, MLE, and NLE performed best to inhibit microbial and fungal activity which directly affects the postharvest shelf life of fruits (Nicosia *et al.,* 2016).

Effect of organic extract on TSS, pH and TA: Fig. 1 shows the TA and pH fluctuations of cherries during storage. TA is a main quality characteristic linked by cherry fruit ripening. The TTA levels in cherries decreased continually during storage. TTA decreased with a steep slope in untreated samples, but this decline was delayed until the 6th day with 30% Moringa leaf extract, 20% Neem leaf extract, and 30% Pomegranate peel extract treated samples (Fig. 1). The decline of TA in the treatments and the increase in the untreated sample represent the improved effectiveness with 30% MLE, 20% NLE and 30% PPE in delaying fruit ripening. TSS measurements increased progressively during cherry fruit storage regardless of treatment, reaching a maximum on the 8th day (Fig. 1). TSS concentration may be enhanced due to H_2O loss, maturing, and softening which is caused by improved enzyme activity and less osmosis pressure (Radi *et al.,* 2017; ShM *et al.,* 2017). The rise in TSS was higher in untreated samples than in treated fruits (Fig. 1). Increasing the soluble substance level was clearly slowed in MLE-, NLE-, and PPE-treated cherries.

Our findings correspond with Nair *et al.,* (2018), who found a lesser decrease in TA in guava treated with pomegranate peel extract. According to this study, the effect of MLE, NLE and PPE extract on pH and TA was stronger as compared to the control. Previous research has found that PPE, NLE and $CaCl_2$-treated peach and blackberry have increased titratable acidity (Modesto *et al.,* 2020). Less increase in soluble solids in MLE- and PPE-treated samples is most likely due to a leisurely respiration rate and lower change of organic acids to sugars (Nicosia *et al.,* 2016).

Effect of organic extracts on Ascorbic acid (AAC) and Total sugar content (TSC) of cherry fruits: Ascorbic acid decreased during the storage interval; treated fruit had a less significant increase in AA, while the highest increase was observed in the control at the end of 8 days (Fig. 2). Postharvest AA content loss may have happened as a result of biochemical oxidation (Zhao *et al.,* 2019). The application of MLE, NLE and PPE extract significantly delayed the reduction in AA content (Fig. 2). Fruits treated with 30% MLE, 20% NLE and 30% PPE had higher AA content than control fruits throughout the storage period. Higher AA retention in MLE, NLE and PPE-treated fruits may be due to less O_2 permeability and restricted enzyme movement (Amal *et al.,* 2010). On the other hand, ascorbic acid content decreases during storage, which leads to higher sugar content in fruit. The higher the TSC in fruit degradation is, the more. Fruit treated with MLE, NLE and PPE showed a slower increase in sugar content as compared to control during storage (Fig. 2). Our findings correspond with those of Modesto *et al*., (2020) and Nair *et al*., (2018), who demonstrated that MLE, PPE and NLE application prevented the ascorbic acid decline in blackberry and strawberry.

Table 1. Effect of organic extracts on weight loss and decay parentage of cherry fruit.

