THE USE OF AQUEOUS 1-METHYLCYCLOPROPENE (1-MCP) IN PACKAGED CARROTS (*Daucus carota* L.)

Awat Ali HUSSEIN

Master's Thesis

Department of Horticulture

Supervisor: Prof. Dr. Muharrem ERGUN

2017

REPUBLIC OF TURKEY
BİNGÖL UNIVERSITY
INSTITUTE OF SCIENCE

THE USE OF AQUEOUS 1-METHYLCYLOPROPENE (1-MCP) IN PACKAGED CARROT (*Daucus carota* L.)

MASTER'S THESIS

Awat Ali HUSSEIN

Department : Horticulture

Supervisor : Prof. Dr. Muharrem ERGUN

June 2017

REPUBLIC OF TURKEY
BİNGÖL UNIVERSITY
INSTITUTE OF SCIENCE

THE USE OF AQUEOUS 1-METHYLCYCLOPROPENE (1-MCP) IN PACKAGED CARROT (*Daucus carota* L.)

MASTER'S THESIS

Awat Ali HUSSEIN

Department : HORTICULTURE

This master's thesis was accepted by the following committee on 08.06.2017 with the vote unity.

Prof. Dr. Muharrem ERGUN	Assist. Prof. Dr. Abdullah OSMANOĞLU	Assoc. Prof. Dr. Koray ÖZRENK
Head of examining committee	Member of examining committee	Member of examining committee

I confirm the result above

Prof. Dr. Ibrahim Y. ERDOĞAN
Director of the Institute

PREFACE

My thesis was a long journey with roller coaster ride at every steps of it, which I would never finish without the support of some special people.

First a very special thanks to my advisor Prof. Dr. Muharrem ERGUN to tolerate me with my vacuumed mind. He has not only tolerated me but he has filled my mind with appropriate knowledge.

I am also very grateful to Zahide SUSLUOGLU and Nazan ERGUN, who helped me and they are tired with me during the experiment. I would also like thanks to assistance Prof. Dr. Nusret OZBAY and Dr. Nasreen ABDULRAHMAN, I would also like to thanks my dear friend Aram H. MOHAMMED, Shakar B. MOHAMMED and dear friend Najat GHARIB to help in rephrasing my writing.

I am also very grateful to Dr. Ali O. MUHEDDIN. Who advise me and he available his time for each question.

I owe my loving thanks to my parents, who have been seeing me graduated since the day one. They have made sure that I never stay without any resources required in my life till date. My dad has compromised his every joy to full fill all my wishes. My mom's love is courage of my life.

Awat Ali HUSSEIN

Bingöl 2017

CONTENTS

LIST OF SYMBOLS

A-1-MCP	: Aqueous-one-Methylcyclopropene
G-1-MCP	: Gas-one-Methylcyclopropene
MAP	: Modified Atmosphere package
CO_2	: Carbon dioxide
O_2	: Oxygen
N_2	: Nitrogen
pH	: Potential of hydrogen
TA	: Titratable acidity
SSC	: Soluble Solid Content
N	: Newton
PET	: Plastic packaging box
LDPE	: Low-density polyethylene
L	: Liter
cm	: Centimeter
mm	: Millimeter
g	: Gram
ml	: Milliliter
$\mu.l^{-1}$	: Micro liter
In	: Inch
mg	: Milligram
^oC	: Celsius degree
%	: Percentage
α	: Alfa
β	: Beta

LIST OF FIGURES

LIST OF TABLES

PAKETLENMİŞ HAVUÇLARDA SIVI 1-METİLSİKLOPROPEN (1-MCP) KULLANIMI

ÖZET

Bu çalışmanın amacı sıvı ve gaz 1-metilsiklopropropen (1-MCP) ve modifiyeetmosfer paketlemesi (MAP) kullanarak havuçların derim sonrası raf ömrünü uzatmak ve kalitelerini korumak olmuştur.

Çalışma Bingöl üniversitesi laboratuvarlarında 2016 yılında gerçekleştirilmiştir. Çalışmada kullanılan 'Nantes' havuç çeşidi Hatay'ın Kırıkan ilçesinden elde edilmiştir.Havuçlar uygulamalar öncesi çeşme suyu ile yıkanmış ve daha sonra 4 gruba ayrılmıştır: Birinci grup kontrol, ikinci grup MAP, üçüncü grup sıvı 1-MCP ve dördüncü grup gaz örneklerini oluşturmuştur. Havuçlar uygulamalar sonrası 10 gün süre ile 23 ± 1 °C'de muhafaza edilmiştir. MAP uygulaması için bir LPDE tipi paketleme materyali, 1-MCP uygulamaları için SensyFresh Tozu (aktif bileşen % 3,3 1-MCP; Agroberst Firması, İzmir) kullanılmıştır. Havuç örneklerinde depolama boyunca kalite değişimleri, görsel gözlemeler, ağırlık kaybı, sertlik kaybı, paket gaz içeriği (O_2,CO_2,andN_2), SEK, pH, titre edilebilir asit, klorofil içeriği ve çürüme oranı ile gözlemlenmiştir.

Sonuçlar gaz 1-MCP uygulamasının özellikle çürüme oranın bastırabilme özelliği ile havuçların derim sonrası raf ömrünü uzatma potansiyeli taşıdığını ortaya koymuştur. Diğer taraftan sıvı 1-MCP uygulaması ne raf ömrünü uzatmada ne de kaliteyi muhafaza etmede etkili olabilmiştir. MAP uygulaması ise su ve sertlik kaybını hızlandırarak hem kalite hem de raf ömrü üzerine olumsuz etkide bulunmuştur.

Anhtar kelimeler: Havuç, MAP, sıvı 1-MCP, gaz 1-MCP.

THE USE OF AQUEOUS 1-METHYLCYCLOPROPENE (1-MCP) IN PACKAGED CARROTS (*Daucus carota* L.)

ABSTRACT

The aim of this study was to prolong the postharvest shelf life and maintain the quality and by using aqueous and gaseous 1-methylcylopropene (1-MCP), and modified atmosphere packaging (MAP) treatments.

This work was carried out in the Bingöl University laboratory in the 2016. 'Nantes' carrot cultivar obtained from Kırıkhan, Hatay was employed in the present study. Carrots were washed with tap water prior to the experiment, and distributed into four lots: the first one was for the control, the second one for MAP, the third one for aqueous 1-MCP and the fourth one for gaseous 1-MCP applications and stored at 23 ± 1 °C for 10 days. For the MAP application, a LPDE-type packaging material was used and for 1-MCP application, Sensy Fresh powder (active ingredient 3.3% 1-MCP; Agrobest, Izmir) was used. After treatments control, aqueous 1-MCP and gaseous 1-MCP-treated fruits were placed into the PET boxes. Samples of carrots were then tested periodically to note the changes in quality as determined by visual observation, weight loss, firmness, color, gas composition (O_2, CO_2, and N_2), SSC, PH, titratable acidity (TA), chlorophyll content, and decay during the storage time.

The results indicated that gaseous 1-MCP application has a potential extend postharvest shelf life of carrot especially by suppressing decay ratios. Aqueous 1-MCP was however ineffective on either prolonging or extending shelf life of the treated carrots. MAP application accelerated both water and water loss thus had an adverse effect on the quality and shelf life.

Keywords: carrot, MAP, aqueous 1-MCP, and gaseous 1-MCP.

1. INTRODUCTION

A member of *Umbelliferae* family, Carrot (*Daucus carota* L.) is grown-up for its fleshy roots used like vegetable. *Umbelliferae* includes about 2,500 species such as parsnip, celery, caraway, fennel, cumin, chervil, coriander, anise and parsley. It also includes poisonous species such poison hemlock, water hemlock and fools' parsley. Carrots are usually orange in color but yellow, red, white, black and purple cultivars do exist as well. According to (FAO 2014), carrot and turnips were cultivated in 1,368.358 ha area, and a total of their production was 38,835.235 tons. China (17,311.975 tons), Uzbekistan (1,791.540 tones) and USA (1,443.120 tones) are the chief carrot and turnip producing countries. The production amount of carrot in Turkey was 534,988 tons, and cultivated in 101.003 ha area. Besides its fresh consumption, carrots are used in cakes, puddings, jams, preserves and fruit juices.

Carrots are harvested when they reach a diameter of 20 mm and more, still young and tender or carrots can be harvested after maturity by machine or sometime by hand for the small areas. After harvest, some quality defects such as loss of sweetness and carotenoids and formation of bitterness and oxidized flavor are taking place in carrots. To decrease the quality harm of carrots, have to be stored at 0°C with a RH of 93-98% (Salunkhe and Desai 1984). From a commercial point of view, carrots can be treated into frozen, dried, canned and fermented products, and even baby foods (Niketic-Aleksic et al. 1973; Ramdas and Kulkami 1987).

Carrot is wealthy with a precursor of vitamin A and carotene (Howard et al. 1962), whose dietary shortages can lead to premature childhood mortality and blindness (Burns et al. 2003 Surles et al. 2004). Carrot also includes appreciable amounts of protein, sugar, thiamine, fiber, riboflavin, carbohydrate, potassium and sodium (Wolf 1996).

Although carrot is one of the most commonly consumed vegetables but marketing is limited because physiological changes reduce its shelf life, so carrot rapidly deteriorates during the storage (Peiyin and Barth 1998). Both during storage and transportation, carrots subject to some inevitable changes which decrease fruit quality and causes postharvest and physical loss (Will et al. 2007). During storage, several chemical changes happen as well (Simon et al. 1994) polysaccharides are transformed in simple sugars and sucrose into decreasing sugars which leads to the emission of structural break down, color change, off flavors and textural changes (Phan et al. 1993).

Senescence and deterioration of vegetables, such as carrots, cannot be stopped but can be delayed and slow down by using some technologies such 1-methylcylopropene (1-MCP) and modified atmosphere packaging (MAP). 1-MCP has been extensively used in research to expand postharvest life of a broad range of horticultural products, including flowers, climacteric and non-climacteric fruits, and vegetables (Huber 2008). 1-MCP is a gaseous cyclic olefin that apparently binds irreversibly to the cellular ethylene receptors inhibiting the action of ethylene (Blankenship and Sisler 1993a). 1-MCP can effectively inhibit the ethylene-induced bitterness of carrots (Fan and Mattheis 2000). 1-MCP treatments encourage beneficial properties in fruit quality, such as delays in physicochemical variations related to ripening, as well as a dropping in decay, weight loss, and thereby extend the storage life of a range of both climacteric and non-climacteric fruit (Blankenship and Dole 2003).

MAP, can be explicated as a dynamic system with two gas fluxes, the gas exchange through the packaging film and the respiration rate of the fresh product (Van de Velde and Kiekens 2002), and has been shown to increase shelf life of many fresh-cut products (Barriga et al. 1991 Bennik et al. 1996). The goal of MAP of fresh crop is to create an equilibrium package modified atmosphere with an O_2 partial pressure low enough and a CO_2 partial pressure high enough to effect in beneficial effects to the harvest and not be too low or too high, respectively, such that they become harmful (Zagory 1998).

There are very rare work reports associated to the technique of using 1-MCP and MAP on carrots to appreciate the outcome of in-pack in details. This study attempts to explore the influence of aqueous and gaseous 1-MCP as well as treatments through MAP on postharvest life and value of carrots.

2. LITERATURE REVIEW

2.1. Carrots

Carrots are one of the most important root vegetable in the World. The vegetables are thought be first cultivated in in Afghanistan than spread to other countries. It is generally assumed that the eastern, purple-rooted carrot originated in Afghanistan in the region where the Hindu Kush and Himalayan mountains meet, and that it was domesticated in Afghanistan and adjacent regions of Iran, Russia, Pakistan, Iran, and Anatolia. Yellow carrot, together with a purple variant, was spread to the Mediterranean states and Western Europe in the 11-14th centuries, and to Japan, India, and China in the 14-17th centuries (Mackevic 1929).

Carrots are an important crop in Turkey. The overall area under carrot and turnip cultivation in Turkey is about 30,000 ha, which is about 2.5% of the world carrot and turnip cultivated land (FAO 2012). About 60% of the whole production of carrot in Turkey is from the Konya TR (TUIK 2013).

Carrots differ in color from orange, yellow, black, purple, pinkish, white and red. There are two main kinds of cultivated carrots: 1) Eastern/Asiatic carrots. These are frequently called anthocyanin carrots because of their purple roots, though some have yellow root. 2) Western or Carotene carrots. These have orange and white or red roots. The carrot roots are the main edible part and can be used in every salad, eaten raw, drunk as a juice, cooked as a vegetable, made in to marmalade, jam, syrup and sweet dishes.

