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Araştırma Makalesi (Research Article)

Effect of Methyl Jasmonate on Enzymatic Browning and Antioxidant Enzyme System of Eggplant Fruit (*Solanum melongena* L.) **

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Abstract: Eggplant fruit result in significant economic losses, as being non-climacteric is sensitive to chilling injury and short postharvest life. Eggplants were harvested in Gevas district of Van, Turkey. The eggplant fruits were harvested by taking maturity levels into consideration and then placed in foam plates and covered with Modified Atmosphere Packaging (MAP) for 21 days in cold air depots containing 10 and 20 °C temperature and 90-95% relative humidity. The fruits of the same size were divided into 3 different groups. The first group of fruits was immersed in distilled water as a control. The second group of fruits were immersed in 1 µM MeJA solution for 10 minutes. The third group was immersed in 5 µM MeJA solution for 10 minutes. The effect of postharvest Methyl Jasmonate treatment during the storage period on respiratory rate, Superoxide dismutase (SOD), catalase (CAT), polyphenol oxidase (PPO), and malondialdehyde (MDA) were evaluated. The results obtained from this study suggest that 1 µM Methyl Jasmonate application gives the best results in terms of parameters such as respiratory rate, SOD, PPO, and MDA at 20 °C, while 5 µM Methyl Jasmonate was found to be the most positive one in terms of CAT enzyme activity. As a result, it can be suggested that MeJA treatments were effective on antioxidativ enzymes and respiration rate during the storage period.

Patlıcan Meyvelerinde (*Solanum melongena* L.) Metil Jasmonat Uygulamalarının Enzimatik Kararma ve Antioksidatif Enzimler Üzerine Etkileri

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Anahtar kelimeler

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Depolama.

Öz: Meyveleri klimakterik olmayan patlıcanlar, üşüme zararına hassas ve hasat sonrası raf ömrü kısa olduğundan dolayı önemli ekonomik kayıplara neden olmaktadır. Çalışma materyali olan patlıcanlar Türkiye de Van'ın Gevaş ilçesinde hasat edilmiştir. Patlıcan meyveleri olgunluk seviyeleri dikkate alınarak hasat edilmiş ve daha sonra köpük tabaklarda modifiye atmosfer paketleme yapılarak 10 ve 20 °C'de % 90-95 bağıl nem içeren soğuk hava depolarında 21 gün boyunca depolanmıştır. Aynı olgunluğa sahip meyveler 3 ayrı gruba ayrılmıştır. Birinci grup meyveler kontrol olarak saf suya daldırılmıştır. İkinci grup meyveler 1 µM Metil Jasmonat (MeJA) çözeltisine 10 dakika süreyle daldırılmıştır. Üçüncü grup meyvelere ise 5 µM Metil Jasmonat (MeJA) çözeltisine 10 dakika süreyle daldırılmıştır. Hasat sonrası uygulanan Metil Jasmonat'ın solunum hızı, Süperoksit dismutaz (SOD), katalaz (CAT), polifenol oksidaz (PPO) ve malondialdehit (MDA) üzerine olan etkisi araştırılmıştır. Çalışmadan elde edilen sonuçlara göre, 20 °C'de depolanan meyvelerde 1 uM Metil Jasmonat uygulamasının, solunum hızı,

SOD, PPO ve MDA gibi parametreler açısından en iyi sonuçları verdiği tespit edilirken, 5 uM Metil Jasmonatın ise CAT enzim aktivitesi açısından en iyi sonucu verdiğini göstermiştir. Sonuç olarak, MeJA uygulamalarının depolama periyodu boyunca antioksidatif enzimler ve solunum hızı üzerine etkisi olduğu söylenebilir.

