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EGE UNIVERSITY
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EFFECT OF SALINITY AND METHYL JASMONATE ON THE PRODUCTION AND QUALITY OF SEA FENNEL (*Crithmum maritimum* L.)

MSc THESIS

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Department of Horticulture

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Department of Horticulture
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EGE UNIVERSITY

GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES

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25 / 03 / 2021

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dirigido por D. **Juan A. Fernández y Dña MCarmen Martínez**

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- ☐ Grado en Ingeniería Agroalimentaria y de Sistemas Biológicos
- ☐ Máster Universitario en Ingeniería Agronómica
- ☒ Máster Universitario en Técnicas Avanzadas en Investigación y Desarrollo Agrario y Alimentario

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ÖZET

TUZLULUK VE METİL JASMONATIN DENİZ REZENESİ (*Crithmum maritimum* L.) ÜRETİMİ VE KALİTESİNE ETKİSİ

VAROL, Hafise

Yüksek Lisans Tezi, Bahçe Bitkileri Anabilim Dalı
Danışman: Prof. Dr. Yüksel TÜZEL
İkinci Danışman: Prof. Dr. Juan A. FERNÁNDEZ HERNÁNDEZ
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Bu projede, fakültatif halofit bir bitki olan C. maritimum yüzen sistemlerde yetiştirilmiştir ve iki deneme gerçekleştirilmiştir. Birinci denemede tuzluluğun büyüme ve gelişme üzerindeki etkisi araştırılmıştır. Bu nedenle, biyokütle, yaprak alanı, kök büyüme parametreleri, element (anyon ve katyon) içerikleri, hasat sonrası kalite (% ağırlık kaybı; L,a,b değerleri, HUE, renk değerleri), duyusal ve mikrobiyal kalite analizleri yapılmıştır. İkinci denemede, MeJa'nın tuzluluk stresi ve fitokimyasal içerik üzerindeki etkisi araştırılmıştır. Bunun için biyokütle ve kök büyüme parametreleri, element analizleri (anyon ve katyon), toplam fenolik madde, flavonoid ve antioksidan içerikleri için analizler gerçekleştirilmiştir. Birinci deneme sonuçlarına göre, küçük yapraklı C.maritimum yüzen hidroponik sistemlerde yetiştirilebilir. NaCl, C. maritimum'un toprak üstü aksamını azaltırken, kök boyu ve yüzeyini arttırmıştır. Tuzluluk köklerden K+, Ca+, Mg+, NO3- ve SO42- alımını kısıtlamıştır. Ayrıca, NaCl uygulamaları C. maritimum bitkilerinin hücrelerinde Na+ ve Cl- iyonlarının birikmesine neden olmuştur. Tuzluluk mikroorganizmaları azaltarak C. maritimum'un raf ömrünü uzatmıştır. İkinci denemede MeJa ilavesi biyokütle üzerinde tuzluluğun olumsuz etkisini azaltmış ve Ca+ ve K+ iyonlarının eksikliğini gidermiştir. NaCl ve MeJa uygulamaları fenolik madde içeriğini azaltmıştır. MeJa, klorofil a, klorofil b ve karotenoidler üzerinde tuzluluğun etkisini de iyileştirmiştir. MeJa uygulaması ile maksimum flavonoid içeriği elde edilmiştir. MeJa ilavesi tuzluluğa maruz kalan bitkilerde antioksidan içeriğini etkilememiş ancak yenilebilir kısımların gelişimine ve element eksikliklerinin giderilmesine neden olmuştur.

Anahtar kelimeler: Metil Jasmonat, tuzluluk, mineraller, Crithmum maritimum, sea fennel.

ABSTRACT

EFFECT OF SALINITY AND METHYL JASMONATE ON THE PRODUCTION AND QUALITY OF SEA FENNEL (*Crithmum maritimum* L.)

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In this project, *C. maritimum*, a facultative halophyte plant, was grown in floating systems and two experiments were carried out. Experiment 1 investigated the effect of salinity on growth and development. Therefore, biomass, leaf area, root growth parameters, mineral (anion and cation), post-harvest quality (% weight loss; L, a, b values; HUE, Chromaticity values), sensory and microbial quality analyzes were performed. In the Experiment 2, the effect of MeJa on salinity stress and the phytochemical content was investigated. To that, biomass and root growth parameters, mineral analysis (anion and cation), total phenolic component, flavonoid and antioxidant capacity analyzes were carried out. According to the results of the first experiment, *C. maritimum* baby leaf can be grown in floating hydroponic systems. NaCl increased root length and surface, while reduced the aerial parts of *C. maritimum*. Salinity hindered to intake of minerals of K^+, Ca^+, Mg^+, NO_3^- and SO_4^{2-} from the roots. And also, NaCl treatments caused to accumulate Na^+ and Cl^- ions in cell of *C. maritimum* plants. Salinity enhanced shelf life of *C. maritimum* by decreasing microorganisms. In the second experiment, MeJa addition reduced the adverse effect of salinity on biomass and recovered Ca^+ and K^+ ions. NaCl and MeJa treatments decreased phenolic content. Also MeJa improved the effect of salinity on chlorophyll a, chlorophyll b and carotenoids. Maximum flavnoid content was obtained with MeJa treatment. MeJa addition did

not affect antioxidant capacity in plants exposed to salinity but caused edible parts to grow and recovery minerals.

Keywords: Methyl jasmonate, salinity, minerals, *Crithmum maritimum* sea fennel.

PREFACE

The conditions required for agriculture are gradually decreasing due to climate change, drought, salinity and an increase in population. Salinity and drought-resistant crops must be grown İn order to prevent food shortages in the world. Some halophytes are used as food and animal feed. The nutritional value of baby leafy vegetables is higher than mature vegetables. Therefore baby leafy vegetables are on the market shelves. Hydroponic floating systems are used in agricultural researches due to some advantages (saving water, low cost, etc.). We set our hearts on scientific research by considering all the positive and negative factors (salinity, drought, etc.). I really appreciate the sincerity and dedicated efforts of my supervisors especially Prof. Dr. Yüksel Tüzel and Prof. Dr. Juan A. Fernandez Hernandez. I really grateful to them much to guiding and helping me. Also, I sincerely thank you who guided and supported me in hard times.

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1. INTRODUCTION

1.1 The Importance of Baby Leaf as a Ready-To-Eat Food

Baby leaf vegetables are usually 12 cm in size that are harvested within 35-40 days (Gil et al., 2012; Grahn, et al.,2015) and used in the ready to eat vegetable industry. Baby leafy vegetables have soft leaves and their oxidation is minimal compared to mature vegetables, what is a benefit for the fresh-cut market (Martínez-Sánchez, 2012). Thus, basil (*Ocimum basilicum*), tatsoi (*Brassica rapa* subsp. *narinosa*), endive (*Cichorium intibus*), red, and green lettuce (*Lactuca sativa* L.), rucola (*Eruca sativa* (syn. *E. vesicaria subsp. sativa* (Miller) and *Diplotaxis tenuifolia*) spinach (*Spinacia oleracea*) are normally used in baby leaf production (Aires et al., 2013; Giménez et al., 2019; D'Imperio et al., 2016). Vegetables reduce the risk of diabetes, cancer, and obesity thanks to the phytochemicals they contain (Talalay and Fahey, 2001). Due to the fact that baby leaf vegetables are richer in phytochemicals than mature vegetables, their nutritional value, shelf life, texture, and quality characteristics, their production and consumption have increased globally (Carlsen et al., 2010). When the amount of phenolic components is compared with mature vegetables, it was observed that the amount of baby leaves is quite high (Aires et al., 2013). In addition, some baby leaves have high antioxidant capacity due to which they have antiradical activity (Aires et al., 2013). Furthermore, baby leafy vegetables are important sources of minerals. Thus, green lettuce, swiss chard, watercress, lambs lettuce, wild rocket, organic wild rocket, spinach and parsley baby leaves contain K, Na, Ca, Mg, P, Fe, Mn, Zn, Cu minerals and show similar contents to mature vegetables (Santos et al., 2014). The quantity of vitamins and minerals in wild plants is generally very high respect to cultivated vegetables. Therefore, wild plants are very noteworthy for diet (Sundriyal et al., 2001) and it is thought that they can be used in baby greens production due to their high nutritional values. As example, *Sanguisorba minor* Scop., *Sinapis arvensis* L., *Taraxacum officinale* Weber ex F. H. Wigg. wild plants are suitable to production of baby leafy vegetables. However, wild plants consumption can be considered a risk factor due to their high nitrate content, although their amount can be controlled when the plants are grown under controlled conditions (water, nutrient solution, substrates, etc.) (Lenzi et al., 2019).

1.2 Baby Leaf Growing Media

According to research hydroponic systems are known as agricultural systems containing soil-free water and fertilizers (Sheikh, 2006). Rock wool, coir, perlite, vermiculite, gravel/quartz, sand, and expanded clay materials are used as plant support materials in soilless culture systems (Pandey et al., 2009). Wick system, drip system, ebb and flow system, (deep) water culture system, nutrient film technique system, aeroponic systems, and floating systems, are used as hydroponic production methods (Lee and Lee, 2015). Soil or soilless growing environments, light, water and nutrients are required for growing baby leaf vegetables. For this reason, baby leaf vegetables are grown using aquaponic and hydroponic systems because of they provide the necessary intermediate conditions (Nicoletto et al., 2018). Controlling environmental conditions such as nutrient solution affects the flavor and quality characteristics of plants (Santamaria et al., 2001). Greenhouse conditions are the most suitable and controlled conditions in which baby leaves can be grown. Perlite, coconut fiber and expanded vermiculite are common substrates for growing baby leaf vegetables (Moraes et al., 2016; Kılıç and Duyar, 2016). Therefore, the growing environment was thought to be important for baby leafy vegetables (Atikah and Widyawati, 2019). Thus, when growing lettuce grend rapid, lettuce new rapid, and lettuce delicato lettuce varieties, plants yielded the best results in terms of the plant height, number of leaves, and root wet weight when sandy soil and peat soil were used.

1.3 Floating System

In floating hydroponic systems, plants are grown in plastic or high-density polystyrene trays by filling suitable nutrient solution into the tanks. The amount of nutrient solution in the tanks varies between 150-250 liters/m^2. It is known that the use of floating hydroponic system enables producing cleaner foods, saving water. In addition, controlling nutrient solutions, can reduce nitrate content in vegetable production (Kotsiras et al., 2016). In addition, the fact that it does not require electricity in some facilities is another advantage of floating systems (Iulia-Adriana and Maria, 2015). In addition, floating systems have the lowest cost among hydroponic systems (Gonnella, et al., 2003). It is known that floating culture

systems are frequently used in agricultural researches, especially in the production of herbs and leafy vegetables, whereas their commercial use is less extended (Pardossi et al., 2011; Chun and Takakura, 1994). Like in other hydroponic systems, plant growing in a floating system may suffer hypoxia because the roots gradually consume the oxygen dissolved in the nutrient solution. By using pumps, pipes, and diffusers placed in the system, the plant roots are provided to receive oxygen (Kittas et al., 2013). In a study on spinach plants in floating systems, aerated and unventilated nutrient solutions were compared and was observed that aeration improves yield and reduces nitrate accumulation in spinach plants (Lenzi et al., 2011). In another study with tomato seedling, different dissolved oxygen concentrations in the nutrient solution affected some properties of plants such as fresh and dry weight, leaf area and, stem diameter (Zheng et al., 2007). Chemical reactions of ions in the solution can cause certain elements to precipitate and alter their bioavailability of plants. In order to increase the bioavailability of plants, the pH range appropriate for the grown plant should be determined and nutrient solutions must contain components in appropriate concentrations (De Rijck and Schrevens, 1997). In commercial applications, it is known that strong acid or base solutions are added to change the pH of nutrient solutions. In hydroponic systems, the recommended pH range is 5.5-7.2 for the plants to benefit optimally nutrients uptake in the nutrient solution (Cerozi and Fitzsimmons, 2016). In addition, nutrient solutions with electrical conductivity between 1-3 dSm^{-1} are normally used in hydroponic systems.