The carrot is an herbaceous plant containing approximately 87% water, rich in mineral salts and vitamins (B, C, and D). Carrots are a superb source of vitamin A, providing 210% of the average adult’s needs for the day. They also provide 2% of

Calcium needs, 6% of vitamin C needs, and 2% of iron needs per serving. They are also a good source of thiamine, potassium, copper, vitamin B_6, folic acid, and magnesium. Carrots also contain vitamin K, fiber, potassium, foliate, phosphorous, manganese, vitamin E and zinc. Carrots also includes substantial amount of protein, riboflavin, thiamine, fiber, sugar, potassium, sodium and carbohydrate (Wolf 1996). Carrot includes high level carotene such as Alfa-carotene and beta-carotene. Beta-carotene has a useful effect to human health: for example, it can decrease the risk of skin cancer (Mathews-Roth 1985; Krinsky 1989; Ziegler 1989), as well can prevent against liver damage (Zamora et al. 1991), and to raise immune response (Bendich and Shapiro 1986; Bendich 1989; Prabhala et al. 1990).

2.1.2. Harvest Maturity Indices for Carrots

Carrots are harvested around 50 to 70 from planting, depending on the variety, market outlet and use. Fresh market carrots are harvested partly mature, when the roots about 1.8 cm (0.75 in) or larger in diameter at the upper end (Kotecha et al. 1998). Late harvesting can improve storability by dropping decay through extend storage (Suojara 1999). Fresh-cut carrots are harvested immature to certify they are tender and sweet.

Carrots generally harvested by machines but small areas can be hand-bunched if needed. However, hand bunching better is than machine harvest but harder to use every time and with a greater area. Carrots are normally loss nutrients after harvesting and processing when they are fresh. Bitterness may increase in carrots during processing and storage period (Burg and Fraile 1995; Galindo et al. 2004; Galindo et al. 2005; Lathrop and Leung 1980; Murcia et al. 2000; Rao et al. 1981).

Carrot can be stored 2-3 moths at 0°C and 98 to 100% RH. However commercial storage and distribution of carrots in Turkey solely depend upon the weather conditions thus the ideal storage conditions can be never achieved. Carrots like other many vegetables loss quality starting from harvest. Temperature and related moisture are chief factors that affect the quality and shelf life (Seyoum 2010; Tigist et al. 2011; Workneh et al. 2010 and 2011). Low temperature decreases the rate of respiration and biochemical activity, which are accountable for quality changes of carrots (Zagory and Kader 1988). To reduce quality loss carrots, need to be stored at 0°C with relative moisture of 93-98% (Salunkhe

and Desai 1984).

To reduce deterioration and extend the shelf life carrots, some postharvest technologies may be used, such as 1-methylecyclopropene (1-MCP), modify atmosphere (MAP), low storage temperature and etc.

2.1.3. Some Physiological and Pathological Disorders for Carrots

Carrots are very susceptible to physical damages. Shatter-cracking, bruising, tip breakage and longitudinal cracking are sings of extremely coarse handling (McGarry 1993). Some other problem may also be seen such as cutworms, pale-striped flea beetle larvae grasshoppers and crickets when seedling emerges. (UC Cooperative Extension-Imperial County Vegetable Crops Guidelines Aug 2004-05). The most common decays seen in carrot are *Rhizopus* soft rot induced by (*Rhizopus* spp.), sour rot (*Geotrichum candidum*), soft rot (*Pseudomonas* or *Pectobacterium*), water soft rot (*Sclerotinia sclerotiorum*) and gray mold rot (*Botrytis cinerea*) (Snowdon 1992).

2.2. Methylcyclopropene (1-MCP)

1-MCP is an ethylene an antagonist to prevent/suppress ethylene production in potted flowers, bedding, cut flowers, nursery and foliage plants, and in stored vegetables and fruits. It is accepted for use only in enclosed spaces, such as store rooms, greenhouses, and enclosed truck trailers, coolers, shipping containers and controlled atmosphere food storage facilities. 1-MCP is a novel compound that can prolong the shelf life of fresh produce by inhibiting the action of ethylene. 1-MCP is a gaseous compound with the molecular weight of 54.09 and boiling point 12°C at standard temperature and pressure. Its chemical formula is C4H6. It is registered under trade name of SmartFresh™ or EthylBloc™ by Agro fresh Inc. / Rohm and Haas Company (Philadelphia, USA). 1-MCP is a highly volatile gas, thus commercially it is available in an encapsulated form in α-cyclodextrin. When applied during the pre-harvest period, 1-MCP has the useful effects of slowing fruits maturations, delaying fruit drop and ripening, and maintaining postharvest quality (McArtney et al. 2008; Watkins 2010; Watkins et al. 2010).

The plant hormone ethylene affects an extensive range of physiological processes in horticultural crops, including senescence, abscission, and ripening, chlorophyll loss,

softening, physiological disorders, sprouting, isocoumarin synthesis, lignifications, discoloration (browning), decay, and stimulation of defense systems (Saltveit 1999). 1-MCP has been successfully used on flowers, some fruits, vegetables, and plotted plants, but its efficiency varies for various products. 1 -MCP as EthyleBloc™ use was approved for ornamental plants in 1999 by Environmental Protection Agency (EPA). The commercialization of 1-MCP for edible horticulture products was approved in 2002 by EPA (Watkins 2006).

2.2.1. 1-MCP Application Methods

1-MCP is used as plant active regulator ingredient by combining with other components, when mixed with other specific amount of water or other solution 1-MCP gas is released to the atmosphere. Flowers, Plants, vegetables and fruits must be treated for several hours in closed atmosphere space and that for the 1-MCP to be more active, 1-MCP is used after the harvest to fruits and vegetables. It's better to use it immediately after harvest and also in combination with chilling, it's recommended to be used after harvest and before storage, prior shipment, or before sale, it's applied in closed atmosphere so that the volatile ingredients can be more effective. Workers are not allowed to be inside the treatment area until 30 minutes has been past after the application. A number of reports on postharvest dipping of fruits into aqueous 1-MCP treatment have been published (Choi et al. 2008), but this technique is not currently used commercially.

2.2.2. 1-MCP Mechanism

Ethylene exists as a gas and it turns at trace levels through the life of a plant by motivating or regulating various processes for example the ripening of climacteric fruit the opening of flowers, and the shedding of leaves. 1-MCP treatment has 10 times bigger attraction than ethylene to attach with to bind with receptor sites (Sisler and Serek 1997). 1-MCP blocks ethylene binding to its receptor. The fruit (plant) may still produce some ethylene, but there is no response to any ethylene, regardless of source (Blankenship 2001). In a normal plant response, ethylene (C2H4) attaches to a receptor molecule and a response occurs. The binding of 1-MCP to ethylene receptor sites is irreversible, but the configuration of new receptor sites during the climacteric period is a continuous process and ethylene regains sensitivity to trigger ripening (Sisler and Dupille et al. 1996). the

attachment of ethylene to the receptor is more like key fitting in a look, and when the ethylene attaches the receptor a cascade of events takes a place, such as the fruit begins to: Soften, Leaves turns yellow, or flowers falling (Blankenship 2001).

1-MCP has the ability to attribute to the ethylene receptor, it has also the ability to act as 'key' and open the door, when the 1-MCP the 'key' is in the 'lock' it's not possible for the ethylene (key) to go in the lock again. The 1-MCP stops the 'lock' from turning (reacting) so the door won't be open. By this way the 1-MCP work as ethylene inhibitor in plants (Blankenship 2001).

2.2.3. 1-MCP Effects in Some Vegetables or fruits

(Song et al. 2002) showed the effect 1-MCP applications on quality of carrots; fresh carrots were treated without or with 1.0 μl.L^{-1} 1-MCP treatment at 0°C for 16 hours before storage or after 12 weeks of storage, and then exposed to 0, 300, or 1000 nl μl L^{-1} ozone for 0, 1, 2, or 4 days at 10°C. Then stored carrot at 0°C for up to 24 weeks, treatment with 1-MCP effectively decreased 6-methyoxymelline (6-MM) accumulation induced by the ozone treatments. The concentration of 6-MM remained below 150 μg g^{-1} in carrots treated with 1-MCP and 1000 nl L^{-1} ozone for 4 days.

(Forney et al. 2007) reported that 1-MCP treatments of fresh carrots, carrot vegetables were treated with or without 1.0 μl L^{-1} 1-MCP treatment for 16 hours at 0°C, and then exposed to 300 or 1000 nl L^{-1} ozone at 10°C for 0, 1, 2, or 4 days. The carrots were stored at 0°C for 24 weeks. At the end, they found the effect 1-MCP on decay resistance and quality of carrots, Treatment with 1-MCP reduced *B. cinerea*. Loss of sucrose, respiration rates, and increase in fructose and glucose storage period were also decreased by 1-MCP treatment. Treatment with 1-MCP had no effect on firmness or weight loss.

(Choi and Huber 2008) the investigated about effect 1-MCP concentration on the ripening of early ripening-stage tomato. Tomato fruits at the breaker-turning stage were fully immersed in aqueous 1-MCP at 50, 200, 400 and 600 μl L^{-1} for 1 minute, and then stored at 20°C. They found that the effect of aqueous 1-methylecyclopropene concentration on color, respiration, soften, rate of accumulation of lycopene and polygalacturonase activity and ethylene production.

(Kramer 2012) treated carrots with 1-MCP then stored in the dark for 7 days at 17°C under aeration with and without added 7–10 μl L^{-1} ethylene, and an aliquot was pre-treated with 1-methylcyclopropene (1-MCP) to prevent the effect of ethylene. Generally, accumulation of 6-MM was preserved after pre-treatment with 1-MCP. Pre-treatment of carrots with 1-MCP resulted in significantly lower sensory scores for bitterness of ethylene-exposed carrots compared to carrots without 1-MCP treatment.

(Piazzolla et al. 2015) used cherries fruits which were exposed to 1 ppm of 1-MCP at 4°C for 24 hours and then stored for 13 days at 4 and 20°C. The effect 1-MCP on weight loss, respiration rate, chroma, decay, color (L*, a*, and b*) value and chlorophyll content fruits were investigated. 1-MCP decreased weight loss and respiration rate compared to control fruits.

2.3. Modified Atmosphere Packaging (MAP)

MAP is a method for expanding the shelf life of fresh food products. The technology substitutes the atmospheric air inside a package with a protective gas mix. The gas in the package helps ensure that the product will stay fresh for as long as possible. This way the initial fresh state of the product may be prolonged. It is the shelf-life of perishable products like meat, fish, fruits and vegetables that will be prolonged with MAP since it slows the natural deterioration of the product. Various changes occur during extended shelf life of fresh vegetables and fruits the primary causes of quality deterioration are therefore due to microbiological growth physiological deterioration and biochemical changes, which lead to undesired color changes, off-flavor and firmness loss.

Modified atmosphere packaging is effective in maintaining quality through its effects on modification of the gas composition in the package headspace (Schlimme and Rooney 1994; Jacxsens et al. 2002; Kim et al. 2004; Luo et al. 2004). MAP is the removal and/or replacement of the atmosphere surrounding the product before sealing in vapor-barrier materials (McMillin, Huang, Ho, and Smith 1999). There are various methods for retarding respiration and biochemical activities during storage, the more successful method being modify atmosphere (MAP) (Zagory and Kader 1988; and Kader et al. 1989). Modified atmosphere can reduce the natural production by the fruit or vegetable of

a gas called ethylene, which speeds up the ripening process. The goal of MAP of fresh produce is to create an equilibrium package modified atmosphere with an O_2 partial pressure low enough and a CO2 partial pressure high enough to result in beneficial effects to the produce and not be too low or too high, respectively, such that they become injurious (Zagory 1998). MAP can be vacuum packaging (VP), which removes most of the air before the product is enclosed in barrier materials, or forms of gas replacement, where air is removed by vacuum or flushing and replaced with another gas mixture before packaging sealing in barrier materials. The effects of modified atmosphere packaging (MAP) on the quality maintenance of baby spinach have been extensively reviewed (Babic and Watada 1996; Ko et al. 1996; McGill et al. 1996; Tudela et al. 2013).

2.4. Previous Carrots and Handling and Storage Related Researches

(Workneh et al. 2001) investigated that carrots were stored at 0^{o}C and ambient temperature 15 to 25^{o}C and packaged in low density polyethylene (LDPE) and polypropylene (PP). The results showed LPED film allowed lower respiration rates and is perfected to the PP material, also the free sugar in carrots were observed to reduce at a slower rate for packaging in LPED. At the end modified atmosphere packaging joint with low temperature storage of carrots about (1^{o}C) decreases both biochemical and biological activities resulting in improved keeping quality.

(Lacroix and Lafortune 2004) investigated about modified atmosphere (MAP) with gamma irradiation on bacterial resistance in grated carrots (*Daucus carota*) were immunized with *Escherichia coli* (10^6 CFU g^{-1}) and packed under MAP condition (60% O_2, 30% CO_2 and 10% N_2) or air. The packages were then, gamma irradiated at does from 0.15 to 0.9 kGy and stored 4-$^{+}$1^{o}C. *E. coli* counts were cyclically evaluated during 50 days of storage. Results that at first day, an irradiation treatment at a dose of 0.15 kGy reduced by 3 and 4 log the microbial level representing a level of 3 and 2 log CFU/g when samples were irradiated under air and MAP respectively. When samples were irradiated at doses > 0.3 kGy no *E. coil* were detected during the whole storage in samples treated under MAP.