Parameter	Treatments	Storage interval				
		0 day (harvest)	2nd day	4th day	6th day	8th day
Weight loss % (2022)	Control	0 ± 0	1.10 ± 0.06 a	1.9 ± 0.06 a	2.57 ± 0.09 a	3.2 ± 0.15 a
	MLE 10%	0 ± 0	0.19 ± 0.12 f	0.6 ± 0.15 f	1.23 ± 0.09g	2.53 ± 0.12e
	MLE 20%	0 ± 0	0.2 ± 0.06 e	0.5 ± 0.26 g	1.7 ± 0.06 c	2.6 ± 0.15 b
	MLE 30%	0 ± 0	0.1 ± 0.06 h	0.27 ± 0.07 i	0.53 ± 0.09 i	0.9 ± 0.06 j
	NLE 10%	0 ± 0	0.5 ± 0.12 b	0.8 ± 0.06 b	1.87 ± 0.03b	2.57 ± 0.15 c
	NLE 20%	0 ± 0	0.1 ± 0.06 h	0.3 ± 0.06 h	0.46 ± 0.15 j	0.93 ± 0.15 i
	NLE 30%	0 ± 0	0.4 ± 0.23 c	0.7 ± 0.17 e	1.4 ± 0.23 f	2.47 ± 0.09g
	PPE 10%	0 ± 0	0.3 ± 0.15 d	0.77 ± 0.09 c	1.53 ± 0.23d	2.54 ± 0.12d
	PPE 20%	0 ± 0	0.4 ± 0.12 c	0.73 ± 0.07 j	1.5 ± 0.25 e	2.50 ± 0.2 f
	PPE 30%	0 ± 0	0.17 ± 0.09g	0.37 ± 0.15g	0.63 ± 0.17h	0.97 ± 0.09h
Weight loss % (2023)	Control	0 ± 0	1.1 ± 0.06 a	1.93 ± 0.06 a	2.69 ± 0.07 a	3.27 ± 0.12 a
	MLE 10%	0 ± 0	0.4 ± 0.06 f	1.02 ± 0.06 g	1.82 ± 0.05 d	2.7 ± 0.12 b
	MLE 20%	0 ± 0	0.52 ± 0.19 c	1.13 ± 0.06 f	1.84 ± 0.09 c	2.67 ± 0.12 c
	MLE 30%	0 ± 0	0.12 ± 0.05 h	0.27 ± 0.07 j	0.75 ± 0.06 i	1.37 ± 0.05 g
	NLE 10%	0 ± 0	0.63 ± 0.18 b	1.28 ± 0.06 b	1.89 ± 0.01 b	2.57 ± 0.15 d
	NLE 20%	0 ± 0	0.11 ± 0.03 i	0.3 ± 0.06 i	0.67 ± 0.05 g	1.56 ± 0.06 f
	NLE 30%	0 ± 0	0.49 ± 0.18 d	1.14 ± 0.07 e	1.61 ± 0.11 h	2.47 ± 0.09 e
	PPE 10%	0 ± 0	0.47 ± 0.19 e	1.19 ± 0.07 c	1.7 ± 0.15 f	2.57 ± 0.12 d
	PPE 20%	0 ± 0	0.63 ± 0.15 b	1.17 ± 0.05 d	1.72 ± 0.11e	2.57 ± 0.2 d
	PPE 30%	0 ± 0	0.16 ± 0.09 g	0.33 ± 0.10 h	0.73 ± 0.03 j	1.3 ± 0.06 h
Decay % (2022)	Control	0 ± 0	$2.37 \pm 0.27_{a}$	$5.2 \pm 0.17_{a}$	$8.73 \pm 0.23_{a}$	$11.23 \pm 0.2_{a}$
	MLE 10%	0 ± 0	$0.37 \pm 0.19_{e}$	$2.4 \pm 0.17_{d}$	$4.27 \pm 0.19_{f}$	$7.3 \pm 0.21_{f}$
	MLE 20%	0 ± 0	$0.53 \pm 0.29_{c}$	$2.47 \pm 0.09_{c}$	$4.1 \pm 0.12_{g}$	$7.5 \pm 0.35_{c}$
	MLE 30%	0 ± 0	$0.13 \pm 0.09_{i}$	$0.93 \pm 0.12_{i}$	$2.1 \pm 0.36_{i}$	$4.6 \pm 0.25_{j}$
	NLE 10%	0 ± 0	$0.63 \pm 0.13_{b}$	$2.23 \pm 0.15_{g}$	$5.27 \pm 0.32_{b}$	$7.37 \pm 0.15_{d}$
	NLE 20%	0 ± 0	$0.07 \pm 0.03_{j}$	$0.9 \pm 0.17_{j}$	$1.9 \pm 0.32_{j}$	$5.13 \pm 0.2_{h}$
	NLE 30%	0 ± 0	$0.47 \pm 0.26_{d}$	$2.3 \pm 0.15_{f}$	$5 \pm 0.32_{c}$	$7.33 \pm 0.32_{e}$
	PPE 10%	0 ± 0	$0.23 \pm 0.12_{g}$	$2.37 \pm 0.09_{e}$	$4.43 \pm 0.29_{e}$	$7.2 \pm 0.21_{g}$
	PPE 20%	0 ± 0	$0.27 \pm 0.12_{f}$	$2.53 \pm 0.09_{b}$	$4.57 \pm 0.32_{d}$	$7.97 \pm 0.12_{b}$
	PPE 30%	0 ± 0	$0.2 \pm 0.12_{h}$	$0.97 \pm 0.19_{h}$	$2.5 \pm 0.23_{h}$	$4.73 \pm 0.22_{i}$
Decay % (2023)	Control	0 ± 0	2.32 ± 0.21 a	5.27 ± 0.39 a	8.56 ± 0.34 a	11.74 ± 0.29 a
	MLE 10%	0 ± 0	0.3 ± 0.15 e	3.17 ± 0.37 f	6 ± 0.31 f	8.91 ± 0.41 e
	MLE 20%	0 ± 0	0.83 ± 0.12 b	3.2 ± 0.3 e	5.77 ± 0.24 g	9.1 ± 0.42 c
	MLE 30%	0 ± 0	0.13 ± 0.09 i	1.23 ± 0.12 g	3.43 ± 0.27 j	5.07 ± 0.38 h
	NLE 10%	0 ± 0	0.63 ± 0.13 c	3.2 ± 0.51 e	6.27 ± 0.32 d	9.03 ± 0.35 d
	NLE 20%	0 ± 0	0.1 ± 0.06 j	1.22 ± 0.02 h	3.57 ± 0.12 h	5.1 ± 0.35 g
	NLE 30%	0 ± 0	0.47 ± 0.26 d	3.57 ± 0.27 c	6.8 ± 0.21 b	8.67 ± 0.45 f
	PPE 10%	0 ± 0	0.23 ± 0.12 g	3.99 ± 0.21 b	6.1 ± 0.42 e	9.3 ± 0.36 b
	PPE 20%	0 ± 0	0.27 ± 0.12 f	3.46 ± 0.31 d	6.73 ± 0.26 c	9.3 ± 0.26 b
	PPE 30%	0 ± 0	0.17 ± 0.18 h	1.16 ± 0.07 i	3.44 ± 0.29 i	5.07 ± 0.12 h