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1.Introduction

Eggplant (*Solanum melongena* L.) being a member of the Solanaceae, is grown as an annual vegetable crop in warm climates and several years in the form of a bushy in tropical climates (Eşiyok and Bozokalfa, 2007). According to FAO statistic, it was produced 54.07 million tons in 2018 (FAO, 2020). Eggplant has been found to be among the top ten vegetables with regards to antioxidants claimed to have several health benefits (Ames et al., 1993; Hung et al 2004). Physical injury, slicing/chopping causes quality impairment giving rise to water loss, softening, microbial contamination, enhanced respiration rate and enzyme activity. The major restricting factor that brings down the shelf-life of fresh-cut eggplants is the oxidation of phenolic compounds due to polyphenol oxidase (PPO) (Barbagallo et al., 2012). It can be stored in low temperature so as to decrease browning and delay senescence. However, cold storage cannot be utterly utilized, as eggplants are sensitive to chilling injury (Concellón et al., 2007). Besides, storage of eggplant in controlled or modified atmospheres does not exhibit any important benefits. For instance, decreasing oxygen to 3–5% only protect it from rotting for a couple of days (Cantwell and Suslow, 2009). The main principle of using lower O_2 and higher CO_2 in Modified Atmosphere is theoretically expected to reduce the respiration rate, ethylene production, browning, weight loss, etc. (Toivonen and DeDell, 2002). Superoxide dismutase (SOD), catalase (CAT), ascorbate peroxidase (APX) (and other peroxidases), or redox regulatory enzymes such as glutathione reductase (GR) perform mostly related to antioxidant enzymatic systems activated in plants to neutralize the detrimental effects of oxidative stress (Gill and Tuteja, 2010; Karuppanapandian et al., 2011; Kıpcak et al., 2019).

Lately, the necessity of sustainability and food security has brought about significant changes in product marketing. This has showed favor the emergence of trade barriers restricting pesticide residues. In this sense, there have been struggle to reduce the use of inorganic pesticides, and when these are turned to account the preference to use organic matters (Janisiewicz and Korsten, 2002). Given these conditions, Methyl jasmonate (MeJA) is a natural compound and it has no restrains for postharvest practices. So, it has been proved to extend the postharvest life of many fruit crops (Ghasemnezhad and Javaherdashti, 2008). The application of MeJA on many kinds of fruit/vegetable by means of vapor, immersing or spraying increases the amount of antioxidant compounds and thus increasing antioxidant activity, since it enhances activity of antioxidant enzymes such as (SOD) (Cao et al., 2009), (CAT) (Asghari and Hasanlooe, 2015), (APX) (Cao et al., 2009), (PPO) (Asghari and Hasanlooe, 2015). In addition, the applications of MeJA poise membrane structure and reduce lipid peroxidation (Ziosi et al., 2008).

Therefore, in this study, it was aimed to determine the effect of MeJA on antioxidant enzymes and respiration rate during 10 and 20°C.

2. Materials and Methods

The ‘cv. Anamur Karası’ (*Solanum melongena*) eggplants was used for this study. Eggplants were harvested in Gevaş district of Van. The fruits of the same size were divided into 3 different groups. The first group of fruits was immersed in distilled water as a control. The second group of fruits were immersed in 1 µM MeJA solution for 10 minutes. The third group was immersed in 5 µM MeJA solution for 10 minutes. The eggplant fruits were harvested by taking maturity levels into consideration, and then placed in foam plates containing 3 fruits with stretch film (used as MAP)

during 10 °C for 15 days and 20 °C for 21 days 90-95% relative humidity. All analyses were conducted at 3-day intervals following harvest.

2.1. Respiration rate

CO_2 production of the eggplant fruits in the jars after a keeping period of 2 hours CO_2 value was detected with the Headspace Gas Analyzer GS3 / L analyzer at room condition (25 °C). The respiration rate values of eggplants were calculated by using weight and size values (Cavusoglu, 2018).