(Alasalvar et al. 2005) packed shredded purple and orange carrots when ready to eat in air (control) or modified atmosphere packaging (MAP) (90% N_2, 5% O_2 and 5% CO_2 and 95% O_2 +5% CO_2), and stored chilled for up to 13 days. The MAP treatment (90% N_2, 5% O_2 and 5% CO_2) gave superior sensory quality and extended shelf life for purple carrots (2 to 3 days longer shelf life than other treatment), also no different was detected for orange carrots, and shredded purple carrots can be stored under (90% N_2, 5% O_2 and 5% CO_2) treatment for up to 10 days. Also height nitrogen treatment may be used in preserving the storage quality of shredded purple carrots.

(Ayhan et al. 2008) investigated about effect of modified atmosphere packaging on the shelf life and quality of minimally processed carrots during cold storage. Also packaged in air or in active modified atmosphere packaging high (80% O_2, 10% CO_2 and 10% N_2) and low oxygen concentration (5% O_2, 10%CO_2 and 85%N_2). The carrots packed with height oxygen and passive MAP treatment retained quality properties superior compared to low oxygen.

(Caleb 2013) showed effect modified atmosphere packaging (MAP) on pomegranate arils (*Punica granatum* L.) fruit cvs. “Acco” and “Herskawitz”, package fruits at 5, 10 and 15^{o}C for 14 days then affect MAP on volatile composition and postharvest of minimally processed during storage. Based on the microbial evaluation and physiochemical attributes, the postharvest life of MAP “Acco” and “Herskawitz” was limited to 10 days due to fungal growth at 5^{o}C. However, the compositional changes and concentration in volatile compounds indicated that the flavor life 7 days was shorter than the postharvest shelf life based on appearance and other physiochemical 10 days for both cultivate.

3. MATERIAL AND METHOD

3.1. Plant Material

Carrots (*Daucutus carota* L. cv. 'Nantes') were obtained from a farmer in Kırıkhan, Hatay (Figure 3.1). The carrots were sorted for uniformity of size and color; roots with physical damage or infections were not used. Prior to the experiment, the carrots were washed with tap water to remove any dirt and surface dried in a slow air draft.

Figure 3.1. Carrots used for the experiment

3.2. 1-MCP and MAP Treatments

The carrots were randomly distributed into four lots. The first one was for the control, the second one for MAP, the third one for aqueous 1-MCP and the fourth one for gaseous 1-MCP applications. Approximately 80 kg carrots were used in the

study; 75 carrots were employed for each treatment.

For the control, a 2-l rigid PET box (8 x 12.5 x 20 cm^3; Petsa, K-002447, Gaziantep, TR) were used. Before packaging, a 5 mm-hole was made in the upper side of the boxes in order to permit exchange gas and water vapor. Three roots were placed into the boxes.

Figure 3.2. Gaseous 1-MCP application

For the MAP application, a LPDE-type packaging material (LIFEPACK) was obtained from Aypek Ltd. Co. (Bursa, TR). The company were not released the thickness and water vapor transmission rate of the film. In the present experiment, one MAP bags were cut into 6 same sized bags. Loose ends of the bags were hot-sealed by a hot sealer and only one side of the bag was left unsealed. Three carrots were placed into the bags and the loose end was loosely enclosed by a rubber band. Pics.

Aqueous 1-MCP was acquired from Sensy Fresh powder (active ingredient 3.3. % 1-MCP; Agrobest, Izmir). Required amount of the powder was dissolved in the 20-l distilled water to obtain 1000 $\mu.l^{-1}$ concentration. The solution was stirred with a plastic spatula for 1 min and waited for 9 more min. Carrots were immersed into the solution in a 50-l plastic cap and waited for 30 min. The carrots were then dried with a paper towel

and placed into the PET boxes detail described above.

Gaseous 1-MCP was prepared from the same powder used for the aqueous 1-MCP application. According the company instruction 0.042 g powder releases 625 ppb in a m^3. Desired amount of powder dissolved in a glass vial to obtain 1 ppm (1000 $\mu g.l^{-1}$) 1-MCP gas. Carrots were placed in a 50-l plastic cap along with the vial containing the solution, and then the lid sealed with a duct tape and waited for 12 h (Figure 3.2). The lid was opened the vial was replaced containing fresh solution and treated 12 more h. A total 24 h gaseous 1-MCP application was applied to the carrots. The carrots were then placed into the PET boxes detail described above.

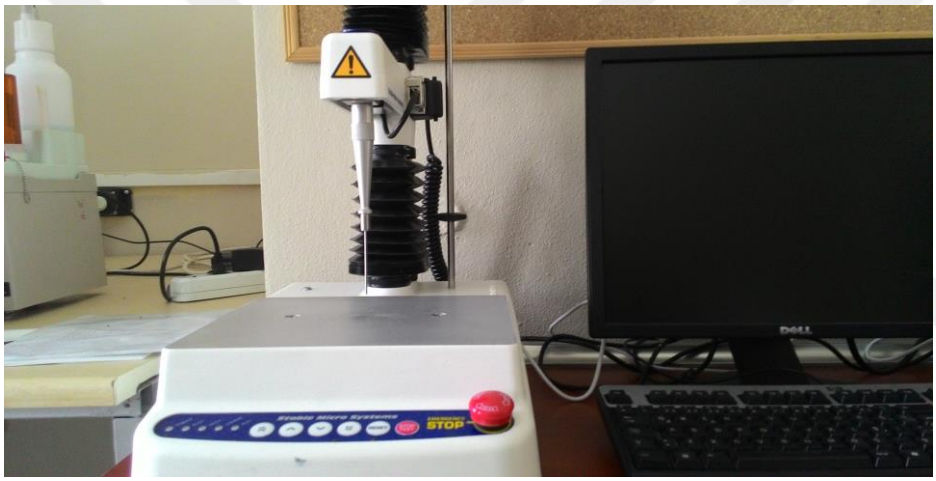

Figure 3.3. Firmness assessment

3.3. Weight Loss

Five boxes or bags from each treatment were weighed starting from day zero for every other day to calculate the weight loss percentage.

4.4. Firmness loss

A total of five carrots from five different bags or container were randomly selected for firmness, color, TSS, pH and TA measurement. For firmness, TA-XT Plus Texture Analyzer was used (Stable Micro System Ltd., Surrey, UK). A probe with 2-mm diameter was inserted into carrot at the equatorial area at a speed of 0.83 $mm.s^{-1}$ with a depth of

100 mm, then the reading was recorded as N (newton) at the depth of 0.2 or 0.5 mm (Figure 3.3).

3.5. Color Measurement

Lovibond (RT 300; Amesbury, Germany) reflectance colorimeter was used to quantify peel, cortex and endocarp color (Figure 3.4). The values L*, a* and b* were recorded from the carrots. At the equatorial area, peel color was read, then the carrot was sliced to read cortex and endocarp values.

3.6. TSS, pH and TA Measurement

A total of 5 carrots were used for the measurements. Carrot juice was obtained a fruit juicer (Premier, PR-603, Hong Kong). From the juice, TSS was measured using a digital reflectometer (Krüss, Germany) and pH, a pH meter (Hanna, HI 2211, Woonsocket, RI, USA). For TA (%) 6 g juice was titrated with 0.1 M NaOH until the pH reaching 8.2 using automatic titrator (Automatic Potentiometric Titrator, AT-510; KEM Kyoto Elect., Tokyo, Japan; Figure 4.5).

Figure 3.4. Color assessment

Figure 3.5. Automatic potentiometric titrator

3.7. O_2, CO_2 and N_2 Measurement in Packages

Five boxes or bags from each treatment were used to obtain gas composition. The measurement was done by a gas analyzer (Systech Inst., Gaspace Advance, GS3/L; Johnsburg, IL, USA; Figure 3.6).

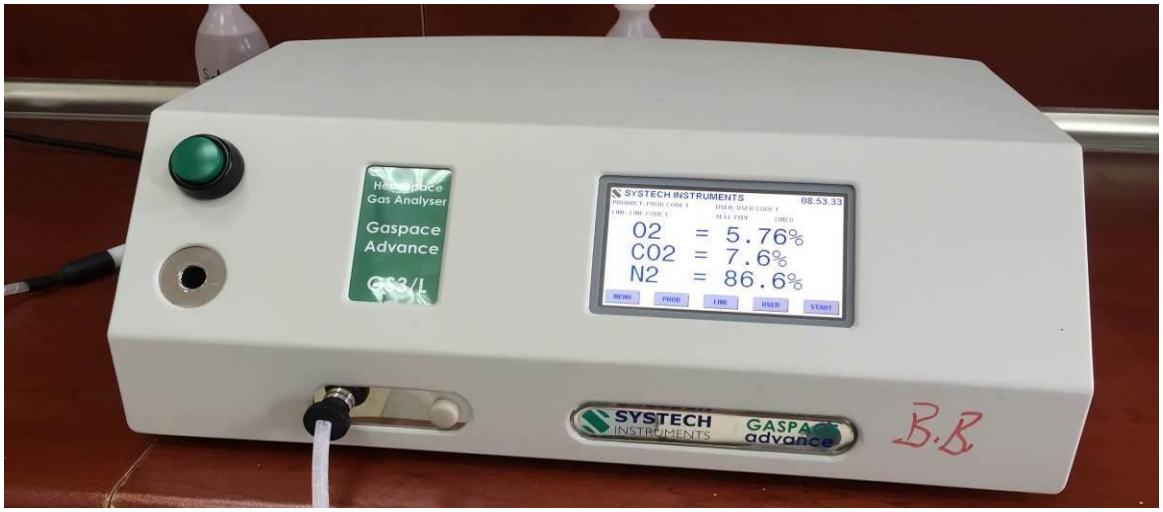

Figure 3.6. Gas analyzer

3.8. Carotenoid Extraction

Five carrots from each treatment were used for carotenoid extraction. After mixing 1 ml carrot juice with 9 ml acetone, the solution was vortexed, and then kept at the dark at 4 °C for at least 4 h. The sample was later centrifuged at a speed of 2,000 rpm for 10 min. The supernatant was separated form and read at a spectrophotometry at 443, 475 and 492 nm for α-carotene; 443 and 492 nm for β-carotene; and 475 nm for total carotenoids.

The calculation was:
Total carotenoids ($mg.100^{-1}$ g fresh carrot weight) = {(((4.143 x Abs475) – 0.561) x ml acetone) / (w (fresh carrot as mg (10) x a (path length of light 1 cm))}

Beta carotene ($mg.100^{-1}$ g fresh carrot weight) = {(((-1.292 x Abs443) + (3.698 x Abs492) + 0.131) x ml acetone) / (w (fresh carrot weight as mg (10) x a (path length of light 1 cm))}

Alfa carotene ($mg.100^{-1}$ g fresh carrot weight) = {(((0.984 x Abs443) + (3.091 x Abs475) – (2.758 x Abs492) - 0.299)) x ml acetone) / (w (fresh carrot weight as mg (10) x a (path length of light 1 cm))}

3.9. Decayed Carrot Ratio

During the experiment, total decayed carrots were counted and ratio was calculated over total carrot counted at the beginning of the experiment.

3.10. Treatment Design and Data Analyzing

There were 4 treatments with 5 replications, and each replication seeded with 3 sub replications when needed. A randomized complete block design (RCBD) was set up for the experiment. Weight loss, firmness, color, TSS, pH, TA, package gas composition was measured bi-daily; chlorophylls extraction was done at day 0, 5 and 10.

Data analysis was done by an analysis of variance, with mean separation of Duncan at 0.05 level, using SAS statistical software (Version 8.1, SAS Inst., Cary, NC, USA). Data are presented as the mean ± standard error of the mean.

4. RESULTS AND DISCUSSION

4.1. Weight Loss

Table 4.1. Changes in weight loss (%) of carrots stored 23 ± 1 °C

Day	Control	MAP	A-1-MCP	G-1-MCP
2	0.43 b	3.30 a	0.34 b	0.15 b
4	0.96 b	9.28 a	0.80 b	0.59 b
6	1.35 b	13.21 a	1.14 b	0.90 b
8	1.80 b	17.50 a	1.58 b	1.31 b
10	2.20 b	21.84 a	2.03 b	1.68 b

Control: no treatment; MAP: modified atmosphere packaging; A-1-MCP: aqueous 1-MCP treatment; G-1-MCP gaseous treatment. Means in the same row with same letters were not significantly different at $P \leq 0.05$.