MLE: Moringa leaf extract; NLE: Neem leaf extract; PPE: Pomegranate peel extract. The ± value showed the standard error

Effect of organic extracts on TPC, TAC, TAA and TFC of cherry fruit: Phenolics are secondary metabolites found in fruits that function as antioxidants, preventing oxidation and the formation of free oxygen. (Peretto *et al.,* 2017). The TPC decreased progressively in all cherry samples throughout storage, obtaining the lowest in untreated samples at 8 days of storage (Fig. 3). These declines, however, were lower in cherries treated with MLE, PPE and NLE extract than in control fruit. A similar study reported phenolic retention in treated fruits of blackberries and cherries (Modesto *et al.,* 2020; Pasquariello *et al.,* 2015).

Anthocyanins are a pigment responsible for the red colour in cherries, which is the most important sign of maturity and quality. The decrease in anthocyanins during storage could be due to a decrease in the activity of anthocyanin production enzymes such as anthocyanin synthase (Severo *et al.,* 2015; Zhang *et al.,* 2021). In comparison to the non-treated samples, the MLE, NLE and PPE extract-treated samples retained more TAC during storage (Fig. 3). Fruit treated with 30% MLE, 20% NLE and 30% PPE extract showed maximum preserved TAC as compared to other treatments, respectively. The outcomes of this study correspond with the results reported by Aghdam *et al*., (2013), who found that postharvest moringa leaf extract and pomegranate peel extract treatment improved the anthocyanin compound of cherry fruit.

The treatments significantly inhibited the slow decline in antioxidant levels in cherry fruits during the storage period. As shown in Fig. 4, fruits treated with MLE, NLE and PPE maintained TAA compared to controls throughout the storage duration, with significant differences observed throughout storage time. 30% MLE, 20% NLE and 30% PPE extract treatments showed maximum retained antioxidants as compared to other treatments during 8 days of storage. A previous study described that treatment with MLE, PPE and $CaSO_4$ may protect antioxidants by reducing gaseous conversion, which helps to reduce the senescence of fruit (Modesto *et al.,* 2020; Nair *et al.,* 2018).