2.2. Antioxidative enzyme analyzes

To determine catalase (CAT) and superoxide dismutase (SOD) activity, 1 g of frozen flesh sample was homogenized with 5 mL of cold 0.1 M Na-phosphate containing 0.5 mM Na-EDTA (pH: 7.5), and then was centrifuged at 18000 rpm for 30 minutes at 4 ºC. (Jebara et al., 2005; Bagcı, 2010; Alp and Kabay, 2019).

2.2.1. Polyphenoloxidase (PPO) activity

Polyphenoloxidase (PPO) activity was determined according to the method indicated by Yemenicioglu et al. (1997). In order to determine the activity, absorbance value was determined on spectrophotometer at 420 nm wavelength for 4 minutes at 5sec intervals (Cavusoglu, 2008).

2.2.2. Superoxide dismutase (SOD) activity

The inhibition of nitroblue tetrazolium (NBT) was determined at a wavelength of 560 nm. As the reaction solution, a mixture of 50 mM Na-phosphate buffer (Na_2HPO_4 x H_2O_2), 0.1 mM Na-EDTA, 33 µM NBT, 5 µM riboflavin, 13 mM methionine (pH: 7.0) were used. 2.5 mL of reaction solution was mixed with 0.1 crude extract. As for SOD activity unit, 50% of NBT was determined as reductive (Jebara et al., 2005; Bagcı, 2010; Alp and Kabay, 2019).

2.2.3. Catalase (CAT) activity

Catalase activity was determined at a wavelength of 240 nm in one minute. 0.05 M phosphate buffer (pH: 7.0) containing 1.5 mM H_2O_2 mixture was used as the reaction solution. 2.5 mL of reaction solution and 0.2 ml of fruit extract were mixed. The reaction was started by adding the crude extract. (Jebara et al., 2005; Bagcı, 2010; Alp and Kabay, 2019).

2.2.4. Lipid peroxidation (MDA)

The levels of lipid peroxidation were assessed with regard to malondialdehyde (MDA) content. Fruit sample (0.5 g) was homogenized by adding 10 mL of 0.1% trichloro acetic acid (TCA) and then was centrifuged at 15,000 g for 5 minutes. 1 mL of the supernatant sample and 4 ml of 20% TCA containing 0.5% of thiobarbituric acid (TBA) were mixed. The mixture was kept at 95 °C for 30 minutes, then rapidly cooled in an ice bath and centrifuged at 10000 rpm for 10 minutes. The absorbance of supernatant was recorded at 532 nm and 600 nm. (Bağcı, 2010).

2.3. Statistical analysis

Descriptive statistics for studied variables (characteristics) were presented as mean and standard error of mean. The study was carried out as factorial experiments with three factors including periods, treatments, and temperature based on a randomized design with 3 replicates. One way ANOVA for completely randomized design was conducted for analyzed the effects of storage duration, treatments and temperature. Duncan multiple comparison test was also used to identify

different groups. Statistical significance levels were considered as 5%. The SPSS (ver. 13) statistical program was used for all statistical computations.

3. Results and Discussion

3.1. Respiration rate

The changes in respiration rate during the storage period of eggplants stored at 10 ºC and 20 ºC are shown in Table 1. Although fluctuations were caused by increases and decreases in other applications except for respiration rate 5 µM MeJA application in samples stored at 10 ºC during the storage period, it was determined that there was generally decreases at the end of storage. When the applications in terms of respiratory rate was evaluated; the lowest respiration rate was found to be 26.37 mL CO_2 kg^{-1} h^{-1} in 5 µM MeJA application and the highest respiratory rate was 32.83 ml CO_2 kg^{-1} h^{-1} in 1 µM MeJA application. While there were fluctuations due to increases and decreases in respiration rate during the storage period samples stored at 20 ºC; decreases in respiration rate in general were observed when the applications were examined at the end of storage. In terms of respiration rate, the lowest respiratory rate was found to be 24.26 mL CO_2 kg^{-1} h^{-1} in fruits treated with 1 µM MeJA, whereas the highest respiratory rate was 29.33 ml CO_2 kg^{-1} h^{-1} in fruits treated with 5 µM MeJA.