Figure 1.1. Sea fennel (*C. maritimum*) cultivars grown in floating system.

1.4 Seeds and Sowing of Baby Leaf

In baby leaf cultivation, ambient conditions, growing method, seed variety are important issues. Processes such as soaking, NaClO, GA_3, KNO_3, cold and heat can be applied to seeds to improve germination (Guijarro-Real et al., 2020). Plant density can affect yield and amount of dry matter. Lettuce (*Lactuca sativa* L. var. *longifolia*): 'Ronda' and 'Amadeus' varieties were grown in a floating system at plant densities of 316 and 620 plants / m^2 and higher fresh leaf yield was obtained from high-density plants. However, higher dry matter content and lower root weight were observed in low-density plants (Gonnella et al., 2003).

1.5 Irrigation and Fertilization of Baby Leaf

Fertilization should be carried out in accordance with the correct rate, correct source, correct placement and correct timing factors, because irrigation and fertilization has a great importance in terms of yield and quality in vegetable growing (University of Florida, 2015). While less irrigation causes the yield and quality of the plants to decrease, excessive irrigation causes the plants to decrease their resistance against diseases (Chen et al., 2019; Pardossi et al., 2009). Since baby leafy vegetables are consumed raw, they should be microbially safe (Allende and Monaghan, 2015; Fallovo et al., 2009). Therefore, the quality and characteristics of the irrigation water used, and the conditions of the European Commission, World Health Organization and Codex Alimentarius Commission should be taken into consideration by the producers (Allende and Monaghan, 2015). The water source should not contain pathogens, and floating systems should be used to prevent the contact of plants with water (Allende and Monaghan, 2015; Fallovo et al., 2009; Kılıç and Duyar, 2016). Water and macro and micro elements are used in nutrient solutions (Fallovo et al., 2009). The concentration of the nutrient solution is very important for the yield of baby leaf vegetables (Fallovo et al., 2009). In lettuce cultivation, the increased in the concentration of the nutrient solution in the floating system increased the fresh yield and leaf mineral content of the plant (Fallovo et al., 2009; Lenzi, 2019). Nitrogen is one of the main fertilizers used in vegetable production, but an excessive use by producers in order to increase yield causes a decrease in vegetable quality, exceeding the limits set by the European

Commission, and provoking water and environmental pollution. Therefore, excessive nitrogen use negatively affects the quality of the baby rocket. In order to overcome this issue, reseachers are focusing their attention on the use of alternative means, such as plant biostimulant application. Thus, in a recent study, it was determined that plant-based biostimulants instead of nitrogen had a positive effect on baby leaf quality, maintaining nitrate content under the legal European Comission limits (Mola et al., 2019).

1.6 Pest and Diseases of Baby Leaf

As the ready-to-eat baby leaf industry has gained great importance in recent years, it is necessary to fight against harmful insects and diseases during the production phase. Although baby leaf vegetables are produced in a short time, it is known that insecticides are generally ineffective (Pests and Vegetables, 2009). It is recommended to implement an Integrated Pest Menagement strategy to prevent pests in baby leafy vegetables (Tesoriero, 2009; Tesoriero et al., 2009). According to a study, diamondback moth, cabbage center grub, aphids, thrips, leaf miner, rutherglen bug, cabbage white butterfly are known as the main pests in baby leaf vegetables, while *Helicoverpa spp.*, jassisds, flea beetle, shore flies, fungus gnats, green mirid, cabbage cluster moth, mites, carabid beetle are known as minor pests (Tesoriero et al., 2009). In addition, there are beneficial insects for baby leafy vegetables such as wasps, spiders, lacewings, hover fly, lady beetles. Pirate bugs, soldier beetle, red and blue beetle, assassin bug, damsel bug and big eyed bug are known as mirator beneficial insects (Pests and Vegetables, 2009). It is known that bacterial, fungal, viral diseases and physiological disorders are seen in leafy vegetables. Leaf spot diseases are seen respectively on spinach and baby leaf lettuce due to bacterias of *Stemphylium botryosum* and *Xanthomonas campestris* pv. *vitians* (Koike and Henderson, 2001; Hayes et al., 2014). Varnish spot diseases are seen butterhead lettuce (*Lactuca sativa* L. var. *capitata)* due to bacterias *Pseudomonas cichorii* (Pauwelyn et al., 2011). Downy mildew disease is seen spinach (*Spinacia oleracea* L.) due to fungal (*Peronospora effusa*) (Kandel et al., 2019). Russet spotting disease is seen in iceberg lettuce (*Lactuca sativa* L.) due to physiological disorder (López-Gálvez et al., 2015). Beet western yellows virus (BWYV) and turnip mosaic virus (TuMV) causes diseases in the Brassicaceae

family. In Lettuce (Asteraceae) lettuce mosaic virus (LMV), mirafiori lettuce virus (MiLV); lettuce big-vein virus (LBVV) - (Lettuce big-vein disease), lettuce necrotic yellows virus (LNYV), turnip mosaic virus (TuMV) viruses cause diseases (Persley and Gambley, 2010).

1.7 Post-Harvest Handling of Baby Leaf

Processes such as cutting, washing, rinsing and packaging are applied to baby leafy vegetables postharvest and these affect the quality of baby leafy vegetables. The properties of bioactive compounds, taste, color, odor, and physical appearance in baby leafy vegetables change during the post-harvest process (Saini et al., 2017). When harvesting baby leaf vegetables, they should not exceed the 'baby stage' (Cheryl and Matt, 2017). Leaf length (cm) and petiole length (cm) are maturity parameters for the harvest phase of baby leafy vegetables for the fresh-cut industry. For example, for red and green batavia, red chard, rocket, spinach baby leaf vegetables, the minimum, optimum, and maximum leaf lengths are 5, 10, and 12 cm, respectively (Gil et al., 2012). Methods and genetic factors applied in the pre-harvest, harvest and post-harvest stages affect the quality of fresh-cut vegetables (Manuela and Santos, 2014). The shelf life time of young leafy vegetables varies according to the type of vegetable (Bonasia et al., 2017). Baby leafy vegetables generally have a shelf life of 7 to 10 days after packaging (Wagstaff et al., 2007). Storage temperature is known as the critical point for the nutritional value of baby leafy vegetables. It has been determined that baby leaf vegetables can be stored at temperatures between 0-7 C, 75-85% RH, controlled atmosphere (0.5 kPa O_2 + 10 kPa CO_2) conditions, using polypropylene (PP) film, polyethylene terephthalate (PET) boxes, and MAP technology (Wagstaff et al., 2007; Saini et al., 2017).

1.8 Halophytes

Human activities, climate change and increasing population cause reduction in arable lands due to the salinization and declining of fresh water availability (Loconsole et al., 2019). Therefore, new crops tolerant and /or resistant crops to salinity and drought could be used and new strategies should be applied to increase food production (Boscaiu et al., 2012). Halophytes are salt-tolerant species that

could be cultivated in salty soil or using sea water due to using mechanisms inorganic ions like Na and Cl^-. There are three basic mechanisms to tolerate salt as salt excluding, salt excreting and salt accumulating. Roots of halophyte plants act as an ultrafiltration in only salt excluding mechanism. *Ceriops candolleana*, *Bruguiera gymnorrhiza* halophyte plants possess this mechanism. In salt excreting mechanism, foliar glands regulate the salt concentration. *Avicennia officinalis* and *A. alba* halophytes are known to have this mechanism. Finally, salt accumulates in cells and tissues in the salt accumulating mechanism. *Sonneratia apetala*, *S. acida* and *S. alba* halophyte plants have this mechanism (Hasanuzzaman et al., 2014). Some halophytes have been used as human food and animal feed. This is advantageous against food shortage in the future (Polit, 2013).

1.8.1 *Crithmum maritimum*

Sea fennel (*Crithmum maritimum* L.) is the only species of the genus *Crithmum*. In German it is named Meerfenchel or Seefenchel; in French Fenouil Marin or passepierre; in Italian finocchio Marino or critama; in Turkish Kaya korugu or Deniz rezenesi (Franke, 1982; Özcan et al., 2001). Among halophytes, sea fennel is a perennial, edible and medicinal halophyte species very common in some Mediterranian countries such as Spain, Greece, and Tunisia (Jallali et al., 2012; Renna and Gonnella, 2012; Pereira et al., 2017). These species can be used as dried, salad or pickled (Renna et al., 2017). The species *Crithmum maritimum* L. belongs to the genus *Crithmum*, the family *Apiaceae*, the order *Apiales*, the class *Magnoliopsida*, the division *Magnoliophyta*, the super-division *Spermatophyta*, the Subkingdom *Tracheobionta*, and the kingdom Plantae (Atia et al., 2010). *C. maritimum* L. has succulent leaves, thick and gnarled roots. Their flowers are yellowish or greenish-white colour (Franke, 1982). Their fruits are composed of a porous outer coat. It is thought that at the maturation stage, this structure may have a crucial role in seed dispersion and germination (Atia et al., 2010). *C. maritimum* is an underutilized crop for commercial cultivation until now (Petropoulos et al., 2015). During the last decade, the floating culture system has become very popular for aromatic and medicinal vegetable cultivation due to rapid plant growth, crop quality, high yield, easy harvest, optimization of water and fertilizer use (Öztekin et al., 2019), as far as it could be used for *C. maritimum* cultivation.