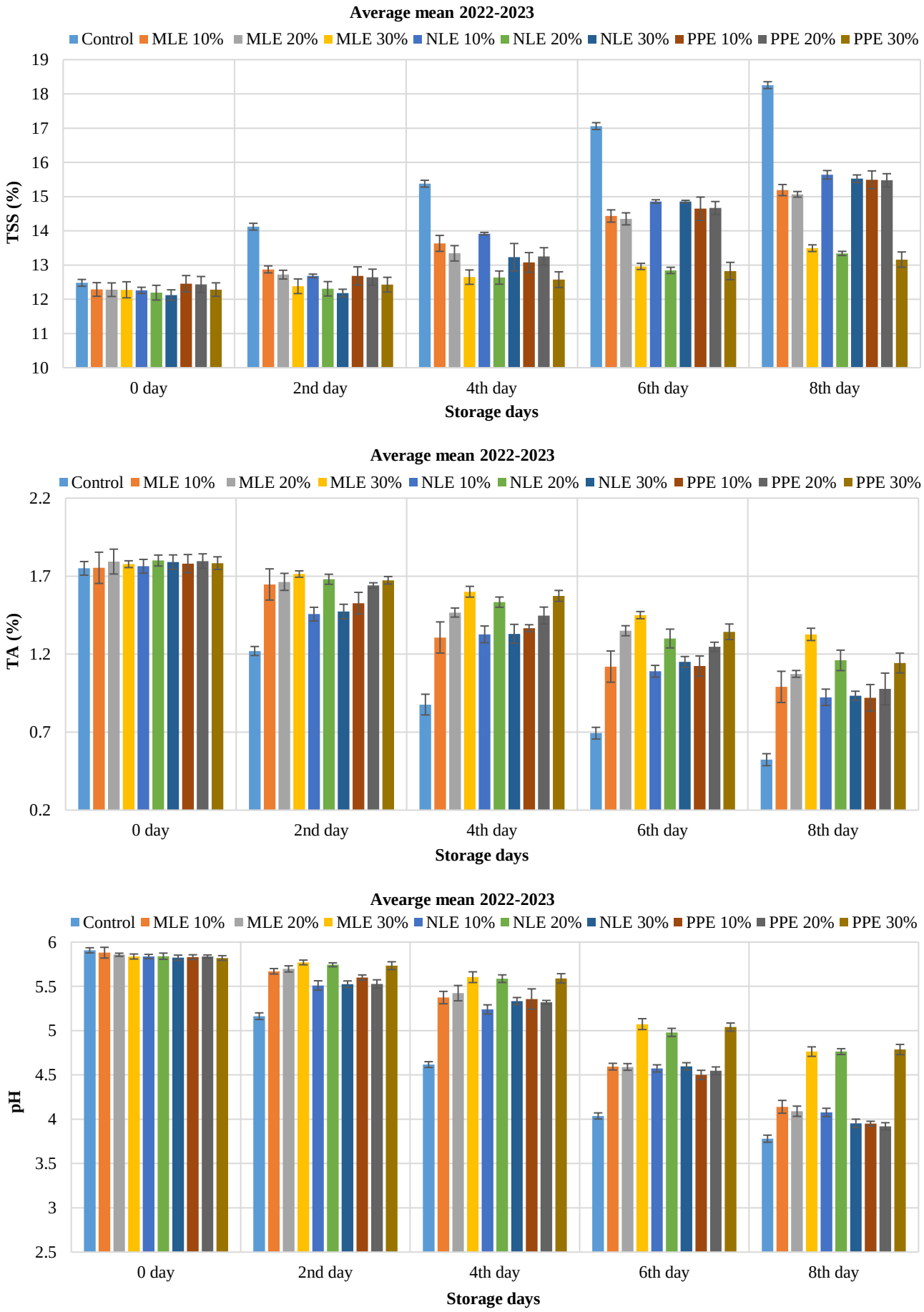

Fig. 1. Effect of Moringa leaf extract, Neem leaf extract and Pomegranate peel extract on TSS, TA and pH of cherry fruit.