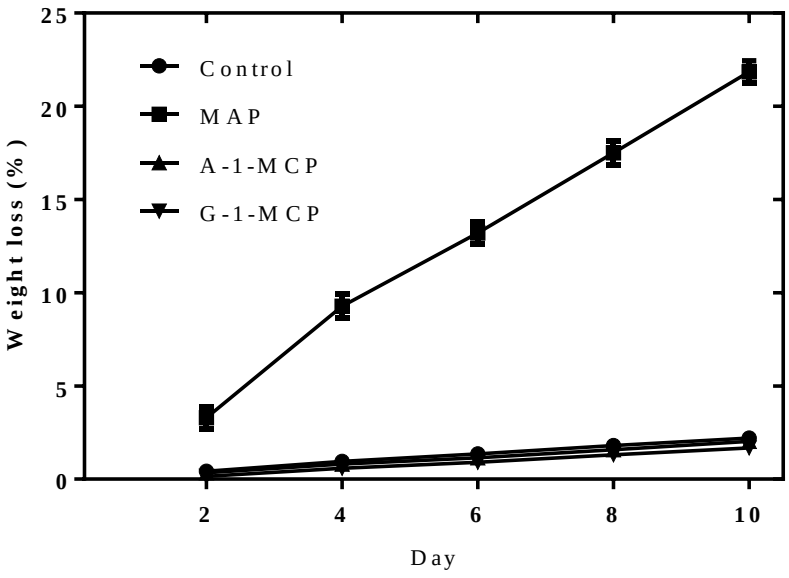

Figure 4.1. Changes in weight loss (%) of carrots stored at 23 ± 1 °C
Control: no treatment; MAP: modified atmosphere packaging; A-1-MCP: aqueous 1-MCP treatment; G-1-MCP gaseous treatment. Vertical bars represent standard errors of means.

Carrots lost weight during storage irrespective of the treatment (Table 4.1 and Figure 4.1). Weight loss percentage of control reached 2.20%, of MAP 21.84%, of A-1-MCP 2.03% and of G-1-MCP 1.68% at the end of storage. Control, A-1-MCP and G-1-MCP did not show a significant difference when compared to each other; however, the weight loss was significantly higher in MAP.

MAP was designed to allow a limited gas exchange including water vapor but the clamshell only diminutive. Therefore, carrot storage in MAP lost water more than those stored in clamshells.

4.2. Firmness

Table 4.2. Changes in firmness of carrots stored at 23 ± 1 °C

Day	Control	MAP	A-1-MCP	G-1-MCP
0	12.42 a	12.42 a	12.42 a	12.42 a
2	9.40 a	10.22 a	10.73 a	11.03 a
4	9.17 a	9.13 a	9.03 a	9.82 a
6	8.73 a	7.45 b	8.44 a	9.29 a
8	8.15 a	6.75 b	8.23 a	8.61 a
10	7.51 a	5.15 b	7.51 a	7.86 a

Table legends are the same in Table 1.

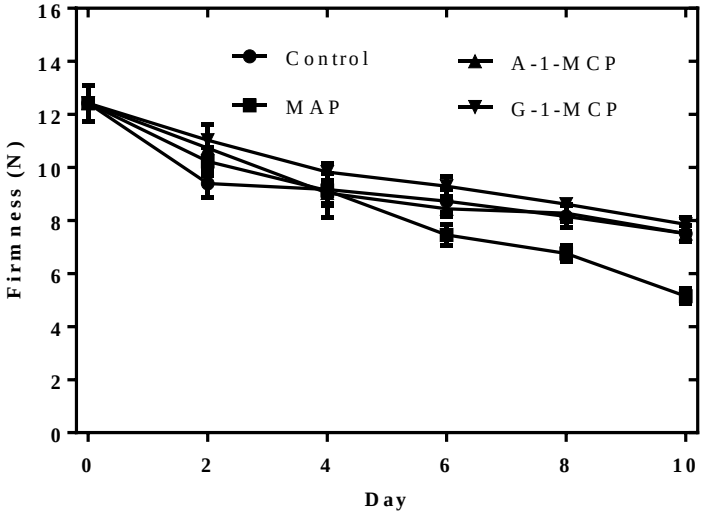

Figure 4.2. Changes in firmness of carrots stored at 23 ± 1 °C
Figure legends are the same in Figure 1.

Carrot firmness gradually reduced during storage in all treatments (Table 4.2 and Figure 4.2). Carrots stored in MAP, however, had significantly higher firmness loss after day 6. The film of the MAP was designed for carrots to allow water vapor exchange, which resulted higher water loss compared to other treatments seen on the Figure 4.1. Water loss eventually causes tissue to soft in carrots. Carrots stored in clamshells had almost same degree of softness during the storage period since the clamshells restricted water losses.

4.3. Peel Color

Table 4.3. Changes in peel color (L*) of carrots stored at 23 ± 1 °C

Day	Control	MAP	A-1-MCP	G-1-MCP
0	58.26 a	58.26 a	58.26 a	58.26 a
2	58.26 a	58.27 a	57.84 a	58.34 a
4	57.86 a	57.96 a	57.67 a	57.89 a
6	57.07 a	58.12 a	57.56 a	57.81 a
8	56.90 a	58.01 a	57.29 a	57.43 a
10	56.62 a	57.40 a	57.30 a	57.50 a

Table legends are the same in Table 1.

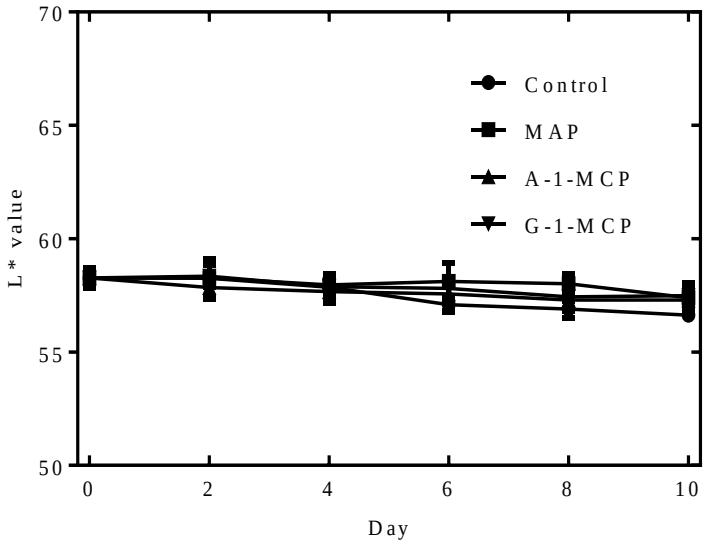

Figure 4.3. Changes in peel color (L*) of carrots stored at 23 ± 1 °C
Figure legends are the same in Figure 1.

After 10 days of storage, carrots peel color (L*) value very slightly reduced in all

treatments, reaching the value of control 56.62, of MAP 57.40, of A-1-MCP 57.30 and of G-1-MCP treatments 57.50 (Table 4.3 and Figure 4.3). There were no differences among treatments. The L* color value indicates darkness; increased values means carrots surface color becomes lighter.

Table 4.4. Changes in peel color (a*) of carrots stored at 23 ± 1 °C

Day	Control	MAP	A-1-MCP	G-1-MCP
0	20.12 a	20.12 a	20.12 a	20.12 a
2	19.11 a	19.20 a	19.67 a	18.40 a
4	18.63 a	19.80 a	18.75 a	18.76 a
6	18.41 a	19.95 a	18.41 a	19.04 a
8	18.60 a	19.56 a	18.84 a	18.61 a
10	16.96 ab	19.57 a	17.46 ab	18.02 a

Table legends are the same in Table 1.

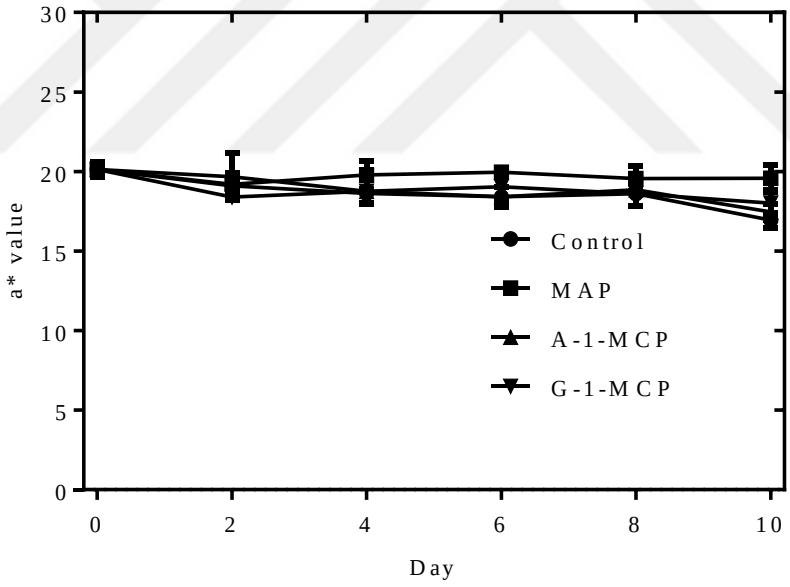

Figure 4.4. Changes in peel color (a*) of carrots stored at 23 ± 1 °C
Figure legends are the same in Figure 1.

Peel color of a* in all treatments remained constant during storage (Table 4.4 and Figure 4.4). No differences were recorded among treatments. The color a* value displays redness which is not a specific color for this carrot variety, thus no significant changes or differences were recorded during the storage.

Table 4.5. Changes in peel color (b*) of carrots stored at 23 ± 1 °C

Day	Control	MAP	A-1-MCP	G-1-MCP
0	29.94 a	29.94 a	29.94 a	29.94 a
2	29.38 a	29.52 a	29.58 a	28.76 a
4	29.38 a	29.75 a	29.68 a	29.47 a
6	29.25 a	30.26 a	29.72 a	30.04 a
8	30.22 a	30.30 a	30.32 a	29.54 a
10	27.14 a	28.90 a	25.25 ab	27.78 a

Table legends are the same in Table 1.

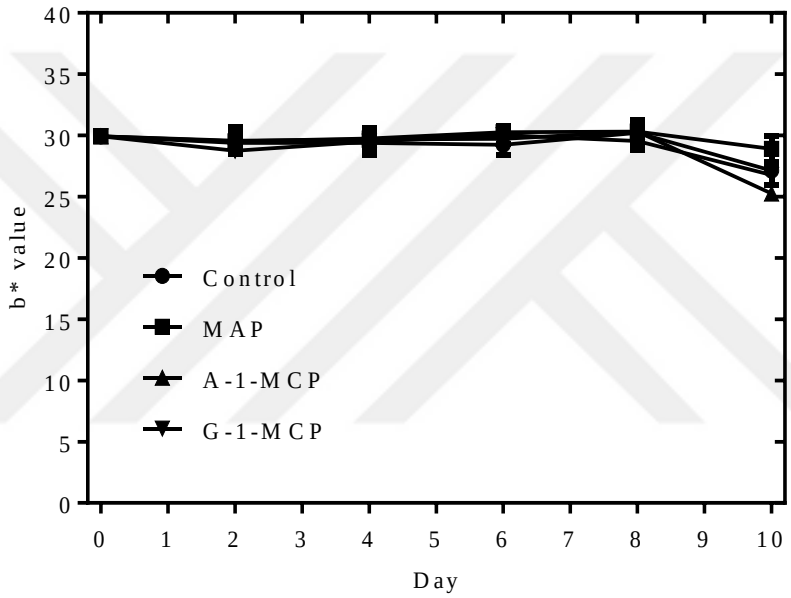

Figure 4.5. Changes in peel color (b*) of carrots stored at 23 ± 1 °C
Figure legends are the same in Figure 1.

The peel color of b* remained constant until day 8, then very slightly decreases in all treatments but no discrepancies among treatments were recorded as shown in Table 4.5 and Figure 4.5. The color value b* represents yellowness; the higher value means yellower color. According to Figure 4.5, all carrots kept yellow peel color during storage.

4.4. Cortex Color

Table 4.6. Changes in cortex color (L*) of carrots stored at 23 ± 1 °C

Day	Control	MAP	A-1-MCP	G-1-MCP
0	61.27 a	61.27 a	61.27 a	61.27 a
2	61.52 a	61.10 a	61.24 a	60.91 a
4	60.44 a	60.92 a	60.15 a	61.05 a
6	59.57 a	60.80 a	60.12 a	59.75 a
8	60.39 b	61.72 a	61.77 a	59.74 b
10	60.67 b	62.65 a	62.12 a	60.96 b

Table legends are the same in Table 1.

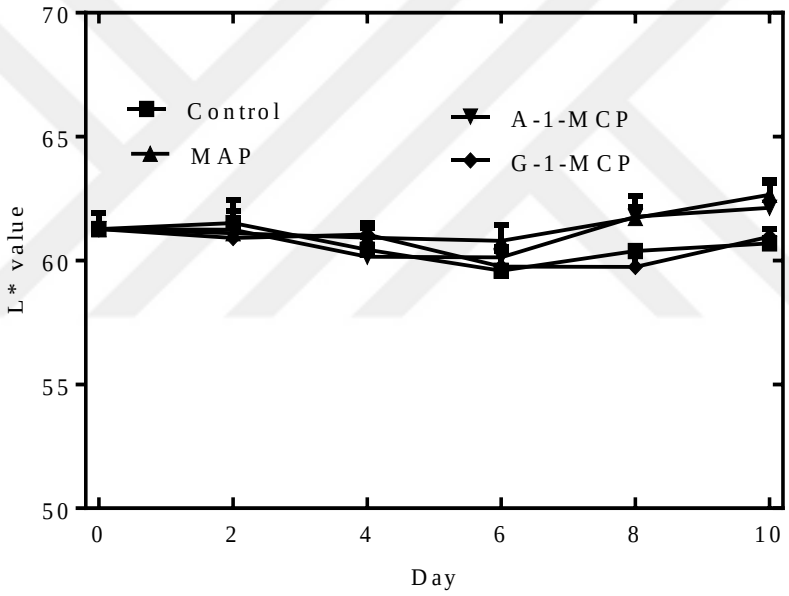

Figure 4.6. Changes in cortex color (L*) of carrots stored at 23 ± 1 °C
Figure legends are the same in Figure 1.