1.8.2 Bioactive compounds in *C. maritimum*

It is known that this specie has been used as food, spice and, medicinal herb (Franke, 1982). *C. maritimum* L. has important economic and medicinal potentials. This edible aromatic plant has also a powerful scent. It is known that their organs containe bioactive substances that could be used as aromatic, antimicrobial, medicine and insecticide (Atia et al., 2009; Meot-Duros and Magné, 2009; Meot-Duros et al., 2010). Recent studies have shown that *C. maritimum* is rich in terms of flavonoids, carotenoids, vitamin C and medicinal components (Ben Amor et al., 2005; Montesano et al., 2018; Renna, 2018). It has been determined that limonene (22.3%), y-terpinene (22.9%) and thymol methyl ether (25.5%) are the main components of *C. maritimum* oil (Ruberto et al., 2000). In leaves of *C. maritimum*, a phenolic compound never described in a halophyte before: chlorogenic acid (CGA) has been also determined (Meot-Duros and Magné, 2009). According to quantitative analyses of the content of tannins and total polyphenols of *C. maritimum*, the content of tannins ranged from 0.10 to 2.65% and the content of total polyphenols varied from 4.72 to 9.48% (Maleš et al., 2003). Also, *C. maritimum* contains chemical components such as saponins, monounsaturated fatty acids (oleic, linoleic acid), saturated fatty acids (palmitic and stearic), linolenic acid, essential oil and falcarindiol. Their antimicrobial, antioxidant and antibiotic activities have been determined by biological tests. It has diuretic, anti-scorbutic, digestive and purgative properties (Ksouri et al., 2012). It was determined that *C. maritimum* contains some important phenolic substances including p-hydroxybenzoic and ferulic acids, epicatechin, pyrocatechol and 4-hydroxybenzaldehyde (Pereira et al., 2017). Generally, it has been concluded that, this plant should be commercialized in order to be used in the food, cosmetics and pharmaceutical industries (Generalić Mekinić et al., 2018).

1.8.3 Mineral content of *C. maritimum*

Due to the increasing interest of people in the "natural life style", consumption of wild plants as vegetables is increasing, and the mineral content of wild plants is being investigated by scientists. The mineral content of *C. maritimum* per 100 g fresh leaves is as follows: N (360 ± 88 mg), P (19 ± 3.1mg), Na (290 ± 26 mg), K

(310 ± 34 mg), Ca (97 ± 6 mg), Mg (82 ± 6 mg), Fe (2.3 ± 0.3 mg), Cu (0.12 ± 0.01mg), Zn (0.46 ± 0.05 mg), Mn (0.71 ± 0.06 mg), K / Na (1± 0.1wt.), Ca / P (5.10 ± 0.54 wt.), K / (Ca + Mg) (0.68 ± 0.07 meq) (Guil Guerrero et al., 1998). As a result of mineral analysis of *C. maritimum* plants collected from the Thigzert region of Algeria, amounts of minerals were identified such as K, 5.2 g/kg dw, Mg 3.4 g / kg dw, Ca 23.3 g / kg dw (Nabet et al., 2017). When the mineral content of C. maritimum halophyte plants obtained from Spain, was analyzed, it was found high Na+ content[77]. In addition, it is also thought that different agricultural practices can improve the mineral content of plants (Martínez-Ballesta et al., 2008).

1.8.4 Effect of salt stress in *C. maritimum*

Important most of arable land in the world are negatively affected by salinity stress. Salinity causes changes in the biochemical and physiological activity of seeds, reducing the germination percentage of seeds (Asgharipour and Rafiei, 2011). The fact that *C. maritimum* seeds have a spongy structure reduces the effect of stress by providing the ion balance of the environment with the seeds. That is, the spongy coating protects the seeds of *C. maritimum* from damage caused by Na^+ and Cl^- accumulation (Atia et al., 2010). Besides, ascorbic acid (40 or 60 mM) and ethanol (% 96) treatments were caused an increase in the germination percentage of *C. maritimum* seeds (Meot-Duros and Magné, 2008). Regarding *C. maritimum* root and shoot growth biomass, root length, and the number of leaves were observed to be maximum at medium salinity levels (50 mM) and minimum at high salinity levels (200 mM) (Ben Amor et al., 2005). While the amount of sodium and chlorine increased in *C. maritimum* shoots in proportion to the increase in salinity, the amount of calcium, magnesium, and potassium decreased (Ben Amor et al., 2005). In addition the amount of antioxidant enzymes in the roots were decreased with increasing salinity, while in the shoots antioxidants were only enhanced at the concentration of 50 mM (Ben Amor et al., 2005). When the salt levels increased the osmotic balance of the plants was disturbed due to the accumulation of Na^+ and Cl^- in the cells of the plant and the growth was reduced (Hamed et al., 2004).

1.8.5 Effect of meja in salt stress

It has been reported methyl jasmonate and jasmonic acid protected plants against pathogens, insects, injuries, and in addition, they play a role in germination, ripening of fruits and development of roots (Wasternack, 1997; Cheong and Choi, 2003). The jasmonates (jasmonic acid and MeJa) are synthesized from linolenic acid by the octadecanoic path in plants, cause signaling in plants and play a role in gen activation and regulation (Creelman, 2002; Cheong and Choi, 2003). In relation to the possible role of MeJa on salinity stress, it has been demonstrated that MeJa reduced salinity stress in strawberry plants (cv. Camarosa), increasing root and shoot dry weight of plants, through an enhanced antioxidant enzyme activity (Faghih et al., 2017). It is also known that salinity stress increases the activity of antioxidant enzymes in plants, as well as stimulates lipoxygenase enzyme. Lipoxygenase enzyme is involved in the synthesis of jasmonic acid as a result of its stimulation (Wang et al., 2008; Ding et al., 2016; Salimi et al., 2016). Also, in *Cakile maritime* and *Thellungiella salsuginea* halophytes, salinity caused oxidative stress and thus increase jasmonic acid accumulation in leaves and roots (Ellouzi et al., 2014). In order to determine the effect of methyl jasmonate on high salt stress, when different MeJa concentrations (0, 0.01, 0.03, 0.05, 0.1) were applied, to *Limonium bicolor*, it was found that treatment with 300 mM NaCl led to dramatic inhibition of seedling growth, but it was significantly alleviated by the application of 0.03 mM MeJa (Yuan et al., 2019).

1.8.6 Effect of meja as plant elicitor of phytochemicals

It has been described that MeJa increased the bioactive compounds composition when is applied to plants due to its elicitor properties (Walker et al., 2002; Singh et al., 2018). It was due in the halophyte ice plant (*Mesembryanthemum crystallinum*) to a stimulating effect on the WI12 gene expression that produces cell wall protein (Yen et al., 2001). In Halophyte *Capparis spinosa* species, MeJa increased the rutin (important type of flavonoid compound) biosynthesis of by gene expression (Kianersi et al., 2020; Kianersi et al., 2020). When different concentrations of methyl jasmonate were applied to increase the phytochemical content of broccoli and radish shoots, low MeJa concentrations increased the

glucosinolate content, and high concentrations reduce it (Baenas et al., 2016). In another study conducted to increase the nutritional value of broccoli shoots, methyl jasmonate at 10 and 25 µM concentrations increased the vitamin C amount, total glucosinolates, caffeoyl-quinic acid derivatives, flavonoids, sinapic and ferulic acid derivatives and total phenolics of plants. However, in terms of phytochemical content 25 µM MeJA concentration and 10mM MeJA concentration gave similar results. This is evidence that low elicitor concentrations will give better results than higher concentrations to increase the phytochemical content of plants (Pérez-Balibrea et al., 2011). MeJa (100 µM) treatment in light and dark environment in "Zi Ying" mustard (*Brassice junca* var. Tumida Tsen et Lee) plants significantly increased the anthocyanin accumulation of the plants (Xie et al., 2019). In general, studies show that MeJa application increases the phytochemical content of plants.

2. OBJECTIVES

The main objective of the project was to study the cultivation of Sea fennel (*C. maritimum*) in floating system under greenhouse conditions determining the salinity and methyl jasmonate effects on plant growth and postharvest quality. For this, partial objectives were:

- To determine the effect of salinity on growth, harvest quality and shelf life during storage as fresh-cut product.
- To determine the effect of methyl jasmonate on growth, functional elements and shelf life during storage as a fresh-cut product of plants grown under salinity.

3. MATERIAL AND METHODS

3.1 Cultivation and Experiment Design

The experiments were conducted during the autumn and spring seasons of 2019 and 2020 at the Technical University of Cartagena, Spain (UPCT; lat. 37º 41‘ N; long. 0º 57‘ W) . Plants were grown in an unheated 145 m^2 greenhouse covered with thermal polyethylene. Aeration was provided and each level of treatment was carried out in a stainless steel flotation bed with dimensions 1.35 × 1.25 × 0.2 m covered with PVC liner. The tap water in the beds was replaced with a nutrient solution (pH of 5.8 to 5.6 and EC around 2.8 dS/m), containing the following elements in mol/L: $NO3^-$, 7200; $NH4^+$, 4800; $H2PO4^-$, 2000; K^+, 6000; Mg^{2+}, 1500; Ca^{2+}, 2000. A commercial mixture of microelements at a concentration of 0.02 g L^{-1} (Nutromix, Biagro S.L., Valencia, Spain) and Fe chelate at a concentration of 0.02 g L^{-1} (Sequestrene, Syngenta AG, Basel, Switzerland) were added to the solution. The EC and temperature of the nutrient solution were monitored during the growing season using Campbell CS547 sensors (Campbell Scientific Inc., Logan, UT, USA). At harvest, a total of 10 plants per tray were taken and shoot and roots separated for measurements and keep into N_2 liquid for subsequent lyophilization.

3.2 Experiment 1: Effect of Salinity on Postharvest

The plants were grown for 1 month in normal conditions (control) and then the salinity treatment was applied for 1 month. Seeds were sown in 60 x 40 cm styrofloat trays and 4 plants were left per fissure (400 plants/ha). The trays of 60 × 41 cm have pyramidal-trunk 172 mm long fissures 20 mm apart and grouped in three for a total of 42 fissures per tray; fissures measure 10 mm on the top and 2.5 mm on the bottom, leading to a volume of 32.4 cm^3 per fissure. After sowing the trays were then transferred to flotation beds floating on fresh tap water. Nutrient solution was replaced weekly and pH measured every three days and adjusted to 6.5. The plants were harvested when they were 2 months old. Two treatments were considered, control plants (Con) and plants treated with 150 mM NaCl (NaCl) for 1 month. Each treatment had three replications. Growth and yield parameters (root parameters), mineral ion concentrations (anions and cations) and postharvest

quality (%weightloss, chromaticity, HUE, CO_2, O_2, sensorial quality, microorganisms) were determined.

3.3 Experiment 2: Effect of MeJa in Salt-Stressed Plants

In this experiment, polystyrene trays containing 54 cells were used. Every cell contained 2 plants. Thus, the plant density was around 400 plants/ha. Five treatments were considered; control plants (Con1), control plants spraying with Tween 20 (1ml L^{-1}) + 0,2% EtOH (Con 2), addition of 150 mM NaCl to the nutrient solution (NaCl), spraying with 0.5 mM methyl jasmonate (MeJa) and 150 mM NaCl + 0.5 mM MeJa (NaCl + MeJa). MeJa was diluted in Tween 20 1 ml por L+ 0.2 EtOH in order to facilitate MeJa leaf penetration. NaCl was applied to the nutrient solution whereas an amount of 100 mL of MeJa was sprayed to the leaves three times (every 10 days). Nutrient solution was replaced weekly and pH measured every three days and adjusted to 6.5. A total of 2 replicates per treatment were carried out. Yield and quality analysis, fresh and dry weights of shoots, root parameters and stem length, shoot colour, clorophyll and carotenoids, content of ascorbic acid, phenolics compunds and antioxidant capacity as DPPH were determined.

3.4 Fresh and Dry Weights of Shoots and Roots

The fresh weight of roots and shoots was measured on a scale (Model: RADWAG PS 4500/C2) that had the level of accuracy of 0.0001 g. The dry weight of shoots and roots were determined by drying in an oven at 60◦C until constant weight.