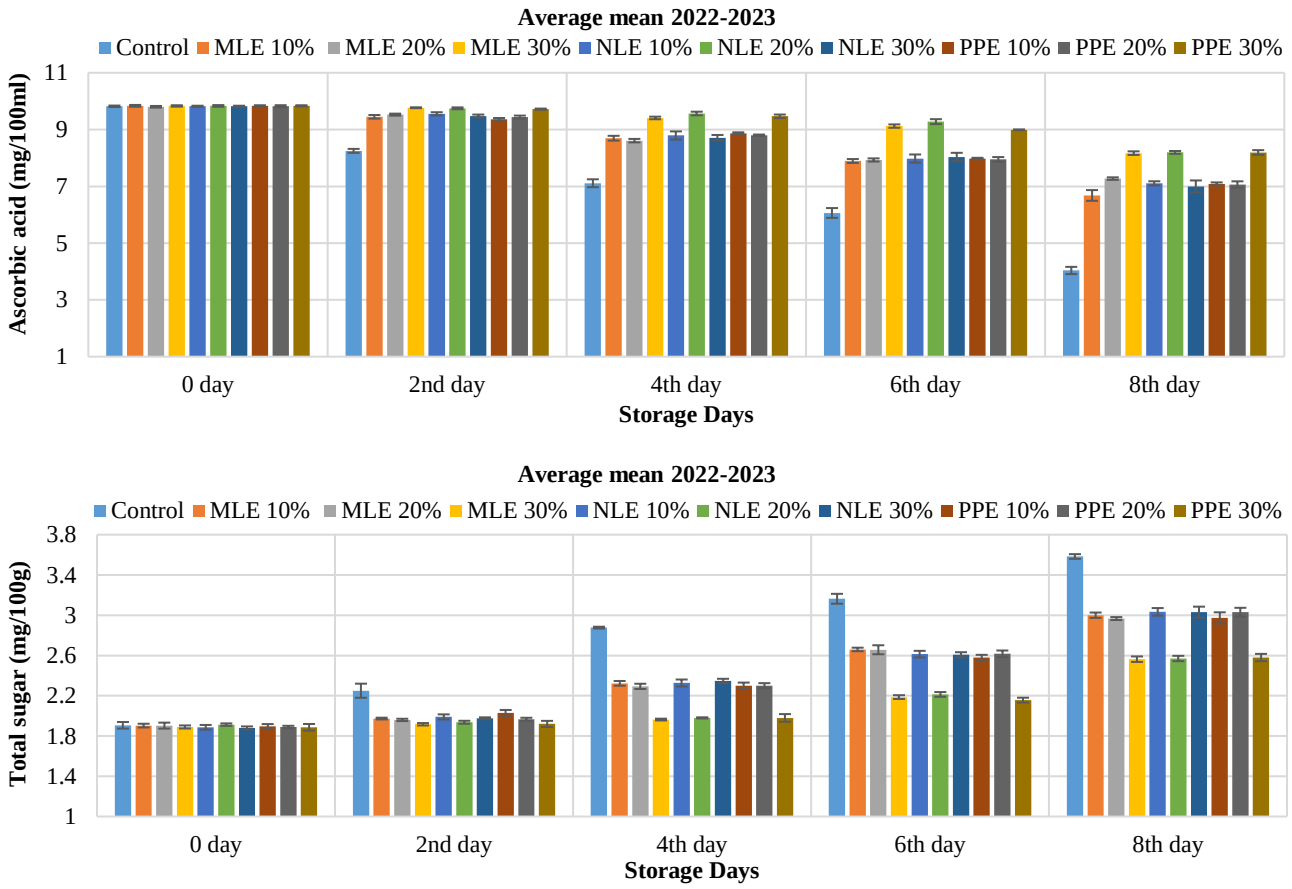

Fig. 2. Effect of Moringa leaf extract, Neem leaf extract and Pomegranate peel extract on Ascorbic acid and Total sugar of cherry fruit.

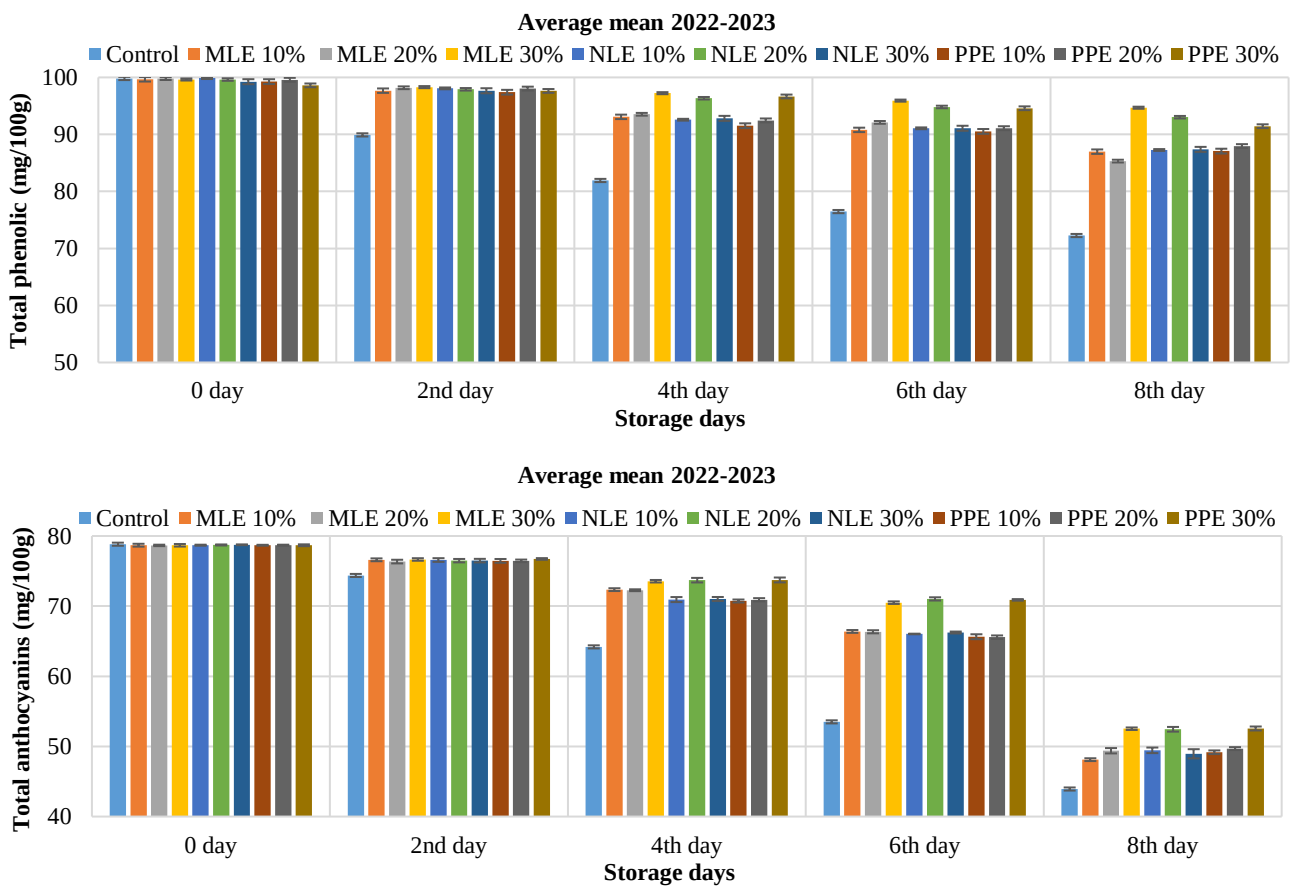

Fig. 3. Effect of Moringa leaf extract, Neem leaf extract and Pomegranate peel extract on total phenolic and total anthocyanin of cherry fruit.