When the changes in respiration rate for the differences among the treatments were assessed statistically; The difference among the treatments was not statistically significant in fruits stored at 10 °C, whereas the difference among applications was found to be significant at the 9th day at 20 °C.

Table 1. The changes in respiration rate ($mLCO_2kg^{-1}h^{-1}$) during storage of cv 'Anamur Karası' (*Solanum melongena* L.) eggplant at 10 and 20 °C.

Storage Temperature	Storage Periods(days)	Control	1 µM MeJA	5 µm MeJA
10 °C	0	45.630 ± 5.338	45.630 ± 5.338	45.630 ± 5.338
	3	33.977 ± 5.490	39.498 ± 9.921	39.592 ± 3.357
	6	37.469 ± 6.116	37.917 ± 7.310	33.591 ± 3.430
	9	21.886 ± 2.489	22.157 ± 5.177	29.972 ± 1.883
	12	26.704 ± 4.716	24.437 ± 3.623	31.067 ± 6.987
	15	28.867 ± 5.607	32.826 ± 2.076	26.367 ± 3.285
p values: $p_{Treatments} = 0,118$; $p_{Storage\ periods} = 0,135$; $p_{Storage\ temperatures} = 0,122$				
20 °C	0	45.630 ± 5.338 a	45.630 ± 5.338	45.630 ± 5.338
	3	34.064 ± 6.021 b	35.955 ± 6.888	30.304 ± 7.201
	6	33.426 ± 4.283 b	37.977 ± 2.054	41.805 ± 3.704
	9	20.957 ± 1.820 B c	28.426 ± 1.398 A	29.506 ± 2.167 A
	12	29.377 ± 5.849 c	25.370 ± 7.319	29.166 ± 1.842
	18	40.175 ± 5.976 a	28.700 ± 7.907	34.437 ± 13.580
	21	24.460 ± 1.516 c	24.262 ± 1.601	29.326 ± 1.238
p values: $p_{Treatments} = 0,004$; $p_{Storage\ periods} = 0,032$				

a, b, c: ↓ Different small letters in the same storage temperature and treatment represent statistically significant differences among the storage periods ($p<0.05$).
A, B, C: → Different capital letters in the same storage temperature and storage periods (the same row) represent statistically significant differences among the treatments ($p<0.05$).

The purpose of preserving products in MAP conditions; is to control weight loss, browning, ethylene production and respiratory rate by reducing physiological changes and quality, through lower O_2 and higher CO_2 (Toivonen and DeDell, 2002). Catalano et al. (2007) suggested that atmospheric conditions with higher CO_2 and lower O_2 had positive effects on quality in eggplants, besides, they reported that PPO enzyme activity is stimulated. As a matter of fact, in the study carried out in MAP conditions, low respiration rate was found in both MeJA treated fruits and control fruits in both storage conditions.

3.2. PPO enzyme activity

PPO enzyme activity and decreases occurred in the samples stored at 10 ºC during the storage period (Table 2). At the end of storage period, the highest PPO enzyme activity was determined in samples treated with 5 µM MeJA with 2.63 mL/unit, while the lowest was in 1 µM MeJA with 1.23 mL/unit. When the changes in fruits stored at 20 ºC for 21 days were examined, there was a continuous increase in both MeJA treated fruit and control fruit up to the 18th day. At the end of storage, the highest PPO enzyme activity was determined in 5 µM MeJA application with 5.12 mL/unit, whereas the lowest was found in 1 µM MeJA application with 2.33 mL/unit.

When the differences among the treatments were examined statistically for PPO enzyme, there was no significant difference in the stored fruits at 10 ℃, while there was significant difference among treatments on the 9th day at 20 °C.