Cortex L* value in all treatments slightly decreased after day 2 through 6, then in MAP and A-1-MCP slightly increased but remained constant in Control and G-1-MCP, causing a significant difference among treatments (Table 4.6 and Figure 4.6). Fruit of MAP or A-1-MCP showed higher L* values at the end of storage, this is possibly due to extensive water loss.

Table 4.7. Changes in cortex color (a*) of carrots stored at 23 ± 1 °C

Day	Control	MAP	A-1-MCP	G-1-MCP
0	32.84 a	32.84 a	32.84 a	32.84 a
2	32.74 a	32.41 a	32.09 a	32.11 a
4	32.65 a	32.49 a	32.02 a	32.39 a
6	31.90 a	32.28 a	32.37 a	32.48 a
8	32.16 a	32.55 a	31.84 a	32.99 a
10	31.32 a	30.64 a	31.12 a	31.59 a

Table legends are the same in Table 1.

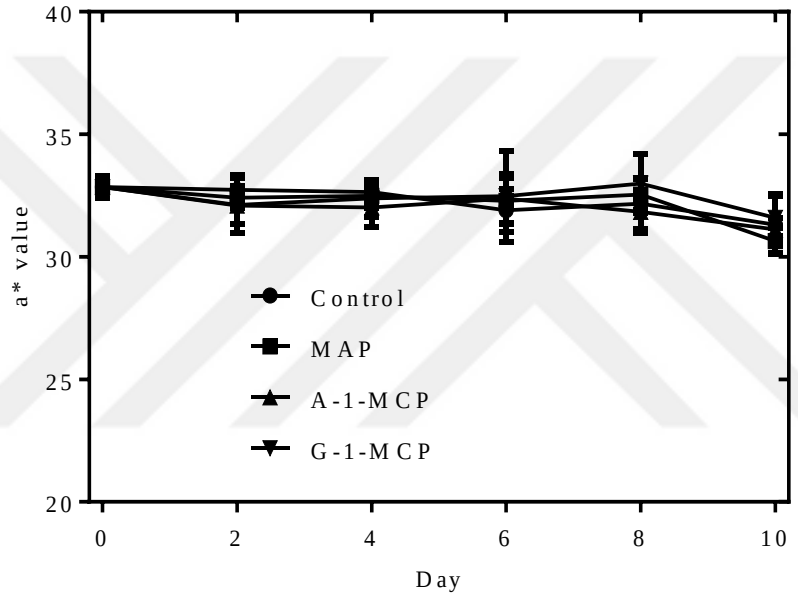

Figure 4.7. Changes in cortex color (a*) of carrots stored at 23 ± 1 °C
Figure legends are the same in Figure 1.

The color value of a* remained constant until day 8, then slightly decreased in all treatments (Table 4.7 and Figure 4.7). No significant differences were recorded among treatments.

Table 4.8. Changes in cortex color (b*) of carrots stored at 23 ± 1 °C

Day	Control	MAP	A-1-MCP	G-1-MCP
0	53.77 a	53.77 a	53.77 a	53.77 a
2	53.50 a	53.72 a	53.27 a	52.30 a
4	52.71 a	53.30 a	52.37a	52.68 a
6	52.11 a	53.10 a	53.64 a	54.32 a
8	52.84 a	52.93 a	53.00 a	52.48 a
10	48.18 a	46.59 a	47.02 a	46.64 a

Table legends are the same in Table 1.

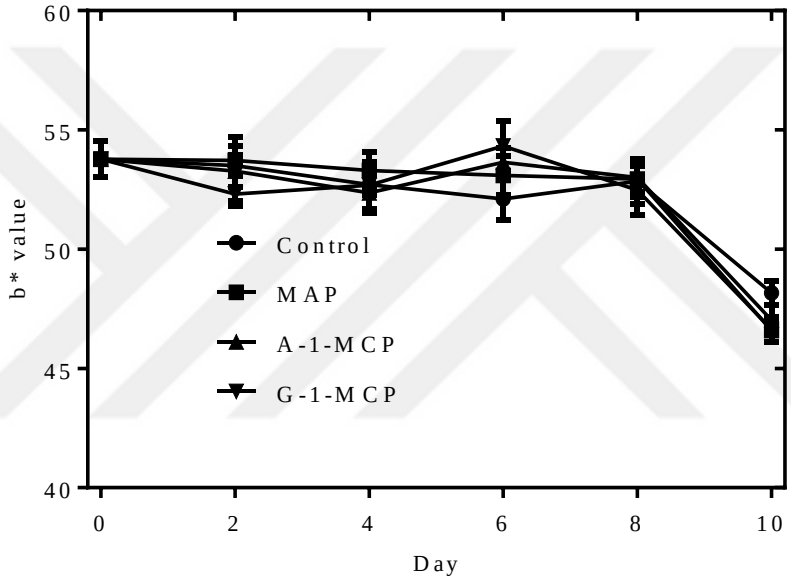

Figure 4.8. Changes in cortex color (b*) of carrots stored at 23 ± 1 °C
Figure legends are the same in Figure 1.

The b* color value remained constant until day 8 then decreased very sharply in all treatments (Table 4.8 and Figure 4.8). The decrease in b* value indicates a loss of yellow color, which seen in all treatments.

4.5. Endocarp Color

Table 4.9. Changes in endocarp color (L*) of carrots stored at 23 ± 1 °C

Day	Control	MAP	A-1-MCP	G-1-MCP
0	61.81 a	61.81 a	61.81 a	61.81 a
2	61.97 a	62.77 a	61.30 a	62.48 a
4	61.49 a	62.86 a	61.62 a	61.00 a
6	61.22 a	61.51 a	60.74 a	60.89 a
8	61.59 a	61.33 a	61.22 a	60.81 a
10	61.37 a	62.84 a	61.96 a	61.42 a

Table legends are the same in Table 1.

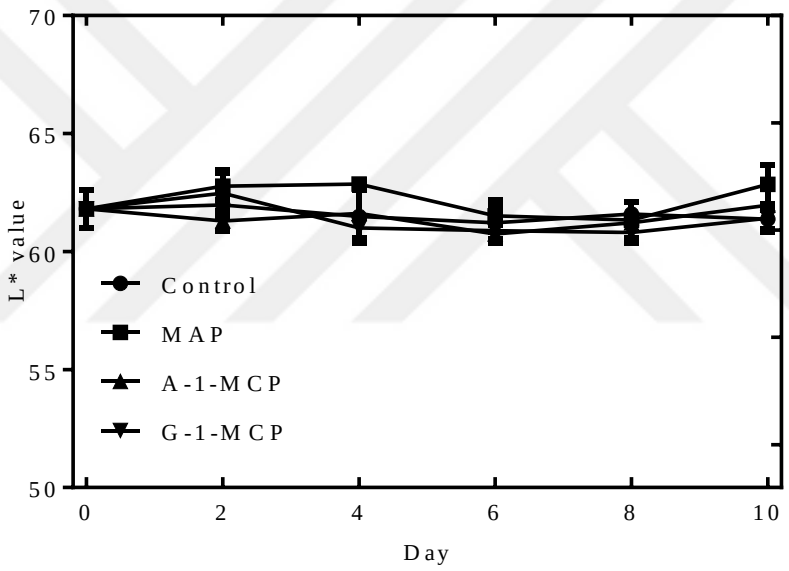

Figure 4.9. Changes in endocarp color (L*) of carrots stored at 23 ± 1 °C
Figure legends are the same in Figure 1.

No significant changes during storage and variations among treatments were recorded as shown in Table 4.9 and Figure 4.9. L* value ranged from around 60 to 63 in all treatments.

Table 4.10. Changes in endocarp color (a*) of carrots stored at 23 ± 1 °C

Day	Control	MAP	A-1-MCP	G-1-MCP
0	32.28 a	32.28 a	32.28 a	32.28 a
2	31.20 a	32.60 a	31.62 a	32.11 a
4	31.97 a	32.93 a	32.91 a	32.56 a
6	31.34 a	32.30 a	32.52 a	33.40 a
8	32.30 a	32.26 a	30.79 a	33.00 a
10	30.03 a	30.98 a	30.98 a	31.96 a

Table legends are the same in Table 1.

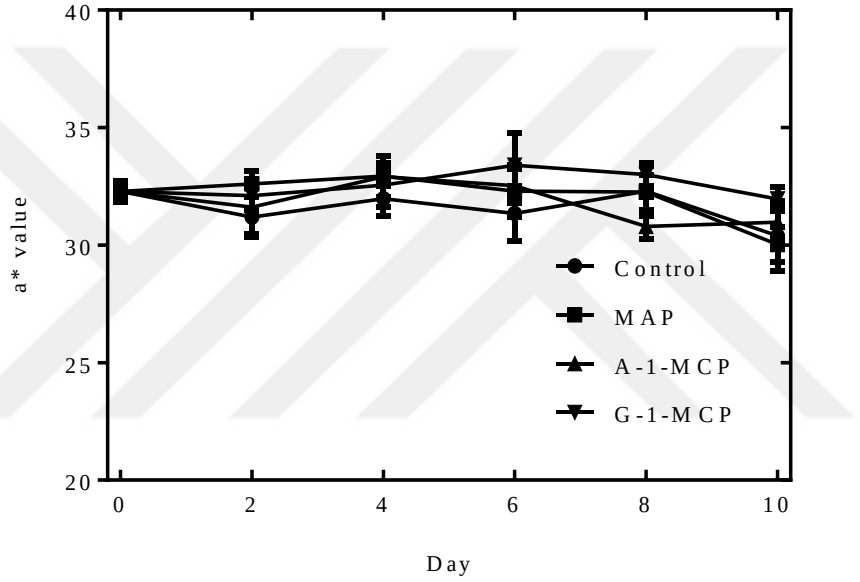

Figure 4.10. Changes in endocarp color (a*) of carrots stored at 23 ± 1 °C
Figure legends are the same in Figure 1.

The *a value remained constant until day 8, then slightly decreased in all treatments (Table 4.10 and Figure 4.10). There were no significant variations among treatments.

Table 4.11. Changes in endocarp color (b*) of carrots stored at 23 ± 1 °C

Day	Control	MAP	A-1-MCP	G-1-MCP
0	54.10 a	54.10 a	54.10 a	54.10 a
2	54.13 a	55.14 a	52.12 a	53.65 a
4	52.98 a	56.36 a	54.98 a	54.38 a
6	52.63 a	53.97 a	53.03 a	55.33 a
8	53.51 a	53.21 a	51.53 a	53.47 a
10	49.16 a	47.51 a	47.65 a	48.31 a

Table legends are the same in Table 1.

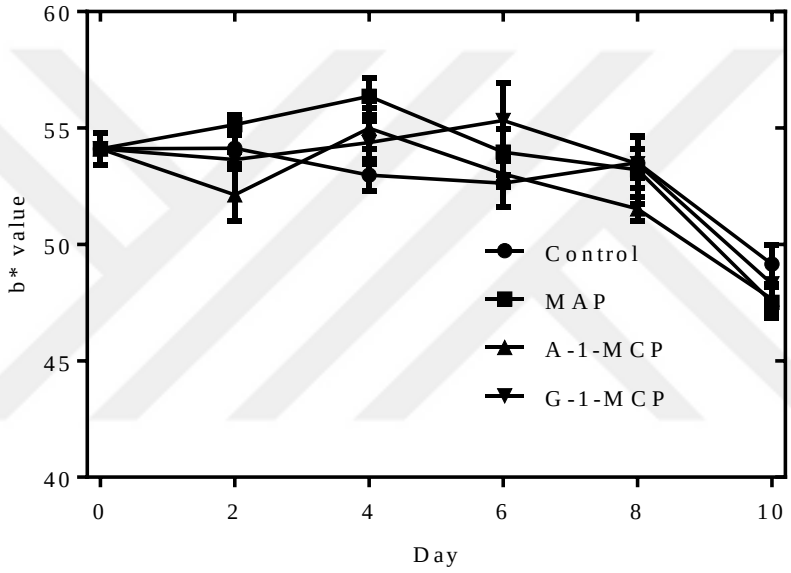

Figure 4.11. Changes in endocarp color (b*) of carrots stored at 23 ± 1 °C
Figure legends are the same in Figure 1.

Similar to b* values registered in endocarp tissues, the b* value stayed constant through day 6, then decreases in all treatments as seen in Table 4.11 and Figure 4.11. No significant differences among treatments were recorded.