3.5 Root Parameters

Root length (cm), project area (cm^2), surface area (cm^2), average diameter (mm) and root volume (cm^3) parameters were measured using a Winrhizo LA 1600 root counter (Regent Inc., Quebec, Canada) (Campoy, 2015).

3.6 Colour

Colour measurements were performed using a colorimeter. Color measurements was measured on six plants per replicate using a colorimeter model (Minolta CR-10; Konica- Minolta Sensing Inc., Osaka, Japan) equipped with the a* (redness) b* (yellowness) colour scale, according to the procedure described by Montesano et al. (Montesano et al., 2018; Montesano et al., 2016). HUE angle (H*) as H*= tan-1 (b*/a*) and chromacity (C*) as C* = (a*2 + b*2) were also calculated (Montesano et al., 2018).

3.7 Sensory and Visual Quality Analysis

The sensory quality was evaluated in a tasting room after 7 d of cold storage by a test panel consisting of 11 people. Visual quality factors (overall visual quality and global quality) were scored on a 9-point hedonic scale (l=extremely poor, 3=poor, 5= acceptable and limit of usability, 7= good, and 9= excellent). Disorders (browning visual dehydration, off-odors, off-color, and off-flavors) were scored according to the following scale of damage incidence and severity: 1= none, 2=slight, 3=moderate (limit of usability), 4=severe, 5=extreme (Tomás-Callejas et al., 2011).

3.8 Contents of Mineral

0.2 g DW of ground shoot tissue was mixed with 50 ml distilled water in an orbital shaker (Stuart SSL1, Stone, UK) for 45 min at 110 rpm at 50 ° C. While Metrosep A SUPP 5 column (Metrohm AG, Zofingen, Switzerland) was used for flow anions at 0.7 ml min^{-1} flow rate, Metrosep C 2-250 column was used at 1.0 flow min^{-1} flow rate for cations to apply ion chromatography method (Lara et al., 2011)

3.9 Phenolic Compounds

To determine phenolics analysis, the methodology of Tarazona-Díaz et al. (Tarazona-Díaz et al., 2011) was performed (Tarazona-Díaz et al., 2011). Samples

of 0.5 gram of FW. sample was centrifuged at 1,200 x g for 15 min (Heraeus Fresco 21; Thermo Scientific, Osterode, Germany) at 4 ºC using 3.0 ml 100% (v / v). The FolinCiocalteu colorimetric method was chosed to determine the phenolic content. The procedure of Singleton and Rossi (Singleton and Rossi, 1965) was used for this purpose. A (0.1 ml) aliquot of the extract supernatant, (0.15 ml) of FolinCiocalteu reagent, and (1.0 ml 4 g l^{-1}) NaOH / (20 g l^{-1}) Na_2CO_3 were mixed. Absorbance was measured at 750 nm by spectrophotometric (SmartSpecTM Plus; BioRad Laboratories, Inc., Hercules, CA, USA) method. Results (CAE) were expressed in kg^{-1} FW chlorogenic acid (Lara et al., 2011).

3.10 Chlorophylls and Carotenoids

For chorophyll determination, 50 gr of lyophilised sample in 1 ml de methanol was used. For the analysis of chlorophyll and carotenoids, firstly the samples were extracted using 1 ml of methanol and 100 mg of sample (samples were triturated with liquid N_2). After mixing with vortex, extract was incubated overnight at 4 °C. Then, 16 g of extract was centrifuged at 4 ° C for 5 minutes and methanol extract was obtained. Chlorophyll a and b and total carotenoids were measured by the method determined by Lichtenthaler and Buschmann (Lichtenthaler and Buschmann, 2001). Measurement was made with ethanol extracts. Spectrophotometric measurements were carried out by measuring the absorbances at 665, 652, and 470 nm and mathematical expressions corresponding to methanol as the solvent was applied (Lichtenthaler and Buschmann, 2001).

3.11 Flavonoids

Method of Zhishen was used to determination of total flavonoid content (Zhishen et al., 1999). In order to determine the total flavonoid content, 100 µL of the hydro-methanolic extract were dissolved using 400 microliters of pure water. 30 µL of 5% sodium nitrite and 30 µL of 10% aluminum chloride and 200 µL of 1M sodium hydroxide was added to the solution, at intervals of 5 minutes. The volume of the mixture was completed to 1 ml by adding pure water. The absorbance of samples as measured at 510 nm. The results were expressed in mg of rutin equivalents per kilogram of fresh weight (mg Rutin kg-1 FW) (Nabet et al., 2017).

3.12 Antioxidant Capacity

The antioxidant capacity was evaluated in terms of free radical-scavenging capacity (Cuvelier and Berset, 1995) with the modifications described by Perez-Tortosa et al. (Cuvelier and Berset, 1995).

3.13 Shelf Life During Storage Analysis

Shelf life and storage of *C. maritimum* conditions were tested. For that, plants were transported immediately after harvesting to a disinfected cold room at 10˚C, where all shoots free from defects were taken. They were disinfected washing for 2 min with a solution containing 100 ppm NaOCl and 0.2 g. 1.-1 citric acid. Then, the shoots were rinsed with tap water to eliminate chlorine residues. Excess surface water was removed by using a handheld salad spinner for the 30s. Then, 20 g of shoots were placed in 0.04-mm thick polyethylene bags, and the control group was stored at 5℃ in dark condition for 7 days. Microbial growth was assessed after 7 days of storage. Samples of 10 g fresh weight (FW) from each treatment was blended with 90 ml of sterile tryptone phosphate water at pH 7.0 for 1 min in a sterile bag by using a stomacher as reported in Niñirola et. al., (Niñirola et al., 2014). Serial dilutions were prepared in 9 ml tryptone phosphate water. From each dilution, 1 ml aliquots were aseptically pipetted for microbial population counting. Plate count agar (PCA) for both mesophilic aerobic microorganisms, incubated at 26 o c for 3 d, and psychrophilic microorganisms, incubated at 4 0 C for 10 d, was used. Microbial counts will be reported as long as 10 colony-forming units (CFU) per gram of FW. Changes in O_2 and CO_2 levels were determined by gas chromotography.

3.14 Statistics

Statistical analyzes were made with IBM SPSS Statistics 20 program. Analysis of variance was done using ANOVA. The differences were set at the 5% level. Results are expressed as mean and standard deviation.

4. RESULTS

4.1 Experiment 1: Effect of Salinity on Growth Postharvest Parameters of *C. maritimum*

4.1.1 Biomass, leaf area and root growth parameters

Biomass, determining as fresh weight per plant did not show significant differences between under salinity and non-salinity growth conditions. Similarly, leaf area remained unchanged after NaCl addition with regard control plants, showing the ability of *C. maritimum* to tolerate saline environmental conditions (Table 4.1).

Table 4.1. Effect of 150 mM NaCl on fresh and dry weight of whole plant and leaf area (n=20).

Sample	**Weight (gr/plant)**	**Leaf area (cm^2/plant)**
Control	2.1 ± 0.25a	3.43 ± 0.38 a
NaCl	2.45 ± 0.27a	2.54 ± 0.17a

Although numerical values were higher for control plants, no significant differences were found in the root growth parameters, between 0 and 150 mM NaCl-treated plants (Table 4.2).

Table 4.2. Effect of 150 mM NaCl on root growth parameters (length, root area, root diameter and root volume) (n=20).

Root Parameters	**Length (cm)**	**SurfArea (cm^2)**	**AvgDiam (mm)**	**RootVolume (cm^3)**
Control	546,73±53,86a	63,46±6,44a	0,38±0,01a	0,60±0,07a
NaCl	541,16±45,11a	54,51±4,03a	0,33±0,02a	0,46±0,05a

4.1.2 Mineral ion concentrations (Anions and cations)

Exposure of *C. maritimum* plants to salinity caused a decrease in the concentration of NO_3^-, NO_2^-, Br^-, SO_4^{2-} anions compared to control plants, while an increase in the concentration of C1- PO_4^{3-} anions was observed. However, oxalate ($C_2O_4^{2-}$) concentration remained unaltered after salinity addition with respect to control (Table 4.3). It has been observed that concentrations of K^+, Ca^+, and Mg^+ decreased with saline treatment while concentrations of Na^+ and NH_4^+ increased (Table 4.4).

Table 4.3. Effect of 150 mM NaCl Salinity on anions content (n=10).

ANIONS

	NO_3^-	NO_2^-	Cl^-	Br^-	PO_4^{3-}	SO_4^{2-}	$C_2O_4^{2-}$
Treatment	**(mg/kg FW)**	**(mg/kg FW)**	**(mg/kg FW)**	**(mg/kg FW)**	**(mg/kg FW)**	**(mg/kg FW)**	**(mg/kg FW)**
Control	1530,31±586,47a	743,69± 525,85a	1810,97±120,56b	152,00±2,82a	947,01±94,14a	1699,55±32,28a	88,19±33,59a
NaCl	1263,03±19,79b	203,83±177,23b	6718,18±1029,31a	125,98±3,46b	1154,39±142,73a	671,25±47,66b	88,70±28,87a

Table 4.4. Effect of 150 mM NaCl Salinity on cations content (n=10).

CATIONS

Treatment	**Na^+ (mg/kg FW)**	**K^+(mg/kg FW)**	**$NH4^+$(mg/kg FW)**	**Ca^{2+}(mg/kg FW)**	**Mg^{2+}(mg/kg FW)**
Control	777,57±54,46a	3642,49±109,48a	50,92±20,89b	1108,08±20,91a	379,07±12,46a
NaCl	4639,88±703,02b	1070,45±345,86b	425,31±49,74a	532,05±143,54b	203,42±10,47b

4.1.3 Postharvest quality

4.1.3.1 Weightloss percentage of *C. maritimum* plants

It was observed that the exposure of plants to salinity increased weightloss with regard to control plants. Percentage of weightloss at day 6 was higher than at day 12 for both treatments (Table 4.5).

Table 4.5. Effect of 150 mM NaCl on % weightloss (n=20).

%Weightloss		
Treatment	**Day 6**	**Day 12**
CONTROL	1,45±1,49b	0,32±0,16c
NaCl	2,74±1,67a	1,24±0,38b
Significance (1)		
Treatment ***		
Day of Storage ***		
Treatment x Day Storage *		

(1) Significance of F-test: *** and ns, respectively, significant for $P \leq 0,05$ and $P \leq 0,001$.

4.1.3.2 L, a and b values

Considering the change of colour parameters, it has been observed that the L value in control plants ranged from 35.79 to 37.96, a value ranged from -11.44 to 10.63 and the value of b ranged from 17.33 to 19.11. In plants exposed to salinity, L value varied from 38.12 to 40.12, a value from -11.13 to 11.04 and b value from 19.25 to 21.99. From the statistic analysis no significative effect of day of storage was observed in colour parameters in any treatment. However, salinity increased L values at all storage days (Table 4.6). Intereaction between treatment and days of storage showed no significant differences.

Table 4.6. Effect of NaCl on L, a, and b values (n=10).