While the difference among storage periods was significant in 5 µM MeJA application, the difference was not statistically significant in control and 1 µM MeJA application at 20 °C.

In samples treated with 1 and 5 µM MeJA and stored at 10 ˚C, samples were found statistically significant-at the 9th day in terms of difference between storage temperatures (Table 2).

Table 2: The changes in PPO enzyme activity (mL/unit) during storage of cv 'Anamur Karası' (*Solanum melongena* L.) eggplant at 10 and 20 °C.

Storage Temperature	Storage Periods(days)	Control	1 µM MeJA	5 µm MeJA
10 °C	0	1.049 ± 0.219 c	1.049 ± 0.219 d	1.049 ± 0.219
	3	2.795 ± 0.912 ab	1.632 ± 0.204 c	1.086 ± 0.463
	6	1.712 ± 0.473 c	2.215 ± 0.748 bc	2.358 ± 0.431
	9	3.287 ± 1.075 a	2.192 ± 0.111b #	1.797 ± 0.160 #
	12	2.185 ± 0.428 b	4.801 ± 0.000 a	3.075 ± 1.278
	15	1.770 ± 0.571 c	1.239 ± 0.628 cd	2.637 ± 0.738
p values: $p_{Treatments}$ = 0,142; $p_{Storage\ periods}$ = 0,032; $p_{Storage\ temperatures}$ = 0,021				
20 °C	0	1.049 ± 0.219	1.049 ± 0.219	1.049 ± 0.219 c
	3	0.884 ± 0.206	1.929 ± 0.979	1.293 ± 0.785 c
	6	2.059 ± 0.465	2.094 ± 0.733	3.320 ± 1.521 b
	9	2.401 ± 0.127 C	4.518 ± 0.070 A	3.420 ± 0.213B b
	12	2.862 ± 0.488	3.492 ± 1.026	3.619 ± 0.392 b
	18	6.777 ± 1.641	7.235 ± 0.649	6.734 ± 0.916 a
	21	2.556 ± 0.257	2.330 ± 0.693	5.129 ± 0.947 a
p values: $p_{Treatments}$ = 0,015; $p_{Storage\ periods}$ = 0,022				

#: The difference from the 20 °C temperature in the same storage period and treatment is statistically significant ($p<0.05$)
a, b, c: ↓Different small letters in the same storage temperature and treatment represent statistically significant differences among the storage periods ($p<0.05$).
A, B, C: → Different capital letters in the same storage temperature and storage periods (the same row) represent statistically significant differences among the treatments ($p<0.05$).

PPO is found in other cell parts, on the other hand, phenolic compounds are found in vacuoles; this separation restrains enzymatic browning. If the cell membrane structure of fruits and vegetables is destroyed by metabolic disorders under stress, PPO interacts with the phenolic compounds to form browning substances (Lin et al., 2013). Seylam Küşümler (2011) reported that the browning was chiefly related to high levels of saturated fatty acids and lower unsaturated fatty acids. It also reported that browning demonstrates a positive correlation with high levels of PPO, phenylalanine ammonia lyase (PAL) and SOD enzymes, but there is a negative correlation with CAT and peroxidase (POD) enzyme activities. In eggplants exposed to MeJA applications and stored under modified atmospheric conditions; they reported that PPO enzyme activity was lower while POD and CAT enzyme activity was higher in fruits treated with MeJA compared to control group. It was reported that browning of calyx during eggplant storage is the most important indicator of quality loss (Fan et al., 2016; Mishra et al., 2013). Mishra et al. (2013) suggested that increased browning due to senescence and ripening is related to PPO and phenolics. It was reported that maintaining product quality and antioxidant activity increased with high POD and CAT enzyme activity in eggplants (Jing et al., 2014; 2015). Moreover, Shi et al. (2019) suggested that MeJA combined with low-temperature conditioning delayed the accumulation of MDA, decreased PPO enzyme activity, and increased the activity of the antioxidant enzymes such as CAT and POD in eggplant fruit.