4.6. Gas Composition

Table 4.12. Changes in O_2 gas composition of packages stored with carrots at 23 ± 1 °C

Day	Control	MAP	A-1-MCP	G-1-MCP
2	18.32 a	17.38 b	18.32 a	18.14 a
4	17.98 a	17.02 b	18.16 a	18.10 a
6	18.00 a	17.20 b	18.14 a	18.02 a
8	17.76 a	17.22 b	18.08 a	17.98 a
10	17.68 a	17.36 a	18.06 a	17.92 a

Table legends are the same in Table 1.

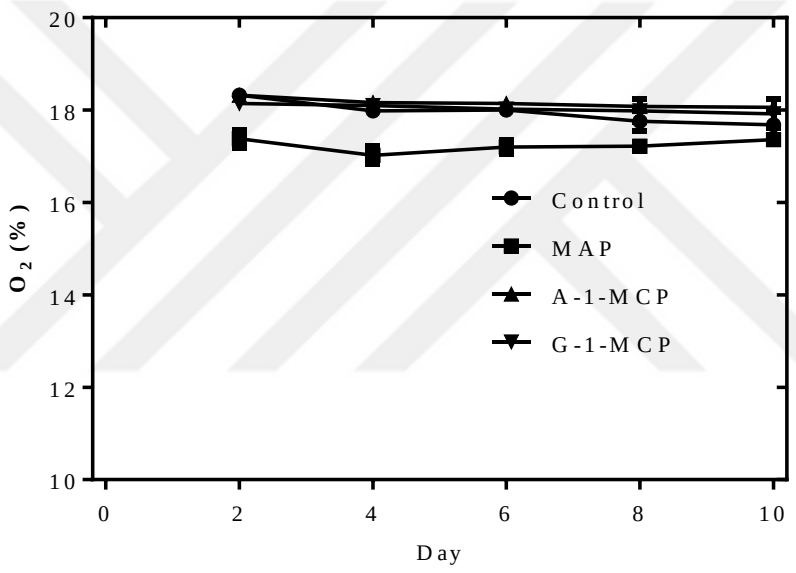

Figure 4.12. Changes in O_2 gas composition of packages stored with carrots at 23 ± 1 °C
Figure legends are the same in Figure 1.

The O_2 concentrations for all treatments were recorded around 18% in all treatments (Table 4.12 and Figure 4.12). The concentration of MAP was statistically lower until day 8, then leveled the values of others. The film used for MAP limits gas exchange. This is reason of lower O_2 concentration in MAP.

Table 4.13. Changes in CO_2 gas composition of packages stored with carrots at 23 ± 1 °C

Day	Control	MAP	A-1-MCP	G-1-MCP
2	1.52 b	2.74 a	1.54 b	1.66 b
4	2.08 b	2.98 a	1.48 b	1.80 b
6	2.20 b	2.88 a	1.60 b	1.90 b
8	2.32 b	2.86 a	1.92 b	2.04 b
10	2.28 a	2.64 a	1.90 a	1.98 a

Table legends are the same in Table 1.

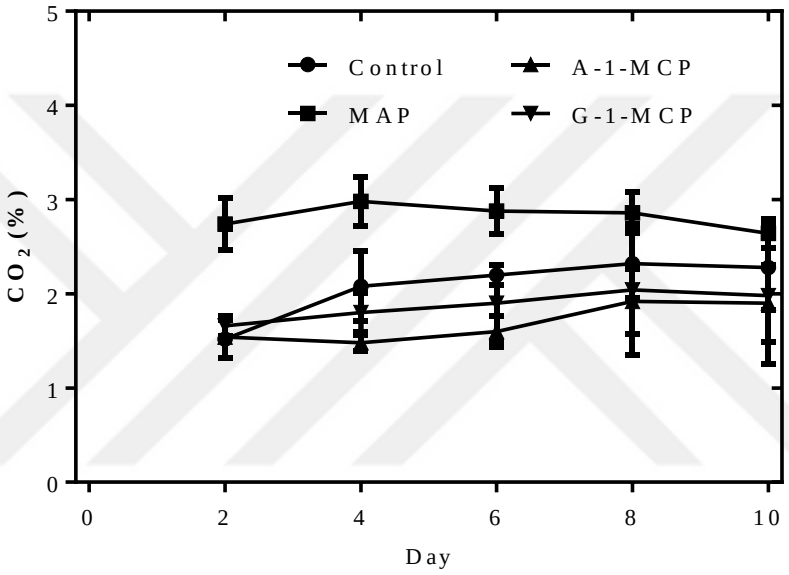

Figure 4.13. Changes in CO_2 gas composition of packages stored with carrots at 23 ± 1 °C
Figure legends are the same in Figure 1.

As anticipated from the previous data, CO_2 concentration was higher in MAP than in other treatments during most of the storage (Table 4.13 and Figure 4.13). The CO_2 concentrations for all treatments were recorded around 2% in all treatments.

Table 4.14. Changes in N_2 gas composition of packages stored with carrots at 23 ± 1 °C

Day	Control	MAP	A-1-MCP	G-1-MCP
2	80.16 a	79.88 a	80.14 a	80.20 a
4	79.94 a	80.00 a	80.16 a	80.10 a
6	79.80 a	79.92 a	80.26 a	80.08 a
8	79.92 a	79.92 a	80.00 a	79.98 a
10	80.04 a	80.00 a	80.04 a	80.10 a

Table legends are the same in Table 1.

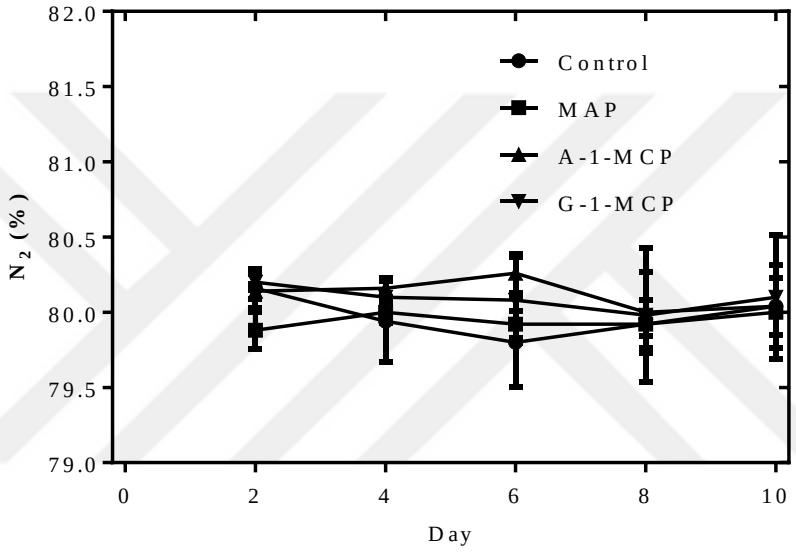

Figure 4.14. Changes in N_2 gas composition of packages stored with carrots at 23 ± 1 °C
Figure legends are the same in Figure 1.

The N_2 concentrations for all treatments were registered around 79% as shown in Table 4.14 and Figure 4.14. No significant changes during the storage period and no significant differences among the treatments were recorded.

4.7. SSC Content

Table 4.15. Changes in SSC content of carrots at 23 ± 1 °C

Day	Control	MAP	A-1-MCP	G-1-MCP
0	9.40 a	9.40 a	9.40 a	9.40 a
2	8.96 a	9.20 a	9.20 a	9.04 a
4	9.46 a	9.80 a	9.80 a	9.40 a
6	9.32 a	9.90 a	9.90 a	10.24 a
8	9.68 a	10.12 a	10.12 a	9.46 a
10	9.45 a	10.17 a	10.17 a	9.85 a

Table legends are the same in Table 1.

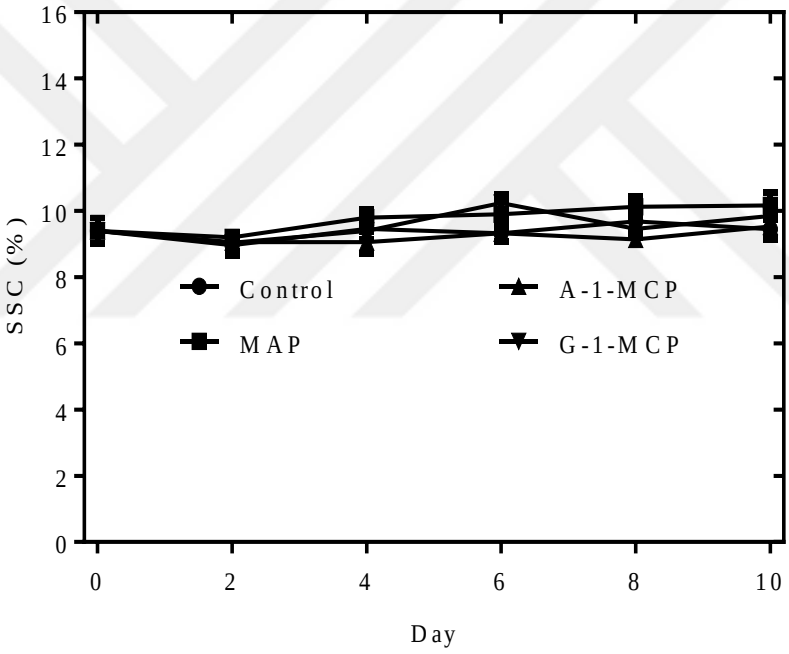

Figure 4.15. Changes in SSC content of carrots at 23 ± 1 °C
Figure legends are the same in Figure 1.

SSC remained around 10% in all treatments during the course of the storage as seen in Table 4.15 and Figure 4.15. There were no variations among treatments.

4.8. pH Content

Table 4.16. Changes in pH content of carrots at 23 ± 1 °C

Day	Control	MAP	A-1-MCP	G-1-MCP
0	6.15 a	6.15 a	6.15 a	6.15 a
2	6.04 a	6.10 a	6.10 a	6.02 a
4	6.20 a	6.18 a	6.09 a	6.09 a
6	6.16 a	6.15 a	6.16 a	6.09 a
8	6.06 a	6.14 a	6.09 a	6.07 a
10	6.08 a	6.06 a	6.12 a	6.06 a

Table legends are the same in Table 1.

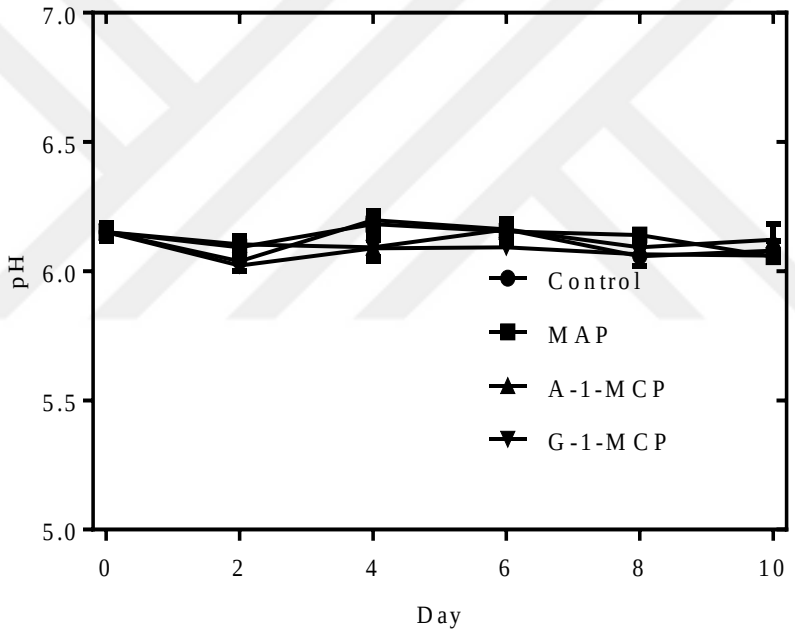

Figure 4.16. Changes in pH content of carrots at 23 ± 1 °C
Figure legends are the same in Figure 1.

The pH values stayed unchanged in all treatments during the storage, with having a value around 6 (Table 4.16 and Figure 4.16). No significant variation among treatments were registered.

4.9. TA Content

Table 4.17. Changes in TA content of carrots at 23 ± 1 °C

Day	Control	MAP	A-1-MCP	G-1-MCP
0	0.94 a	0.93 a	0.94 a	0.90 a
2	0.96 a	0.93 a	0.90 a	0.90 a
4	0.93 a	0.85 a	0.95 a	0.92 a
6	0.92 a	0.95 a	0.85 a	0.90 a
8	0.88 a	0.95 a	0.91 a	0.83 a
10	0.86 a	0.90 a	0.88 a	0.97 a

Table legends are the same in Table 1.