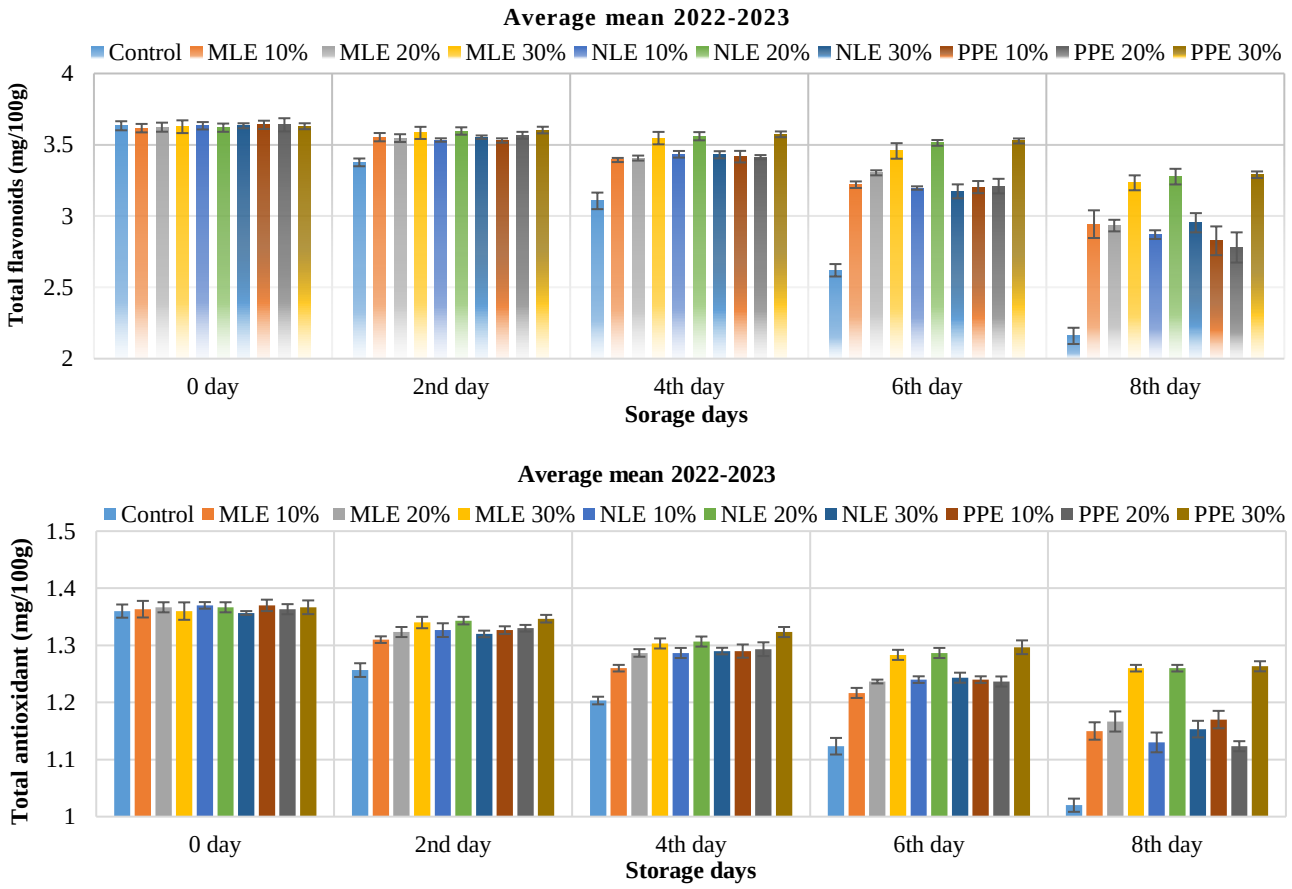

Fig. 4. Effect of Moringa leaf extract, Neem leaf extract and Pomegranate peel extract on total flavonoid and total antioxidant of cherry fruit.