3.3. SOD enzyme activity

While the increases and decreases in all applications during the storage period in the 'cv Anamur Karası (*Solanum melongena* L.)eggplant fruits stored at 10 ºC and 20 ºC in terms of SOD enzyme activity were observed, an overall increase was found at the end of the storage compared to the beginning of the storage (Table 3).

At the end of storage, the highest value was found in 1 µM MeJA application with 459.34 unitsgr^{-1} and the lowest value was found in 5 µM application with 352.89 unitsgr^{-1} FW in eggplants stored at 10 ºC in terms of the change of SOD activity (Table 3). At the end of storage, the highest value was 542.15 unitsgr^{-1} FW in control fruits, on the other hand, the lowest value was found to be 5 µM MeJA with 418.45 unitsgr^{-1} FW (Table 3).

When the changes in SOD enzyme activity was statistically examined in terms of the differences among applications; the difference among the treatments was not statistically significant in fruits stored at 10 °C, whereas the difference among the treatments was significant at the 9th day at 20 °C (Table 3).

There was statistically significant in the control group, but the difference between storage temperatures was found to be statistically significant in 1 µM and 5 µM MeJA applications (Table 3).

Table 3: The changes SOD (unitsgr^{-1} FW) during storage of cv 'Anamur Karası' (*Solanum melongena* L.) at 10 and 20 °C.

Storage Temperature	Storage Periods(days)	**Control**	**1 µM MeJA**	**5 µm MeJA**
10 °C	0	242.938 ± 101.977	242.938 ± 101.977	242.938 ± 101.977
	3	313.148 ± 81.839	506.667 ± 126.667	335.667 ± 95.841
	6	285.000 ± 54.848	572.559 ± 190.017	269.658 ± 35.532
	9	326.501 ± 153.483	696.667 ± 36.566 #	382.559 ± 22.198 #
	12	265.564 ± 105.359	492.593 ± 70.370	334.936 ± 71.797
	15	417.436 ± 173.342	459.341 ± 83.517	352.898 ± 97.033
p values: $p_{Treatments}$ = 0,438; $p_{Storage\ periods}$ = 0,327 ; $p_{Storage\ temperatures}$ = 0,029				
20 °C	0	242.938 ± 101.977	242.938 ± 101.977	242.938 ± 101.977
	3	778.214 ± 560.905	414.226 ± 37.610	404.630 ± 46.546
	6	957.037 ± 497.395	347.374 ± 18.308	520.741 ± 120.249
	9	928.889 ± 168.889 A	303.214 ± 85.968 C	497.619 ± 22.619 B
	12	646.325 ± 311.202	264.098 ± 140.267	212.413 ± 84.984
	18	468.584 ± 156.591	345.350 ± 145.496	217.138 ± 64.546
	21	542.156 ± 366.089	485.556 ± 138.435	418.452 ± 92.572
p values: $p_{Treatments}$ = 0,025; $p_{Storage\ periods}$ = 0,621				

#: The difference from the 20 °C temperature in the same storage period and treatment is statistically significant ($p<0.05$)
A, B, C: → Different capital letters in the same storage temperature and storage periods (the same row) represent statistically significant differences among the treatments ($p<0.05$).

Menga et al. (2017) in their study have been reported to play an important role in the antioxidative enzymes SOD and CAT in fruit quality and protection against oxidative stress, as they provide membrane integrity by destroying active oxygen species in mushrooms. In the same study, higher SOD and CAT activities were detected in the mushrooms treated with MeJA than the control during storage. CAT activity was determined in parallel with the study cited above in fruits treated with MeJA under both storage conditions, and in terms of SOD activity; 1 µM MeJA application at 10 °C also showed parallel with higher SOD activity than control. The lower SOD activity was detected in eggplant treated with 5 µM MeJA application stored at 20 °C. So, it can be stated that MeJA may have a positive effect, since browning has a positive correlation with SOD enzyme (Seylam Küşümler, 2011).