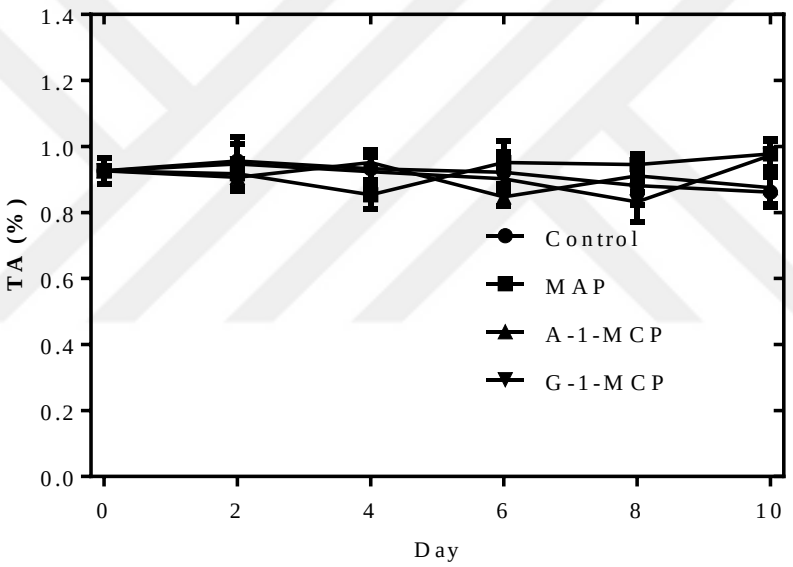

Figure 4.17. Changes in TA content of carrots at 23 ± 1 °C
Figure legends are the same in Figure 1.

Similar to pH values, TA remained steady in all treatments in the course of the storage as shown Table 4.17 and Figure 4.18. TA concentration for all treatments were recorded around 0.9%, with having no significant differences among treatments.

4.10. Carotene Content

Table 4.18. Changes in beta-carotene content of carrots at 23 ± 1 °C

Day	Control	MAP	A-1-MCP	G-1-MCP
0	4.35 a	4.35 a	4.35 a	4.35 a
6	4.20 a	3.91 a	3.48 a	4.00 a
10	3.71 a	3.73 a	3.63 a	3.83 a

Table legends are the same in Table 1.

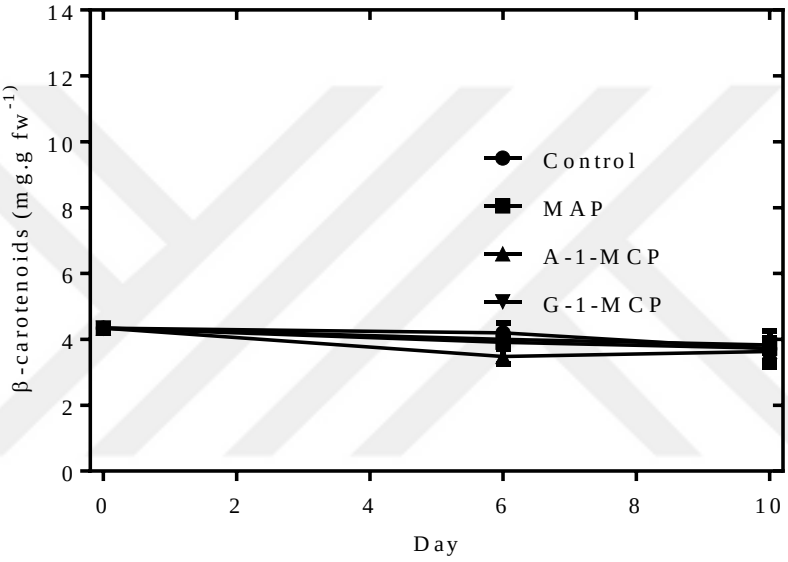

Figure 4.18. Changes in beta-carotene content of carrots at 23 ± 1 °C
Figure legends are the same in Figure 1.

The amount of beta-carotene declined very slightly in all treatment during storage period as seen in Table 4.18 and Figure 4.18. There were however no differences were registered among treatments. Beta-carotene value was around 4 mg g fw^{-1}.

Table 4.19. Changes in alfa-carotene content of carrots at 23 ± 1 °C

Day	Control	MAP	A-1-MCP	G-1-MCP
0	6.00 a	6.00 a	6.00 a	6.00 a
6	5.18 a	4.94 a	4.77 a	5.19 a
10	4.91 a	4.85 a	4.80 a	5.19 a

Table legends are the same in Table 1.

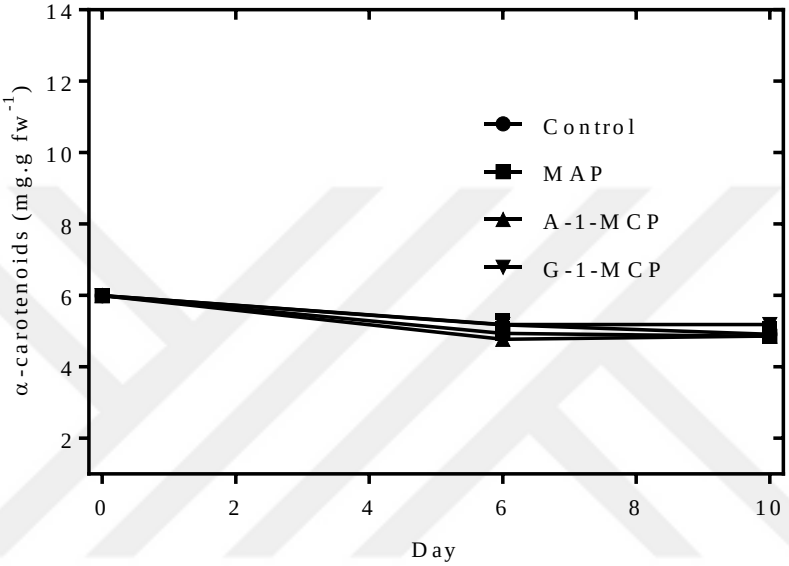

Figure 4.19. Changes in alfa-carotene content of carrots at 23 ± 1 °C
Figure legends are the same in Figure 1.

Comparable to beta-carotene values, alfa-carotene declined very slightly in all treatment during storage period as shown in Table 4.19 and Figure 4.19. There were however no differences were registered among treatments. Alfa-carotene value was around 5 to 6 mg g fw^{-1}.

4.11. Decayed Fruit

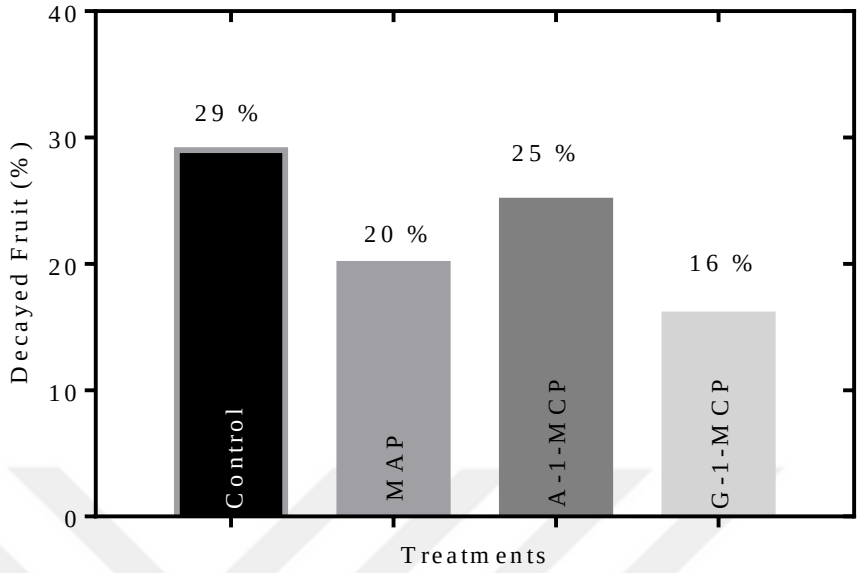

Figure 4.20. Decayed fruit ratio of carrots at the end of storage period stored at 23 ± 1 °C
Figure legends are the same in Figure 1.

Carrots had decays at the end of the storage irrespective of treatments (Table 4.10 and Figure 4.20). The decayed fruit ratio ranged from 29 (control), 25 (A-1-MCP), 20 (MAP) to 16 (G-1-MCP) %. Control fruit had the highest decay ratio followed by A-1-MCP, MAP and G-1-MCP respectively. Especially gaseous application of 1-MCP was very effective in terms of suppressing decay compared to other treatments. MAP or A-1-MCP application did not recorded an effective result as much as G-1-MCP did. This might be resulted from that MAP provided a good environment for microorganisms to flourish in the package or 1-MCP in water penetrated only very little into carrot tissues.

5. CONCLUSION

Carrots are one of the important horticultural crops that have a short shelf life after harvesting. This short shelf life is resulted fromcolor changes, weight loss, firmness loss, and decay. Thus, thepurpose behind this research is to minimize or prevent changes or losses mentioned above by 1-MCP an MAP application.

The basic of this experiment is that how to prolong shelf life of carrot and protect its quality in the 23 ^{o}C ± 1, To achieve this experiment 4 different packaging types were utilized in the varies methods by using 1- MCP in two different ways, which are Aqueous and gas and putting them in to the rigid box (PET) with controlled group. On the other hand, the MAP way is the other method of the process that the carrots are stored in the (LDPE) film. The measurements of the (weight loss, firmness, color, gas composition, pH, TA, SSC, alfa and beta-carotene and decay ratio) also were recorded during the storage.

MAP treatment had an adverse effect on the weight and firmness; the carrots lost more water and became softer comparing to the other applications because of the respiration rate, water evaporation, or change in temperature. The difference of the packaging kind leads to this big alteration.

However, the surface become lighter, there was not significant modification in the peel color (L*) value, but only in the tenth day, the peel color (a*) value a little bit changes with the control and the A-1-MCP. Also, at the same day, the peel color (b*) value color more changes with A-1-MCP comparing to the other treatments.

In the eighth and tenth days, the cortex color (L*) value of control group and G-1- MCP loss their original color comparing to the MAP and A-1-MCP treatments.

In the amountO_2 and CO_2measured for 10 days, the significant difference was noticed in the MAP treatment until the 8^{th} day of the experiment which is happened because of the assets of film that bounds the gas connections with outsider. To clarify, the lower amount of O_2 and the higher amount of CO_2 of the product recorded in the MAP treatment comparing with the other treatments.

The other objects that were notified from the data are ratio of decay. In the all treatments, the decay was observed, but the G-1-MCP has lowest percentage of the decay because it limits the activity of the microorganisms. Furthermore, the control group has the highest decay compare to the other groups because there were not substances inside the box to limit the activity of the microorganisms, which made them more active and effect the carrots more than the other applications.

Most of measurements such as N_2 ratio, SSC, pH and carotene contents were not affected by any of the treatments. Moreover, colors on peel, in mesocarp or cortex were not affected as well.

To conclude gaseous 1-MCP application has a potential extend postharvest shelf life of carrot especially by suppressing decay ratios. Aqueous 1-MCP was however ineffective on both prolonging and extending shelf life of the treated carrots. MAP application accelerated both water and water loss thus had an adverse effect on the quality and shelf life.

REFERENCES

Alasalvar C, Al-Farsi M, Quantick PC, Shahidi F, and Wiktorowicz R (2005) Effect of chill storage and modified atmosphere packaging (MAP) on antioxidant activity, anthocyanins, carotenoids, phenolics and sensory quality of ready-to-eat shredded orange and purple carrots. Food Chemistry 89(1): 69-76

Ayhan Z, Eştürk O, and Taş E(2008) Effect of modified atmosphere packaging on the quality and shelf life of minimally processed carrots. Turkish Journal of Agriculture and Forestry 32(1): 57-64

Babic I, Watada AE(1996) Microbial populations of fresh-cut spinach leaves affected by controlled atmospheres. Postharvest Biol. Technol. 9:187–193

Barriga MI C, Trachy C, Willemot and RE.Simard(1991) Microbial changes in shredded iceberg lettuce stored under controlled atmospheres. *J. Food Sci.* 56: 1586-1588, 1599

Bendich A (1989) Carotenoids and the immune response. J. Nutr**.**119: 112-115

Bendich A,and Shapiro SS (1986) Effect of ß-carotene and canthaxanthin on the rat.J.Nutr 116: 2254-62

Bennik MHJ HW,Peppelenbos C, Nguyen-The F, Carlin EJ, Smid and LGM. Corns(1996) Microbiology of minimally processed, modified-atmosphere packaged chicory endive. Posthar- vest Biol. Technol.9: 209-221

Blankenship SM (2001) Ethylene effect and benefits of 1-MCP.Perishables Handling Quarterly 108: 2-4

Blankenship SM, Dole JM(2003) 1-Methylcyclopropene: a review. Postharvest Biol. Technol. 28: 1–25

Blankenship SM, Sisler EC(1993) Ethylene binding site affinity in ripening apples. J. Am. Soc. Hort. Sci. 118(5): 609–612

Burg P, and Fraile P (1995) Vitamin-C destruction during the cooking of a potato dish. Food Science and Technology-Lebensmittel-WissenschaftandTechnologie, 28(5): 506–514

Burns J, Fraser PD and Bramley PM (2003) "Identification and Quantification of Carotenoids, Tocopherols and Chlorophylls in Commonly Consumed Fruits and Vegetables". Phytochemistry62:939-947