Colour	Treatment	Control	NaCl
Day 0	**L**	37,84±1,91ab	39,17±0,89ab
	a	-11,44±0,95a	-11,13±1,32a
	b	18,51±3,13a	21,99±0,41a
Day 6	**L**	35,79±1,35b	40,12±1,16a
	a	10,63±1,16a	11,04±0,69a
	b	17,33±3,71a	20,63±1,73a
Day 12	**L**	37,96±2,41ab	38,12±0,88ab
	a	-11,86±1,52a	-10,66±0,44a
	b	19,11±3,36a	19,25±1,45a

Significance ([1])	**L**	**A**	**B**
Treatment	*	Ns	Ns
Day of Storage	ns	Ns	Ns
Treatment x Day storage	ns	Ns	Ns

(1) Significance of F-test: * and ns, respectively, significant for $P \leq 0,05$

4.1.3.3 HUE values

Regarding HUE values, no significance differences were observed between control and NaCl-treated plants at any day of storage. Similarly, no effect day was showed in each treatment (Table 4.7).

Table 4.7. Effect of NaCl on HUE values (n=10).

HUE º			
Treatment	**Day 0**	**Day 6**	**Day 12**
Control	122,08±3,22a	121,89±1,74a	121,96±0,86a
NaCl	116,78±1,38a	118,18±0,29a	119,06±1,62a

Significance ([1])	
Treatment	**Ns**
Day of Storage	**Ns**
Treatment x Day storage	**Ns**

(1) Significance of F-test: ns, not significant for $P \leq 0,05$.

4.1.3.4 Chromaticity values

Chromaticity values remained unchanged with the time of storage in both treatments (Table 4.8). However, at day 0, chromacity was higher in NaCl-treated plants compared to control plants, whereas an increase in the days of storage (6 and 12d) reported no significant differences between the Chromacity values of control and NaCl-treated plants (Table 4.8).

Table 4.8. Effect of NaCl on chromaticity values (n=10).

Chromaticity

Treatment	**Day 0**	**Day 6**	**Day 12**
Control	21,83±1,48a	22,47±0,78a	22,50±2,10a
NaCl	24,66±0,53a	23,40±1,07a	22,02±0,62a
Significance ([1])			
Treatment		*	
Day of Storage		Ns	
Treatment x Day storage		Ns	

(1) Significance of F-test: * and ns, respectively, significant and not significant for $P \leq 0,05$.

4.1.3.5 CO_2 and O_2 values of *C. maritimum* plants

The CO_2 and O_2 values did not show significant differences between control and NaCl-treated plants (Table 4.9). However, while CO_2 was enhanced as time of storage was increased in both treatments, O_2 was reduced during the period of storage.

Table 4.9. Effect of NaCl to CO_2 and O_2 values of *C. maritimum* plants (n=10)

Atmosphere	**CO_2**			**O_2**		
Treatment	**Day 0**	**Day 6**	**Day 12**	**Day 0**	**Day 6**	**Day 12**
NaCl	0,03d	4,8±0,4c	9,7±0,3a	21a	16,2±0,4b	11,3±0,3d
Control	0,03d	5,2±0,8c	8,1±0,6b	21a	15,8±0,8b	12,9±0,6c
Significance ([1])	**CO_2**	**O_2**				
Treatment	**ns**	**ns**				
Day of Storage	*******	*******				
Treatment x Day storage	*****	*****				

(1) Significance of F-test: ***, * and ns, respectively, significant for $P \leq 0,001$, $P \leq 0,05$ and not significant for $P \leq 0,05$.

4.1.3.6 Sensorial quality of *C. maritimum* plants

The sensory quality of *C. maritimum* plants were evaluated at days 0, 6, and 12 of storage. At day 0, the visual appearance of the plants was excellent, while the NaCl treated plants had a good visual acceptability. Visual appearance quality was decreased for both treatments as the period of storage increased, being lowest at 6 day than at 12 day. In general, the visual appearance of the control plants was better than NaCl-treated plants (Table 4.10). No changes were observed in the color parameter of the plants at days 0, 6, and 12, for any treatment. The colour determined a good acceptability for all plants (Table 4.10). The texture (crisp) was "perfect" in both control and NaCl treated plants at day 0. However at day 6, control plants had a "good" texture and NaCl-treated plants has a “normal” texture. At day 12, both plants (0 and 150 mM NaCl) had similar and "normal" texture. Flavor (freshness) was determined as perfect for control plants at day 0 and good for NaCl-treated plants. At day 6 and 12, the flavor (freshness) was clasified good and normal, respectively, for both groups of plants. Salinity or storage time had no effect on the aroma of the plants and in all conditions, the aroma of *C. maritimum* plants was "excellent". Global acceptability, was better for control plants than NaCl-treated plants during the entire storage period, but this value decreased from day 0 to day 12.

Table 4.10. Effect of NaCl on sensorial quality (n=10).

Sensorial Quality

	Day 0		Day 6		Day 12	
	CONTROL	**NaCl**	**CONTROL**	**NaCl**	**CONTROL**	**NaCl**
Acceptability						
Visual Appearance	5	4	4,5	4	4	3,5
Colour	4	4	4	4	4	4
Texture (Crisp)	5	5	4	3,5	3	3
Flavor (Freshness)	5	4	4	4	3	3
Aroma	5	5	5	5	5	5
Global Acceptability	5	4,5	4	3,5	3,5	3
Alteratıons						
Strange Smells	5	5	5	5	5	5
Mechanical Damage	4	4	4	4	3,5	3,5
Observatİons		Salty taste, on a scale of 1 to 10 as salty, 7.5		Follow the salty taste, the same		İgual a dequal to day 6ía 6

Acceptability:1=Very bad, 2=bad, 3=Normal, 4=Good, 5=Excelllent **Alterations:**1=Extreme presence, 2= Important presence, 3=Acceptable, Commercialization Limit, 4= Slight Presence, 5= Absence

4.1.3.7 Firmness

Salinity in general decreased firmness in all days of storage excepting at day12 where no significant differences were found between control and salinity firmess values. The day of sotrage had no effect on the vegetable firmess in any of the treatments.

Table 4.11. Effect of NaCl on firmness of *C. maritimum* plants during storage (0, 6, 12 days).

	Firmness		
Treatment	**Day 0**	**Day 6**	**Day 12**
Control	576,79±63,84a	594,79±63,39a	617,23±58,57a
NaCl	412,17±43,34b	435,30±46,12b	526,37±63,27ab
Significance (1)			
Treatment	*		
Day of Storage	ns		
Treatment x Day storage	ns		

(1) Significance of F-test: * and ns, respectively significant and not significant for $P \leq 0,05$.

4.1.3.8 Microbial quality

Microbiological analyzes were carried out determining psychrophiles, yeast and moulds, and enterobacteria at 0,6, and 12 days storage for control and NaCl-treated plants (Table 4.12). At all storage days, the number of psychrophiles, molds and yeasts, enterobacteria were higher in the control plants than in the plants exposed to NaCl. Therefore, salinity reduced the number of microorganisms with the exception of mesophiles which were similar for both treatments. The effect of storage day was similar in control and NaCl-treated plants where the levels of microrganisms were increased.

Table 4.12. Effect of salinity for the number of psychrophiles, mesophyll, mold, and yeast, enterobacter microorganisms of *C. maritimum* plants during the 0, 6 and 12 days storage period (n=10).

		Day 0	Day 6	Day 12
Psycrophile	**Control**	5,00±1,12b	6,06±0,18ab	6,40±0,00a
	NaCl	3,48±0,13c	5,92±0,22ab	6,37±0,05a
Mesophile	**Control**	4,22±0,15c	5,67±0,31b	6,31±0,01a
	NaCl	3,88±0,27c	5,55±0,16b	6,30±0,00a
Mold and Yeast	**Control**	3,28±0,55bc	3,95±0,27ab	4,30±0,26a
	NaCl	2,91±0,13c	3,71±0,20abc	3,40±0,17bc
Enterobacteria	**Control**	3,69±0,47c	5,62±0,39ab	6,14±0,17ab
	NaCl	0,00±0,00d	5,42±0,30b	6,29±0,16a
Significance ([1])	**Psycrophile**	**Mesophile**	**Mold and Yeast**	**Enterobacteria**
Treatment	*	ns	**	***
Day of Storage	***	***	**	***
Treatment x Day storage	*	ns	ns	***

(1) Significance of F-test: *, **, *** and ns, respectively, significant for $P \leq 0,05$, 0,001, 0,001 and not significant for $P \leq 0,05$.

4.2 Experiment 2: Effect of MeJa in Salt-Stressed *C. maritimum* Plants

4.2.1 Biomass and root growth parameters

Leaf biomass, as edible and comercial part of the plant, was evaluated determining fresh (FW) and dry (DW) weights after treatments addition (Table 4.14). The higher FW was observed in Con1 plants without significant differences regarding Con2. NaCl reduced the FW of *C.maritumum* plants while MeJa partially recovered the FW in NaCl+MeJa-treated plants compared the only NaCl addition, reaching values similar to Con2. The only MeJa addition caused a reduction in FW

regarding Con1, but not with respet Con2. In a similar way, DW was higher in Con1 plants and it was signifivative reduced by NaCl with regard the rest of treatments. MeJa addition enhanced DW compared with the only NaCl treatment and NaCl+MeJa-treated plants showed similar DW values than Con2 and MeJa plants. Finally, the colour parameter did not show significant changes in any of the treatments.

Table 4.13. Fresh weight (FW), dry weight (DW), and of the aerial part of *C. maritimum* plants grown under hydroponic conditions with the following treatments; Con1, Con2, MeJa, NaCl-MeJa, NaCl (n=20).

	FW	**DW**	**Chlorophyll Index (SPAD)**
Control 1	11,51 ±0,77a	1,33 ±0,09a	65,86 ±0,85a
Control 2	8,92 ±0,81ab	1,03 ±0,09b	65,08 ±0,92a
MeJa	7,21 ±0,43b	0,83 ±0,05b	66,49 ±0,57a
NaCl	5,25 ±0,49c	0,60 ±0,06c	65,72 ±0,64b
NaCl+ MeJa	7,94 ±0,55b	0,91 ±0,06b	65,82 ±0,61a

Root length and root area were higher in NaCl-treated plants compare with the rest of treatments, which did not show significant differences in these parameters (Table 4.13). Root diameter remained unmodified after the treatment applications. However, root volume was significantly higher in NaCl-treated plants in relation to Con1- and MeJa-treated plants.

Table 4.14. Root growth parameters (Length, surface area, average diameter, root volume) of *C. maritimum* plants grown under hydroponic conditions with the following treatments; Con1, Con2, MeJa, NaCl-MeJa, NaCl (n=20).