3.4. CAT enzyme activity

CAT enzyme activity of fruits were stored at 10 ºC; although there were fluctuations in all applications during the storage period, a decrease in enzyme activity was observed at the end of storage. When catalase enzyme activity of the samples stored at 20 ºC was observed, at the end of

storage, it was determined that enzyme activity decreased in all applications compared to the beginning. At the end of storage enzyme activity; the highest value in 0.005 unitsgr^{-1} FW with 5 µM MeJA application, in contrast, the lowest value was found to be 1 µM MeJA application with 0.002 unitsgr^{-1} FW (Table 4).

When the variations in CAT enzyme activity was statistically evaluated differences among applications; the difference among treatments was statistically significant at the 6th day at 10 °C, whereas there was no significant difference among the treatments at 20 °C. The differences between storage temperatures for both storages were not statistically significant (Table 4).

Table 4. The changes in CAT (unitsgr^{-1} FW) during storage of cv 'Anamur Karası' (*Solanum melongena* L.) eggplant at 10 and 20 °C.

Storage Temperature	Storage Periods(days)	Control	1 µM MeJA	5 µm MeJA
10 °C	0	0.008 ± 0.002	0.008 ± 0.002	0.008 ± 0.002
	3	0.003 ± 0.002	0.003 ± 0.001	0.002 ± 0.000
	6	0.004 ± 0.001 A	0.002 ± 0.001 B	0.001 ± 0.000 B
	9	0.002 ± 0.001	0.002 ± 0.000	0.002 ± 0.000
	12	0.002 ± 0.000	0.002 ± 0.000	0.003 ± 0.000
	15	0.002 ± 0.001	0.002 ± 0.001	0.002 ± 0.000
p values: $p_{Treatments}$ = 0,018; $p_{Storage\ periods}$ = 0,083 ; $p_{Storage\ temperatures}$ = 0,151				
20 °C	0	0.008 ± 0.002	0.008 ± 0.002	0.008 ± 0.002
	3	0.005 ± 0.004	0.003 ± 0.002	0.002 ± 0.001
	6	0.002 ± 0.000	0.001 ± 0.000	0.003 ± 0.002
	9	0.001 ± 0.000	0.002 ± 0.001	0.001 ± 0.001
	12	0.001 ± 0.000	0.001 ± 0.001	0.001 ± 0.000
	18	0.001 ± 0.000	0.002 ± 0.001	0.001 ± 0.000
	21	0.003 ±0.001	0.002 ± 0.000	0.005 ± 0.003
p values: $p_{Treatments}$ = 0,259; $p_{Storage\ periods}$ = 0,121				

A, B, C: → Different capital letters in the same storage temperature and storage periods (the same row) represent statistically significant differences among the treatments ($p<0.05$).

Liu et al. (2016) suggested that MeJA applications reduced chilling injury and also increased CAT enzyme activity by reducing the accumulation of H_2O_2. In fact, researchers have reported that CAT has an important role in H_2O_2 accumulation. Many researchers have reported that the chilling damage prevented by MeJA implementation is associated with the increased CAT enzyme activity (Venkatachalam and Meenune, 2015; Cao et al., 2009; Esim and Atici, 2014; Wu et al., 2014). According to Zhu and Tian (2012), MeJA applications cause the deterioration of H_2O_2 by activating CAT and POD activity, and by regulating the production of reactive oxygen species, MeJA increases the resistance of tomatoes and leads to an increase in CAT enzyme activity. It is reported that MeJA applied to banana trees from the exogenous stimulates CAT and POD activity and induces a decrease in H_2O_2 and O_2 levels (Sun et al., 2013).