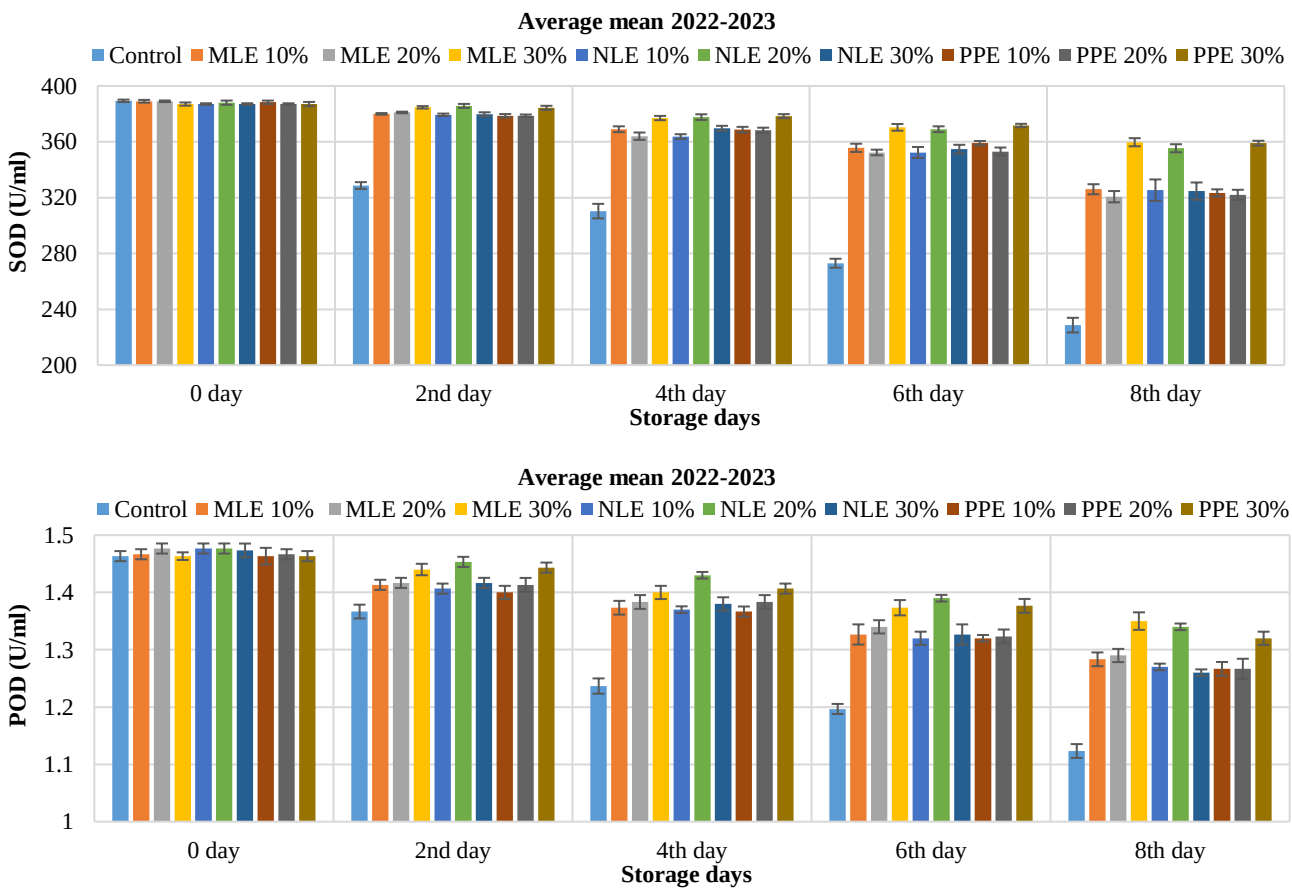

Fig. 5. Effect of Moringa leaf extract, Neem leaf extract and Pomegranate peel extract on SOD and POD of cherry fruit.