Treatment	Length (cm)	SurfArea (cm^2)	AvgDiam (mm)	RootVolume (cm^3)
Control1	222,48 ±38,19b	35,46 ±5,66b	0,54 ±0,04a	0,49 ±0,08b
Control2	207,84 ± 29,75b	38,99 ±5,98b	0,60 ±0,04a	0,62 ±0,12ab
MeJa	207,90 ±25,61b	33,14 ±4,64b	0,50 ±0,03a	0,46 ±0,086b
NaCl-MeJa	219,14 ±37,8b	44,25 ±6,69ab	0,65 ±0,05a	0,75 ±0,12ab
NaCl	347,57 ±49,33a	65,05 ±8,59a	0,63 ±0,05a	1,01 ± 0,13a

4.2.2 Mineral ion concentrations (Anions and cations)

Cations (Mg^{+2}, Ca^{+2}, $NH4^+$ and Na^+) and anions (F^-, Cl^-, NO_2, Br^-, NO_3^-, PO_4^- $C_2O_4^{2-}$) were determined in the leaves of *C. maritimum* (Table 4.15). Regarding cations, Mg^{2+} content was higher in NaCl + MeJa plants compare with the only NaCl-treated plants but no significant differences in Mg^{2+} concentration were found in Con1, Con2, MeJa and NaCl+MeJa plants. Ca^{2+} levels were similar in all treatments with the exception of NaCl treated plants where Ca content was decreased. K^+ content was similar in Con1, Con2 and MeJa plants and it deceased in NaCl and NaCl+MeJa treated plants. The two MeJa treatments increased the $NH4^+$ content regarding Con1, Con2 and MeJa treatments, which did not show significant differences between them in the $NH4^+$ concentrations. Finally, Na^+ was higher in NaCl treatments compared with Con1, Con2 and MeJa plants.

Table 4.15. Cations (Mg^{+2}, Ca^{+2}, K^{+}, $NH4^{+}$, and Na^{+}) (mg Kg^{-1} FW) of *C.maritimum* leaf tissues under the different treatments (Con1, Con2, MeJa, NaCl, NaCl+MeJa), (n=10).

Cationes	**Mg^{+2}**	**Ca^{+2}**	**K^{+}**	**$NH4^{+}$**	**Na^{+}**
Control1	309,00 ±6,09ab	997,72 ±10,036a	2411,01 ±48,78ab	277,59 ±23,13a	977,27 ±70,43b
Control2	299,25 ±20,21ab	901,05 ±53,26a	2295,72 ±125,96ab	251,19 ±14,84a	1086,10 ±67,04b
NaCl	255,03 ±53,10b	692,83 ±36,78b	1628,10 ±113,72c	384,90 ±15,00ab	2698,07 ±16,54a
MeJa	283,91 ±12,15ab	926,53 ±28,21a	2901,40 ±121,81a	449,18 ±104,60b	1308,48 ±51,43b
NaCl+ MeJa	342,78 ±10,98a	1044,16 ±88,79a	2006,77±134,36b	447,61 ±48,50b	2903,18 ±44,96a

Regarding anions, F^{-} and NO_3^{-} content did not show significant differences between treatments in the leaves (Table 4.16). Cl^{-} was higher in the NaCl and NaCl+ MeJa treated plants compared with the rest of treatments. NO_2^{-} was only decreased in $NaCl^{-}$ treated plants and Br^{-} was increased in both MeJa treatments with regard the rest of treaments. PO_4^{3-} was enhanced in MeJa and NaCl+MeJa-treated plants but the increment was higher in NaCl+MeJa plants. Finally $C_2O_4^{2-}$ was similar in both control treatments but it was increased in NaCl treated plants.

Table 4.16. Anions (F^{-}, Cl^{-}, NO_2^{-}, Br^{-}, NO_3^{-}, PO_4^{3-}, $C_2O_4^{2-}$) (mg Kg^{-1} FW) of *C.maritimum* leaf tissues under the different treatments (Con1, Con2, MeJa, NaCl, NaCl+MeJa), (n=10).

Aniones	**F^{-}**	**Cl^{-}**	**NO_2^{-}**	**Br^{-}**	**NO_3^{-}**	**PO_4^{3-}**	**$C_2O_4^{2-}$**
Control1	20,88 ±0,97a	2285,63 ±162,74b	963,25 ±8,94a	109,62 ±0,90b	296,95 ±23,32a	944,38 ±25,93c	116,46 ±4,42b
Control2	25,83 ±4,56a	2515,93 ±104,79b	845,95 ±36,81a	105,87 ±0,86b	229,12 ±8,13a	911,26 ±25,64c	108,28 ±1,11b
NaCl	21,71 ±0,87a	4385,71 ±31,93a	453,87 ±90,22b	109,38 ±0,67b	255,84 ±9,10a	940,02 ±14,36c	134,28 ±1,89a
MeJa	25,83 ±1,25a	2840,38 ±4.00b	970,44 ±12,22a	120,20 ±1,40a	276,49 ±1,66a	1082,62 ±23,03b	128,90 ±7,94ab
NaCl+ Meja	24,81 ±0,75a	4986,10 ±39,67a	954,57 ±15,37a	132,47 ±0,81a	292,59 ±0,74a	1278,91 ±20,64a	126,25 ±6,58ab

4.2.3 Total phenolic compounds, flavonoids and antioxidant capacity

Total phenolic compounds were determined in the leaves of *C.maritimum* plants (Table 4.17). The content of total phenolic compounds was smilar in Con1, Con2 and MeJa plants but it was incrased in NaCl- and NaCl+MeJa- treated plants.

Table 4.17. Total phenolic compounds (GAE mg Kg-^{1} FW), Flavonoids (mg Rutin kg-1 FW), antioxidant capacity (mg DPPH Kg-1 FW) of *C.maritimum* leaf tissues under the different treatments (Con1, Con2, MeJa, NaCl, NaCl+MeJa), (n=10).

Treatment	Total Phenolic Compounds (GAE mg Kg^{-1} FW)	Flovanoids (mg Rutin kg-1 FW)	Antioxidant Capacity (mg DPPH Kg-1 FW)
Con 1	891,79±15,79a	1965,41 ± 47,17 b	113,64 ± 7,17 a
Con 2	883,09±8,11a	1968,39 ± 6,30 b	110,85 ± 5,47 a
NaCl	833,53±9,42b	2167,24 ± 22,09a	109,92 ± 5,84 a
MeJa	901,50±9,71a	2186,94 ± 5,97 a	108,81 ± 1,77 a
MeJa+NaCl	844,40±7,08b	2273,53 ± 0,60 a	117,78 ± 1,09 a

Flavonoids content was increased in NaCl, MeJa and NaCl+MeJa treates plants with regards both controls.

Finally, no significant differences were found in total antioxidant capacity between treatments (Table 4.17).

4.2.4 Chlorophylls and carotenoids

Clorophyll a was higher in MeJa-treated plants regarding the rest of treatments, while a reduction in clorophyll b was induced by MeJa in both MeJa and NaCl+MeJa treatments. Finally, carotenoids were increased in MeJa treated plants.

Table 4.18. Chlorophyll a (mg /dry weight), chlorophyll b (mg/ dry weight) and carotenoids (mg/ dry weight) of *C.maritimum* leaf tissues under the different treatments (Con1, Con2, MeJa, NaCl, NaCl+MeJa), (n=10).

Treatment	**Ca (mg/ dry weight)**	**Cb(mg/ dry weight)**	**C(X+C) (mg/ dry weight)**
Con1	12,68 ±0,05 a	7,51 ±0,40 a	2,43 ±0,09 b
Con2	15,41±0,23 a	7,92 ±0,03 a	2,62 ±0,03 b
NaCl	16,13 ±0,45 a	8,85 ±0,29 a	2,86 ±0,21 b
MeJa	17,77 ±0,05 b	4,98 ±0,03 b	4,25 ±0,00 a
NaCl + MeJa	14,22 ±0,01 a	4,24 ±0,08 b	3,40 ±0,01 ab

5. DISCUSSION

5.1 Experiment 1: Effect of Salinity on Postharvest Quality of *C. maritimum*

It is known that floating systems are an excellent medium for producing ready to eat vegetables with high quality, efficiency, economy, and bioavailability (Tomasi et al., 2014) . Similarly, the growth and development of *C. maritimum* in floating systems was adequated and no nutritional deficiencies symptoms were observed in the plants. It has been reported that *C. maritimum* plants can tolerate extreme salinities ranged from 0 to 512 mM NaCl (Hamdani et al., 2017). These authors showed that the percentage of survival remained unchanged until 171 mM NaCl in an Algerian *C. maritimum* population and significant reductions of shoot heigth were observed at $\geq$ 341 mM NaCl. Similarly, in our *C. maritimum* plants from South Spain, no effect on the biomass and root growth parameters were observed when plants were grown in hydroponics at 150 mM NaCl. This fact corroborates the idea that *C.maritimum* is a facultative halophyte, since plants did not require salinity to reach a maximal growth. However, Ben Hamed *et al*. (2004) showed a reduction in the biomass, the leaf number and total leaf area in a Tunisian *C. maritimum* population after 5 weeks of 150 mM NaCl treatment. These results pointing out the importance of the genotype in the salinity tolerance acclimatation. Mineral analysis showed important restrictions of salinity in nutrients such as K, Ca, Mg, NO_3- and SO_4^{2-}acquisition, which could be due in part to the inhibition of ion transport by salinity rather than a reduction of root intrinsic growth and performance, as can be deduced of root growth parameters. In any case, mineral decreases did not limit the overall plant growth under salt stress and the observed increased in the leaf Na and Cl concentrations could be ameliorated by an ion compartimentation into the leaf vacuoles (Atia et al., 2011). *C.maritimum* cells have high concentrations of Na^+ and Cl^- content. Na^+ ions were accumulated by compartmentation in Na^+ vacuoles (Atia et al., 2010).Therefore, an osmotic effect of NaCl on plant nutrition together a reduced root to leaf translocation may explain leaf minerals redutions of some ions in our plants. The percetange of weightloss with storage time was higher in saline-plants compare to control. However, this fact was not related with firmess, it was lower than control, but remained constant

during storage days for salt-treated plants. Percentage of weightloss was in all cases lower than 3% and fresh horticultural products lose their fresh apparence with weightloss percentages higher than 3% (Ben-Yehoshua and Rodov, 2002). Similar results were found in *Salicornia ramosissima* and *Sarcorconia perennis*, two halophytes with low % weightloss percentages during storage time from 7 to 21 days (Gago et al., 2011). The present results showed that *C. maritimum* can be stored until 12 days without senescence effects. The acceptability of sensorial parameters of the *C.maritimum* saline-treated plants was slightly lower than control plants. *C.maritimum* has been used as a new spice with high sensorial evaluation of their attributes (Renna and Gonnella, 2012). The interest on wild species as new healthy vegetables and as links with the nature and traditional varieties, makes *C.maritimum* a valuable specie since a gastronomic point of view. It is known that salt stress may modify quality factors improving bioactive composition in halophytes (Atzori et al., 2017; Souid et al., 2016; Chen et al., 2018). However, there is a lack of information about how a pre-harvest condition, such as salinity, may act on the maintenance of baby-leaf products shelf-life, especially in halophytes. In our experiment, the postharvest CO_2 and O_2 production was similar in salt-stressed fresh cut products compared to control. This result indicated that salinity did not accelerate respiratory metabolism neither intensifiy senescence processes. In cauliflower florets, salt stress (4.0 dS m^{-1}) increased both CO_2 and O_2 content from 0 to 7 days of storage, but after 7 days, control florets showed an acceleration in respiratory metabolism compared with the florets from saline treated plants. This fact could be due to the delay caused by salinity in the complex metabolic network that acts on post-harvest biological decay (Giuffrida et al., 2018). This was not the case of *C.maritimum* plants, a facultative halophyte, where 150 mM NaCl had similar effect than control plants on CO_2 and O_2 atmosphere. Microbial contamination is an important factor diminishing baby leaf quality (Gil et al., 2015). In fact, several pre and post harvest strategies has been studied in order to cope with microbial contamination and maintain safety fresh leafly vegetables (Gil et al., 2015). In general a lower microbial level was observed in our plants under salinity as the storage period was increased. It has been reported that plants grown in soils contained a higher level of microorganisms than plants grown in hydroponics (Selma et al., 2012). Also, water irrigation during production was evaluated as a major potential risk for microbial baby leaf contamination (Suslow,

2009; Pachepsky et al., 2011). In this sense, the use of halophyte plants as *C.maritimum* growing in floating systems under salinity could represent an advantage.