3.5. MDA activity

When MDA levels of eggplant samples subjected to MeJA applications were examined during the storage period at 10 °C; it is determined that MDA level decreased at the end of storage compared to the beginning, although there were increases and decreases in applications. At the end of storage, the highest value was found in control application with 3.56 unitsgr^{-1} FW, while the lowest value was determined with 5 µM MeJA application with 2.96 unitsgr^{-1} FW. In addition, fluctuations were determined during the storage period, while a decrease was observed at the end of storage. At the end of storage, the highest MDA value was 3.82 unitsgr^{-1} FW in the control group whereas the lowest MDA value was found to be 1 µM MeJA application with 3.48 unitsgr^{-1} FW (Table 5).

In the study, there was no statistically significant difference among the treatments and storage periods in all groups stored at 10 °C and 20 °C. The differences between the storage temperatures for both storages were not statistically significant in the changes MDA levels (Table 5).

Table 5: The changes in MDA (unitsgr^{-1} FW) levels during storage of cv 'Anamur Karası' (*Solanum melongena* L.) eggplant at 10 and 20 °C.

Storage Temperature	Storage Periods(days)	Control	1 µM MeJA	5 µm MeJA
10 °C	0	3.914 ± 0.382 ab	3.914 ± 0.382	3.914 ± 0.382
	3	4.043 ± 0.114 a	3.914 ± 0.188	3.312 ± 0.368
	6	4.172 ± 0.188 a	3.742 ± 0.415	3.398 ± 0.368
	9	2.796 ± 0.114 b	3.183 ± 0.301	3.054 ± 0.172
	12	2.237 ± 0.262 b	3.011 ± 1.145	3.699 ± 0.368
	15	3.570 ± 0.282 ab	3.355 ± 0.649	2.968 ± 0.591
p values: $p_{Treatments}$ = 0,078; $p_{Storage\ periods}$ = 0,033 ; $p_{Storage\ temperatures}$ = 0,151				
20 °C	0	3.914 ± 0.382	3.914 ± 0.382	3.914 ± 0.382
	3	3.355 ± 0.537	4.301 ± 0.410	3.828 ± 0.765
	6	3.355 ± 0.269	3.441 ± 0.455	4.086 ± 0.352
	9	2.753 ± 0.188	3.355 ± 0.325	3.527 ± 0.228
	12	3.828 ± 0.240	3.054 ± 0.479	3.269 ± 0.455
	18	3.484 ± 0.394	3.699 ± 0.114	3.871 ± 0.649
	21	3.828 ± 0.301	3.484 ± 0.149	3.613 ± 0.075
p values: $p_{Treatments}$ = 0,186; $p_{Storage\ periods}$ = 0,253				

a, b, c: ↓Different small letters in the same storage temperature and treatment represent statistically significant differences among the storage periods ($p<0.05$).

Rawyler et al. (1999), have suggested that there is a correlation between ATP and membrane damage in plants. An ATP deficiency can lead to lipid peroxidation as a result of more production of free radicals damaging cell membranes (Harwood, 1998; Alp, 2017). Membrane damage caused by low temperatures is thought to be a major cause of chilling injury. In order to detect membrane damage, chilling injury and loss of integrity in membranes; by examining ion leakage and MDA content can be detected (Wang, 1990). Rui et al. (2010) reported that the application of temperature in the loquat fruit increases the tolerance to chilling injury by providing low ion leakage and MDA content. In a study conducted by Jin et al. (2012) on peach, MeJA application was found to lower MDA contents than control fruits and it was similar to the results of our study.

4. Conclusion

As a result, it can be suggested that MeJA treatments delayed the accumulation of MDA, decreased PPO enzyme activity, and increased the activity of the antioxidant enzymes such as CAT and SOD as well as, were effective on respiration rate during the storage period. 1 µM Methyl Jasmonate application gives the best results in terms of such parameters as respiratory rate, SOD, PPO, and MDA parameters at 20 °C, while 5 µM Methyl Jasmonate was found to be the most positive in terms of CAT enzyme activity.

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