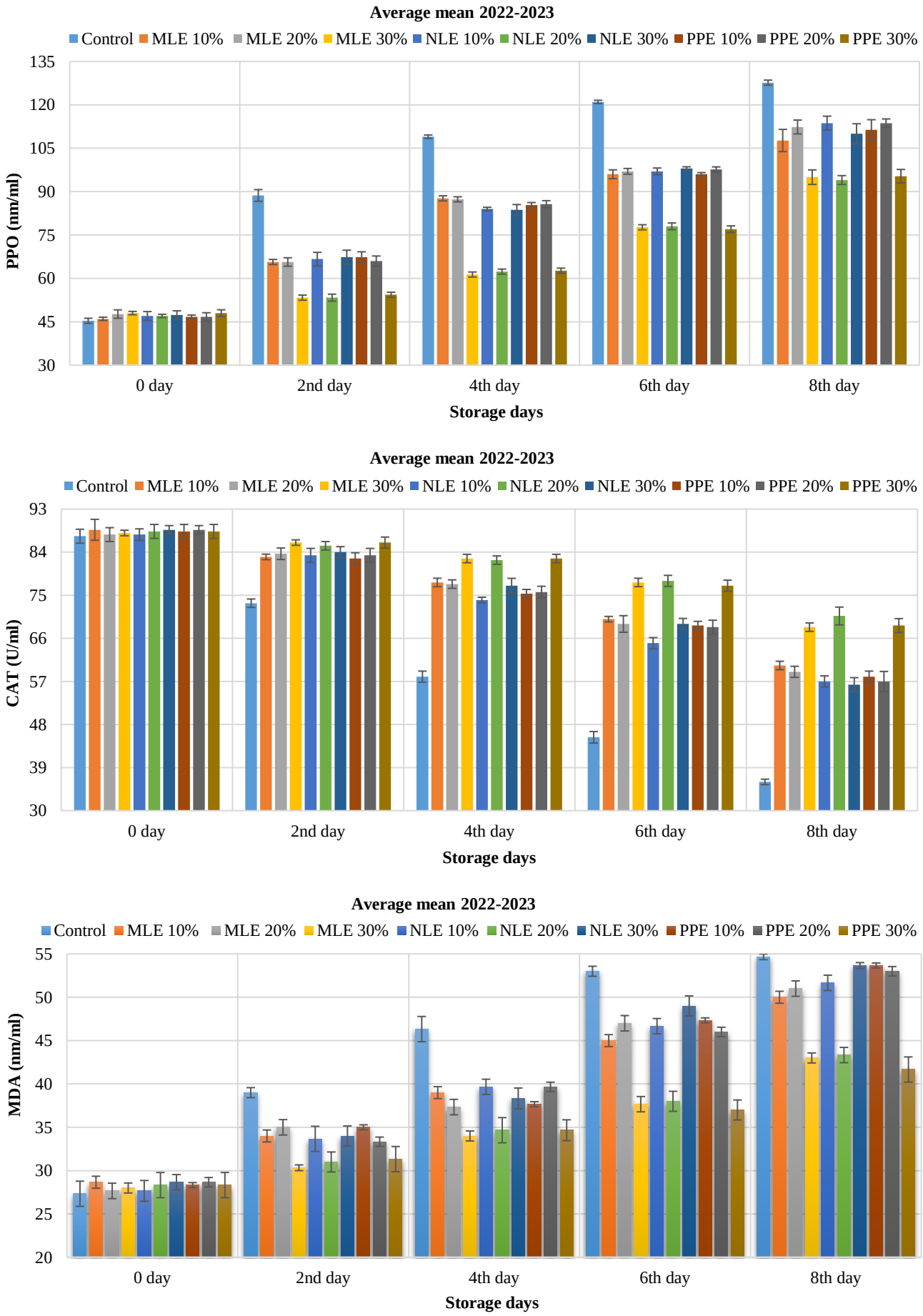

Fig. 6. Effect of Moringa leaf extract, Neem leaf extract and Pomegranate peel extract on CAT, PPO and MDA of cherry fruit.

Fruit treated with 30% MLE, 20% NLE and 30% PPE exhibited the greatest total flavonoids (TFC) levels as compared to other treatments, respectively. These findings follow the research of Shaaban (2020), who found that exogenous application of leaf extracts and salicylic acid treatment dramatically boosted total flavonoid concentration by the 30th day of storage in nectarine fruits.

Effect of organic extracts on PPO, CAT, MDA, POD and SOD of cherry fruit: Enzymatic phytochemicals such as SOD, CAT, and POD activate the plant's defence system against diverse biotic and abiotic stresses. (El Hosry *et al.*, 2023; Zulfiqar *et al.*, 2020). PPO activity in the mesocarp tissue of cherry fruit increased considerably with the storage period for all treatments. The Moringa 30%, Neem 20% and Pomegranate 30% extracts showed the lowest PPO activity as compared to other treatments, respectively (Fig. 6). In this investigation, the fruits treated with 30% MLE, 20% NLE and 30% PPE had the highest CAT and POD activity at 8 days of storage, whereas the untreated fruits had the lowest, which was nearly three times lower than the organic extracts treated fruits (Figs. 5 and 6). The results showed that SOD was a significant difference in treatment, with the control having the lowest superoxide dismutase level, which was much lower than the other treatments. Fruit treated with 30% moringa leaf extract, 20% neem leaf extract, and 30% pomegranate peel extract demonstrated the best superoxide dismutase activity when compared to other treatments (Fig. 5). The control had the lowest levels of superoxide dismutase, while the treated fruit had the greatest values. The highest malondialdehyde was observed in untreated fruit, while the lowest malondialdehyde was recorded in 30MLE, 20NLE, and 30% PPE application, respectively, as compared to other treatments. Treated fruit retains MDA during the storage period as compared to the control (Fig. 6).

The results revealed that treatment of MLE, NLE, and PPE improved antioxidative enzyme activities (SOD and CAT), but MLE treatment had no effect on POD enzyme activity across both years of research. Moringa leaves have been shown to be a source of a robust antioxidant system (SOD, CAT, POD), as well as minerals and ascorbic acid, which enhanced plant antioxidative systems (Anwar *et al.*, 2007; Zhang *et al.*, 2021). The findings of the current study correspond with those that explain the effects of natural extracts on enzyme changes and antioxidant activity (Hafeez *et al.*, 2022; Davarynejad *et al.*, 2013).

Conclusion

Our results indicated that cherry fruit is a rich source of several phytochemicals that play an important role in health improvement. This study demonstrated that applying MLE, NLE and PPE before harvesting greatly preserved the phytochemical activities of cherry during storage. Applications of 30% MLE, 20% NLE and 30% PPE are considered the optimum doses for controlling fruit loss and decay and improving phytochemicals during storage. It is recommended that the growers employ a pre-harvest spray of MLE 30%, NLE 20% and PPE 30% to improve the shelf life and quality of cherry.

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