Caleb OJ, Opara UL, Mahajan PV, Manley M, Mokwena L and Tredoux AG (2013) Effect of modified atmosphere packaging and storage temperature on volatile composition and postharvest life of minimally-processed pomegranate arils (cvs.'Acco'and 'Herskawitz'). Postharvest biology and technology, 79: 54-61

Carlin F, Nguyen-the C, Hilbert G, Chambroy Y(1990) Modified atmosphere packaging of fresh ready-to-use grated carrots in polymeric films. J. Food Sci. 55: 1033–1038

Choi ST, P Tsouvaltzis, CI Lim, and DJ, Huber(2008) Suppression of ripening and induction of asynchronous ripening in tomato and avocado fruits subjected to complete or partial exposure to aqueous solutions of 1-methylcyclopropene.Postharv. Biol. Technol. 48:206-214

Choi ST and DJ, Huber(2008) Influence of aqueous 1-methylcyclopropene concentration, immersion duration, andsolutionlongevity on thepostharvestripening of breaker turning tomato (*Solanumlycopersicum*L.)Fruit. PostharvestBiol. Technol. 49:147–154

Fan X, Mattheis JP(2000) Reduction of ethylene-induced physiological disorders of carrots and iceberg lettuce by 1-methylcyclopropene.HortScience 35(7): 1312–1314

FAO (2012) FAOSTAT. Agricultural Data.Agricultural Production.http://apps.fao.org

Forney CF, Song J, Hildebrand PD, Fan L and McRae KB (2007) Interactive effects of ozone and 1-methylcyclopropene on decay resistance and quality of stored carrots. Postharvest biology and technology 45(3): 341-348

Galindo FG, Brathen E, Knutsen SH, Sommarin M, Gekas VandSjoholm I (2004) Changes in the carrot (*Daucus carota* L. cv. Nerac) cell wall during storage. Food Research International 37: 225–232

Galindo FG, Elias L, Gekas V, Herppich WB, Smallwood M, Sommarin M et al. (2005)

On the induction of cold acclimation in carrots (*Daucus carota* L.) and its influence on storage performance. Food Research International 38: 29–36

Howard F D, JH MacGillivray and M Yamaguchi(1962)Nutrient composition of fresh Califonia grown vegetables, *Bull. No. 788, Calif. Agric. Expt. Stn*., University of Califonia, Berkley

http://www.fao.org/faostat/en/#data/QC(2014)

Huber DJ (2008) Suppression of ethylene responses through application of 1-methylcyclopropene: a powerful tool for elucidating ripening and senescence mechanisms in climacteric and non-climacteric fruits and vegetables. HortScience 43: 106–111

Jacxsens L, F Develieghere and JDebevere(2002) Temperature dependence of shelf-life as affected by microbial proliferation and sensory quality of equilibrium modified atmosphere packaged fresh produce. Postharvest Biol. Technol. 26: 59-73

Kader AA, ZagoryD, and Kerble EL (1989) Modified atmosphere packaging of fruits and vegetables.CRC Rev. Food science and Nutrition. 28(1): 1-30

Kim JG, Luo Y, and Gross KC (2004) Effect of package film on the quality of freshcut salad savoy. Postharvest Biology and Technology, 32(1): 99–107

Ko NP, Watada AE, Schlimme DV, Bouwkamp JC(1996) Storage of spinach under low oxygen atmosphere above the extinction point. J. Food Sci. 61: 398–401

Kotecha PM, BB Desai, and DLMadhavi(1998) Carrot.In DK. Salunke and SS. Kadam, eds., Handbook of Vegetable Science and Technology, Marcel Dekker, New York, NY.pp. 119-139

Kramer M, Bufler G, Ulrich D, Leitenberger M, Conrad J, Carle R and Kammerer, DR (2012) Effect of ethylene and 1-methylcyclopropene on bitter compounds in carrots (*Daucus carota*L.). Postharvest Biology and Technology 73: 28-36

Krinsky N I (1989) Carotenoids and cancer in animal model. J. Nutr119:123-126

Lacroix M, and Lafortune R (2004) Combined effects of gamma irradiation and modified atmosphere packaging on bacterial resistance in grated carrots (*Daucus carota*). Radiation Physics and Chemistry 71(1): 79-82

Lathrop PJ, and Leung HK (1980) Rates of ascorbic-acid degradation during thermal-processing of canned peas. Journal of Food Science, 45(1): 152–153

Liew CL, Prange RK (1994) Effect of ozone and storage temperature on postharvest diseases and physiology of carrots (*Daucus carota* L.). J. Am. Soc. Hort. Sci. 119(3): 563–567

Luo Y, JL McEvoy, MR Wachtel, JG Kim and Y Huang(2004) Package film oxygen transmission rate affects postharvest biology and quality of fresh-cut cilantro leaves. HortScience39(3): 567-570

Mackevic VI(1929)The carrot of Afghanistan. Bul. Appl. Bot., Genetics Plant Breed. 20:517-562

Mathews-Roth MM (1985) Carotenoids and cancer prevention experimental and epidemiological studies. Pure Appl. Chem. 51: 649-660

McArtney SJ, JD Obermiller, JR Schupp et al. (2008)Preharvest 1-methylcyclopropene delays fruit maturity and reduces softening and superficial scald of apples during long-term storage. HortScience 43:366-371

McGill JN, Nelson AI, Steinberg MP(1996) Effects of modified atmospheres on ascorbic acid and other quality characteristics of spinach. J. Food Sci. 31: 510-517

McGrray A(1993) Influence of water status on carrot (*Daucus carota* L.) fracture properties. J.Hort. Sci. 68: 431- 437

McMillin KW, Huang NY, Ho CP and Smith BS (1999) Quality and shelf-life of meat in case-ready modified atmosphere packaging. In Y L. Xiong, F. Shahidi, and C T. Ho (Eds.), Quality attributes in muscle foods. New York: ACS Symposium Series, Plenum Publishing Corporation.pp. 73–93

Murcia MA, Lopez-Ayerra B, Martinez-Tome M, Vera AM and Garcia-Carmona, F (2000).Evolution of ascorbic acid and peroxidase during industrial processing of broccoli. Journal of the Science of Food and Agriculture 80(13): 1882–1886

Niketic-Aleksic GK, Bourne MC and Stamer J R (1973) Preservation of carrot by lactic acid fermentation. J. Food Sci. 38: 84-86

Peiyin L, and Barth MM (1998) Impact of edible coatings on nutritional and physiological changes in lightly-processed carrots. Postharvest Biology and Technology 14: 51–60

Phan CT, H Hsu, and SKSarkar (1993) Physical and chemical changes occurring in the carrot root during storage, Can. J. Plant Sci. 53:635

Piazzolla F, Amodio ML, Colantuono F and Colelli G (2013) June.effects of 1-methylcyclopropene (1-MAP) on quality of sweet cherry (*Prunusavium*L. ferrovia) during storage. In *XI* International Controlled and Modified Atmosphere Research Conference 1071: 551-557

Prabhala RH, Garewal HS, Meyskens F L and Watson R R(1990)Immuno- modulation in humans caused by β-carotene and vitamin A. Nutr. Res10: 1473-1486

RamdasAR, and Kulkarni P R (1987) Fermentative preservation of carrots. Indian Food Packer 41(5): 40-48

Rao MA, Lee CY, Katz J and Cooley, HJ (1981) A kinetic-study of the loss of vitamin-C, color, and firmness during thermal-processing of canned peas. Journal of Food Science 46(2): 636–637

Saltveit ME(1999) Effect of ethylene on quality of fresh fruits and vegetables.Postharv. Biol. Technol. 15:279-292

Salunkhe DK, and Desai BB (1984) Root vegetable. Postharvest Biotechnology of Vegetable.CRC Press, BocaRatonpp. 90-96

Schirra M, P Cabras, AAngioni, GD'hallewin, RRuggiu and EVMinelli(1997) Effect of heated so Shewfelt, R. 1986. Quality characteristics of fruits and vegetables.In RP. Singh and Oliveira, F.A.R.(eds.) Minimal processing of foods and process optimization. An interface. CRC Press, Boca Raton pp. 171-189

Schlimme DV and ML Rooney(1994) Packaging of minimally processed fruits and vegetables.*In: RC. Wiley (Ed.).*Minimally Processed Refrigerated Fruits and Vegetables.Chapmanand Hall, New York pp. 156-157

Seyoum TW (2010) Feasibility and economic evaluation of low-cost evaporative cooling system in fruit and vegetables storage.Afr. J. Food Agric. Nutr. Dev. 10(8): 2984-2997

Simon PW (1994) Genetic effects on the flavor of stored carrot, Acta Hort.163:137 lotions on decay control and residues of imazalil in lemon. J. Agric. Fd Chem. 45:4127-4130

Sisler EC, E Dupille et al. (1996)Effect of 1-methylcyclopropene and ethylenecyclopropane on ethylene binding and ethylene action on cut carnations." Plant Growth Regulation 18(1): 79-86

Sisler EC, Serek M(1997) Inhibitors of ethylene responses in plants at the receptor level. Recent developments. Physiol. Plant 100: 577–582

Snowdon AL(1992) A Color Atlas of Postharvest Diseases and Disorders of Fruits and Vegetables, vol. 2, Vegetables, CRC Press, Boca Raton, FL. pp. 268-293

Song J, Fan L, Forney CF, Hildebrand PD, Jordan MA,Renderos W and McRae KB (2002) August. Ozone and 1-MCP treatments affect the quality and storage life of fresh carrots. In XXVI International Horticultural Congress: Issues and Advances in Postharvest Horticulture 628: 295-301

Suojara T(1999) Effect of harvest time on the storage performance of carrot. J. Hort. Sci. Biotech. 74:484-492

Surles RL, Weng N, Simon PW and Tanumihardjo SA(2004)Carotenoid Profiles and Consumer Sensory Evaluation of Specialty Carrots (*Daucuscarota* L.) of Various ColorsJ. Agric. Food Chem. 52:3417-3421

Tigist M, Workneh TS, Woldetsadik K (2011) Effects of variety on the quality of tomato stored under ambient conditions.Journal of Food Science and Technology. J Food Sci Technol. DOI 10.1007/s13197-011-0378-0

Tudela JA, Marín A, Garrido Y, Cantwell M, Medina-Martínez MS, Gil MI(2013) Off-odour development in modified atmosphere packaged baby spinach is an unresolved problem. Postharvest Biol. Technol. 75: 75–85

TUIK(2013) Turkish Statistical Institute. Agricultural data http://turkstat.gov.tr (accessed 20 August 2014)

UC Cooperative Extension-Imperial County Vegetable Crops Guidelines Aug (2004-05)

Van de Velde K, and Kiekens P (2002) Biopolymers: overview of several properties and consequences on their applications. Polymer Testing 21: 433–442

Watkins (2006) CB, The use of 1-methylcyclopropene (1-MCP)on fruits and vegetables. Biotechnology Advances 24: 389-409

Watkins CB(2010) Managing physiological processes in fruits and vegetables with inhibitors of ethylene biosynthesis and perception. Acta Hort. 880:301-310

Watkins CB, H James, JF Nock et al. (2010)Preharvest application of 1-methylcyclopropene (1-MCP) to control fruit drop of apples, and its effects on postharvest quality. Acta Hort. 877:365-374

Wills R B H, WB McGlasson et al. (2007) Postharvest: an introduction to the physiology and handling of fruit, vegetables and ornamentals, University of New South Wales Press

Wolf George A (1996) History of vitamin A and petinoids", FASEBJ. July (1996); 10: 1102-1107

Workneh TS, Osthoff G and Steyn MS (2001) Effect of Modified Atmosphere Packaging on Microbiological, Physiological and Chemical Qualities of Stored Carrot. Journal of Food Technology in Africa 6(4): 138-143

Workneh TS, Osthoff G, Steyn MS (2010) A review on integrated agro-technology of vegetables. Afr. J. Biotechnology 9(54): 9307-9327

Workneh TS, Osthoff G, Steyn MS (2011) Effects of preharvest treatment, disinfections and storage environment on quality of tomato. J. Food Sci. Technol. DOI: 10.1007/s13197-011-0391-3

Zagory D, Kader AA (1988) Modified atmosphere packaging of fresh produce. Food Techno. 42(9): 70-77

Zagory D(1998) An Update on Modified Atmosphere Packaging of Fresh Produce. Davis Fresh Technologies, Davis, CA. http://www.davisfreshtech.com/articles_map.html (accessed in April 1998)

Zamora R, Hidalgo FJ and Tappel AL (1991) Comparative antioxidant effectiveness of dietary β-carotene, vitamin E, selenium and coenzyme Ql0 in rat erythrocytes and plasma. J. Nutr 121: 50-56

Ziegler RG (1989) A review of epidemiologic evidence that carotenoids reduce the risk of cancer. J. Nutr 119: 116-122

BIOGRAPHICAL SKETCH

In the 24th of January of 1991, he was born, he finished his primary and secondary in Sulaymaniyah, he completed his high school in (Ahmadi Khany) in the 2009. He attainted Agriculture Collage of Halabjah from 2010 through 2014, and graduated in the 2014. He enrolled MSc in Bingöl University in Graduate School of Natural and Applied Sciences in 2015.