5.2 Experiment 2: Effect of MeJa in Salt-Stressed *C. maritimum* Plants

Since salinity has an important problem that prevents the growth and development of plants, scientific studies have been conducted on this subject (Yoon et al., 200). Although halophytes have developed different strategies to cope with salt stress (Ben Hamed et al., 2007; Ben Amor et al., 2005; Aslam et al., 2011), in our second experiment salinity reduced leaf biomass. These results are in consonance with previous reports, where *C.maritimum* plants irrigated with NaCl, from 100 to 500 mM NaCl, reduced their shoot fresh and dry weights (Hamed et al., 2004). Differences in the effect of NaCl on biomass regarding the first experiment could be due the fact that in the first experiment the total plant biomass (aerial part and root) was determined, whereas in the second experiment leaf biomass as edible part (aerial part) of the plant was considered. Therefore the sum of both shows no differences between Control and NaCl as the first experiment. In fact, root length, root area and root volume was significantly higher in NaCl-treated plants with regard the rest of treatments in the second experiment. In any case, MeJa addition recovered the adverse effect of salinity on biomass. It is known that MeJa alleviated the salt stress in glycophyte plants as rice (*Oryza sativa*) (Mahmud et al., 2016) and *B.napus* (Comparot et al., 2002), but less is known about the addition of MeJa under salinity in halophyte plants. In *Limonium bicolor,* exogenous 0,03 mM jasmonic acid (JA) improved plants biomass after 300 mM NaCl addition, demonstrating that the most revelant factor involved in plant growth and salt tolerance by MeJa, was net photosynthesis (Yuan et al., 2019). This could be the case of *C.maritimum* plants, but other mechanisms of MeJa for salt stress alleviation may operate and further research is needed. Considering the recent interest of this halophyte as traditional agri-food product, the increase of the edible part of the plants by MeJa under salinity resulted of great interest and visually the colour chlorophyll index (SPAD) plant acceptance was not modified by any of the treatments. It is well known that salinity may restrict the mineral uptake by the roots (Hamed et al., 2008). This was the case of several cations in our plants as Ca^{2+} and

K^+, demonstrating that limitation in the nutrient uptake may contribute to the general decrease in the leaf growth. Hamed et al. (Hamed et al., 200) found a gradual reduction of Ca^{2+} and K^+ ions with increasing salinity, being the decrase higher in leaves and stems compare to the root. However, nutrient decrase did not induce any necrosis or chorotic lesions in the leaves of our sea fennel plants and nutrient limitation may be due to an osmotic effect rather than a reduction in the root growth. MeJa recovered Ca^{2+} and K^+ ions levels in the leaves of the plants treated with salinity. It has been shown that MeJa may induce root hydraulic conductance in maize (Battal et al., 2008) and tomato plants (Sánchez-Romera et al., 2014) and therefore a higher water uptake may result in higher Ca^{2+} and K^+ uptake and translocation. In carrots plants, MeJa induced changes improving mineral balance under salt stress through a reduction in the Na^+ and Cl^- accumulation (Smoleń et al., 2020). However, in our plants, Na^+ and Cl^- content were similar in the leaves of NaCl and MeJa+NaCl treated plants indicating the importance of the genotype on the effect of MeJa in saline ions uptake. As a facultative halophyte, *C.maritimum* may tolerate Na^+ and Cl^- concentrations that could be compartimentalized in the vacuole (Aslam et al., 2011). In fact, in a glycophyte as tomato, a higher Cl^- content induced the reduction of nitrate uptake (Manaa et al., 2011). In sea fenel plants the levels of NO_3^- were similar in all treatments, indicating the lack of toxicity of Cl^- regarding NO_3^- translocation, but NaCl reduced NO_2^- content. MeJa addition restored the level of NO_2^- as well as increased NH_4^+ concentrations regarding Con1 and Con2 plants. This effect of MeJa was describe previously for *Vaccinium myrtillus* L. plants, where MeJa up-regulated genes involved on nitrite transport and metabolism (Benevenuto et al., 2019). There is a lack of literature of the effect of MeJa on halophytes and to our best of knowledge any report concerning to the combined effect of MeJa to salinity on *C.maritimum*, but a similar up-regulation by MeJa on the genes involved in nitrogen metabolism could operate. In any case, the level of nitrate ions are lower than other baby leaf crops as lettuce (from 700 to 1264 mg Kg-1FW), spinach (from 700 to 2013 mg Kg-1FW), kale (from 600 to 1181 mg Kg-1FW) and chard (from 900 to 1024 mg Kg-1FW) (Brkić et al., 2017). Similarly, low levels of nitrite were detected with regard lettuce and spinach (up to 197.5 mg kg^{-1}) (Iammarino et al., 2014). Acceptable daily intake (ADI) for nitrate determined by the Scientific Committee on Food (SCF) was 0 to 3.7 mg/kg body weight/day, this means that if

the average adult daily consumes approximately 400 g of various vegetables, the intake of nitrate is around 222.0 mg/day (FAO/WHO 2013). In this sense, the consume of 100 gr of *C.maritimum* baby leaf plants did not reach the ADI for nitrate and nitrite. A high content of phenolic compounds has been described in the aerial part of *C.maritimum* plants compared to other crops (Atia et al., 2011). A range from 200 to 700 GAE mg Kg^{-1} FW of total phenolic compounds was detected in lettuce under diffent LEDs light conditions (Son and Oh, 2013). Other vegetables as caraway (770 GAE mg Kg^{-1} FW), Chives (567 GAE mg Kg^{-1} FW), Cowpea (717 GAE mg Kg^{-1} FW), Packchoi (820 GAE mg Kg^{-1} FW) and Perilla leaf (687 GAE mg Kg^{-1} FW) showed lower levels of total phenolic compounds than *C.maritimum* plants grown in floating systems (Deng et al., 2013). Thus, although both saline treatments, NaCl and MeJa + NaCl decreased the content of total phenolic compounds regarding Con 1 and Con2 the plant maintained its nutritional properties under all treatments. A scientific study on Sweet basil (*Ocimum Basilicum* L.) was indicatived of MeJa alleviating the effects of salinity stress on phenolic compound (Kim et al., 2006; Li et al., 2018). The effect of salinity stress on chlorophyll a, chlorophyll b and carotenoid values was no effect much with MeJa application**.** A similar situation has been observed in the scientific study on maize (*Zea maize* L.) (Abdelgawad et al., 2014). In the present experiment, *C.maritimum* showed a good ability to tolerate elevated NaCl concentrations with chlorophyll concentration remaining unchanged with respect to controls. Although NaCl and MeJa increased the flavonoid content, the maximum level was reached with NaCl-MeJa application. A similar report on balackberries *(Rubus sp.)* supported this situation (Wang et al., 2008). The results of our research have shown that the phytochemical content of vegetables can be enriched with MeJa (Ahmadi et al., 2018; Manan et al., 2016).

6. CONCLUSIONS

In conclusion, hydroponic floating systems was an adequate cultivation system that allows *C.maritimum* plants to grow as a new baby leaf product. NaCl had no effect on *C. maritimum* whole-plant growth but decreased the aerial part of the plant while increase root length and surface, pointing out the facultavtive character of this halophyte and 150 mM NaCl a thereshold salnity concentration affecting plant growth.

In spite of the edible part reduction, NaCl did not affect acceptance of the product and enhanced the shelf life of *C. maritimum* baby by reducing the number of microorganisms during storage time.

MeJa was considered for the alleviation of NaCl effects on plant growth. Thus, MeJa addition increased the biomass of the edible parts regarding the only NaCl treatment. Also, while NaCl restricted minerals that K^+, Ca^+, Mg^+, NO_3^- and SO_4^{2-} from the roots, MeJa addition recovered Ca^+ and K^+ ion content, but it did not restrict leaf Na^+ and Cl^- accumulation. This recovering in ion balance increased the tolerance of plants to 150 mM NaCl salt stress.

Regarding nitrite and nitrate content, consumption of 100 gr of *C. maritimum* plants did not reach the ADI (0 to 3.7 mg/kg body weight/day), making them suitable vegetables as new foodstuff.

NaCl-treatments decreased total phenolic content regarding control, but *C. maritimum* increased their flavonoids content and carotenoids under combined NaCl and Meja treatments. In any case, the amount of phenolics was optimal for consume consideration of these plants.

Therefore, the addition of MeJa to NaCl-treated *C.maritimum* has to be considered in this vegetable production, since MeJa addition to saline plants exert a recovery of edible part growth, minerals and flavonoids content.

REFERENCES

Abdelgawad, Z. A., Khalafaallah, A. A. and Abdallah, M. M., 2014, Impact of Methyl Jasmonate on Antioxidant Activity and Some Biochemical Aspects of Maize Plant Grown under Water Stress Condition. *Agric. Sci., 05* (12), 1077–1088. https://doi.org/10.4236/as.2014.512117.

Ahmadi, F. I., Karimi, K. and Struik, P. C., 2018, Effect of Exogenous Application of Methyl Jasmonate on Physiological and Biochemical Characteristics of Brassica Napus L. Cv. Talaye under Salinity Stress. *South African J. Bot., 115*, 5–11. https://doi.org/10.1016/j.sajb.2017.11.018.

Aires, A., Carvalho, R., Rosa, E. A. S. and Saavedra, M. J., 2013, Phytochemical Characterization and Antioxidant Properties of Baby-Leaf Watercress Produced under Organic Production System. *CYTA - J. Food, 11* (4), 343–351. https://doi.org/10.1080/19476337.2013.769025.

Aires, A., Marques, E., Carvalho, R., Rosa, E. A. S. and Saavedra, M. J., 2013, Evaluation of Biological Value and Appraisal of Polyphenols and Glucosinolates from Organic Baby-Leaf Salads as Antioxidants and Antimicrobials against Important Human Pathogenic Bacteria. *Molecules, 18* (4), 4651–4668. https://doi.org/10.3390/molecules18044651.

Allende, A. and Monaghan, J., 2015, Irrigation Water Quality for Leafy Crops: A Perspective of Risks and Potential Solutions. *Int. J. Environ. Res. Public Health, 12* (7), 7457–7477. https://doi.org/10.3390/ijerph120707457.

Asgharipour, M. R. and Rafiei, M., 2011, Effect of Salinity on Germination and Seedling Growth of Lentils. *Aust. J. Basic Appl. Sci., 5* (11), 2002–2004.

Aslam, R., Bostan, N., Nabgha e Amen, Maria, M. and Safdar, W. A., 2011, Critical Review on Halophytes: Salt Tolerant Plants. *J. Med. Plant Res., 5* (33), 7108–7118. https://doi.org/10.5897/JMPRx11.009.

Atia, A., Barhoumi, Z., Mokded, R., Abdelly, C. and Smaoui, A., 2011, Environmental Eco-Physiology and Economical Potential of the Halophyte Crithmum maritimum L. (Apiaceae). *J. Med. Plants Res., 5* (16), 3564–3571.

REFERENCES (continued)

Atia, A., Chokri, H., Mokded, R., Barhoumi, Z., Abdelly, C. and Smaoui, A., 2011, Anatomy of the Fruit of the Halophyte Crithmum maritimum l. with Emphasis on the Endosperm Structure and Histochemistry. *African J. Biotechnol.*, *10* (45), 9193–9199. https://doi.org/10.5897/ajb11.637.

Atia, A., Debez, A., Abdelly, C. and Smaoui, A., 2010, Relationship Between Ion Content in Seed and Spongy Coat of the Medicinal Halophyte Crithmum maritimum L. and Germination Capacity. *Not. Sci. Biol.*, *2* (2), 72–74. https://doi.org/10.15835/nsb224608.

Atia, A., Debez, A., Barhoumi, Z., Abdelly, C. and Smaoui, A., 2009, Histochemical Localization of Essential Oils and Bioactive Substances in the Seed Coat of the Halophyte Crithmum maritimum L. (Apiaceae). *J. Plant Biol.*, *52* (5), 448–452. https://doi.org/10.1007/s12374-009-9057-3.

Atia, A., Debez, A., Barhoumi, Z., Pacini, E., Abdelly, C. and Smaoui, A., 2010, The Mericarp of the Halophyte Crithmum maritimum (Apiaceae): Structural Features, Germination, and Salt Distribution. *Biologia (Bratisl).*, *65* (3), 489–495. https://doi.org/10.2478/s11756-010-0036-4.

Atikah, T. A. and Widyawati, W., 2019, The Growth and Yield of Four Varieties of Lettuce (Lactuca Sativa. L) in Different Planting Media. *EurAsian J. Biosci.*, *2091* (October), 2085–2091.

Atzori, G., de Vos, A. C., van Rijsselberghe, M., Vignolini, P., Rozema, J., Mancuso, S. and van Bodegom, P. M., 2017, Effects of Increased Seawater Salinity Irrigation on Growth and Quality of the Edible Halophyte Mesembryanthemum Crystallinum L. under Field Conditions. *Agric. Water Manag.*, *187* (November), 37–46. https://doi.org/10.1016/j.agwat.2017.03.020.

Baenas, N., Villaño, D., García-Viguera, C. and Moreno, D. A., 2016, Optimizing Elicitation and Seed Priming to Enrich Broccoli and Radish Sprouts in Glucosinolates. *Food Chem.*, *204*, 314–319. https://doi.org/10.1016/j.foodchem.2016.02.144.

REFERENCES (continued)

Battal, P., Erez, M. E., Turker, M. and Berber, I., 2008, Molecular and Physiological Changes in Maize (Zea Mays) Induced by Exogenous NAA, ABA and MeJa during Cold Stress. *Ann. Bot. Fenn.*, *45* (3), 173–185. https://doi.org/10.5735/085.045.0302.

Ben Amor, N., Ben Hamed, K., Debez, A., Grignon, C. and Abdelly, C., 2005, Physiological and Antioxidant Responses of the Perennial Halophyte Crithmum maritimum to Salinity. *Plant Sci.*, *168* (4), 889–899. https://doi.org/10.1016/j.plantsci.2004.11.002.

Ben Hamed, K., Castagna, A., Salem, E., Ranieri, A. and Abdelly, C., 2007, Sea Fennel (*Crithmum maritimum* L.) under Salinity Conditions: A Comparison of Leaf and Root Antioxidant Responses. *Plant Growth Regul.*, *53* (3), 185–194. https://doi.org/10.1007/s10725-007-9217-8.

Benevenuto, R. F., Seldal, T., Hegland, S. J., Rodriguez-Saona, C., Kawash, J. and Polashock, J., 2019, Transcriptional Profiling of Methyl Jasmonate-Induced Defense Responses in Bilberry (Vaccinium Myrtillus L.). *BMC Plant Biol.*, *19* (1), 1–18. https://doi.org/10.1186/s12870-019-1650-0.

Ben-Yehoshua, S. and Rodov, V., 2002, Transpiration and Water Stress. *Postharvest Physiol. Pathol. Veg.*, No. 1982. https://doi.org/10.1201/9780203910092.ch5.

Bonasia, A., Lazzizera, C., Elia, A. and Conversa, G., 2017, Nutritional, Biophysical and Physiological Characteristics of Wild Rocket Genotypes as Affected by Soilless Cultivation System, Salinity Level of Nutrient Solution and Growing Period. *Front. Plant Sci.*, *8* (March). https://doi.org/10.3389/fpls.2017.00300.

Boscaiu, M., Donat, P., Llinares, J. and Vicente, O., 2012, Stress-Tolerant Wild Plants: A Source of Knowledge and Biotechnological Tools for the Genetic Improvement of Stress Tolerance in Crop Plants. *Not. Bot. Horti Agrobot. Cluj-Napoca*, *40* (2), 323–327. https://doi.org/10.15835/nbha4028199.

REFERENCES (continued)

Brkić, D., Bošnir, J., Bevardi, M., Bošković, A. G., Miloš, S., Lasić, D., Krivohlavek, A., Racz, A., Ćuić, A. M. and Trstenjak, N. U., 2017**,** Nitrate in Leafy Green Vegetables and Estimated Intake, Afr J Tradit Complement Altern Med ., (2017) 14 (3): 31-41.

Campoy, D. N., 2015, Effects of Aeration of the Nutrient Solution and Applicationof PGPR on the Production and Quality of Baby Leaf Vegetables Grown in Floating System. Unıversıdad Polıtécnıca De Cartagena Departamento de Producción Vegetal, 1–168.

Carlsen, M. H., Halvorsen, B. L., Holte, K., Bøhn, S. K., Dragland, S., Sampson, L., Willey, C., Senoo, H., Umezono, Y., Sanada, C. et al., 2010, The Total Antioxidant Content of More than 3100 Foods, Beverages, Spices, Herbs and Supplements Used Worldwide. *Nutr. J.*, *9* (1), 1–11. https://doi.org/10.1186/1475-2891-9-3.

Cerozi, B. da S. and Fitzsimmons, K., 2016, The Effect of PH on Phosphorus Availability and Speciation in an Aquaponics Nutrient Solution. *Bioresour. Technol.*, *219*, 778–781. https://doi.org/10.1016/j.biortech.2016.08.079.

Chen, C., Wang, C., Liu, Z., Liu, X., Zou, L., Shi, J., Chen, S., Chen, J. and Tan, M., 2018, Variations in Physiology and Multiple Bioactive Constituents under Salt Stress Provide Insight into the Quality Evaluation of Apocyni Veneti Folium. *Int. J. Mol. Sci.*, *19* (10), 1–16. https://doi.org/10.3390/ijms19103042.

Chen, Z., Han, Y., Ning, K., Luo, C., Sheng, W., Wang, S., Fan, S., Wang, Y. and Wang, Q., 2019, Assessing the Performance of Different Irrigation Systems on Lettuce (Lactuca Sativa L.) in the Greenhouse. *PLoS One*, *14* (2), 1–18. https://doi.org/10.1371/journal.pone.0209329.

Cheong, J. J. and Choi, Y. Do., 2003, Methyl Jasmonate as a Vital Substance in Plants. *Trends Genet.*, *19* (7), 409–413. https://doi.org/10.1016/S0168-9525(03)00138-0.

REFERENCES (continued)

Cheryl, K. and Matt, E., 2017, Baby Vegetables. CCD-CP-86. Lexington, KY: Center for Crop Diversification, University of Kentucky College of Agriculture, Food and Environment. Available: http://www.uky.edu/ccd/sites/www.uky.edu.ccd/files/ babyveggies.pdf .

Chun, C. and Takakura, T., 1994, Original Paper Rate under of Root Respiration Oxygen of Lettuce Concentrations Various Dissolved in Hydroponics. *Environ. Control Bio*, *32* (2), 125–135.

Comparot, S. M., Graham, C. M. and Reid, D. M., 2002, Methyl Jasmonate Elicits a Differential Antioxidant Response in Light- and Dark-Grown Canola (Brassica Napus) Roots and Shoots. *Plant Growth Regul.*, *38* (1), 21–30. https://doi.org/10.1023/A:1020970319190.

Creelman, R. A. and Mulpuri, R., 2002, The Oxylipin Pathway in Arabidopsis. *Arab. B.*, *1* (1), e0012. https://doi.org/10.1199/tab.0012.

Cuvelier, M. E. and Berset, C., 1995, 4A Standard Calibration Techniques. *Microflown E-b.*, *28*, 25–30.

D'Imperio, M., Renna, M., Cardinali, A., Buttaro, D., Serio, F. and Santamaria, P., 2016, Calcium Biofortification and Bioaccessibility in Soilless "Baby Leaf" Vegetable Production. *Food Chem. 213*, 149–156. https://doi.org/10.1016/j.foodchem.2016.06.071.

De Rijck, G. and Schrevens, E., 1997, PH Influenced by the Elemental Composition of Nutrient Solutions. *J. Plant Nutr.*, *20* (7–8), 911–923. https://doi.org/10.1080/01904169709365305.

Deng, G. F., Lin, X., Xu, X. R., Gao, L. L., Xie, J. F. and Li, H., 2013, Bin. Antioxidant Capacities and Total Phenolic Contents of 56 Vegetables. *J. Funct. Foods* **2013**, *5* (1), 260–266. https://doi.org/10.1016/j.jff.2012.10.015.

Ding, H., Lai, J., Wu, Q., Zhang, S., Chen, L., Dai, Y. S., Wang, C., Du, J., Xiao, S. and Yang, C., 2016, Jasmonate Complements the Function of Arabidopsis Lipoxygenase3 in Salinity Stress Response. *Plant Sci.*, *244*, 1–7. https://doi.org/10.1016/j.plantsci.2015.11.009.

REFERENCES (continued)

Ellouzi, H., Hamed, K. Ben, Hernández, I., Cela, J., Müller, M., Magné, C., Abdelly, C. and Munné-Bosch, S. A, 2014, Comparative Study of the Early Osmotic, Ionic, Redox and Hormonal Signaling Response in Leaves and Roots of Two Halophytes and a Glycophyte to Salinity. *Planta*, *240* (6), 1299–1317. https://doi.org/10.1007/s00425-014-2154-7.

Faghih, S., Ghobadi, C. and Zarei, A., 2017, Response of Strawberry Plant Cv. 'Camarosa' to Salicylic Acid and Methyl Jasmonate Application Under Salt Stress Condition. *J. Plant Growth Regul.*, *36* (3), 651–659. https://doi.org/10.1007/s00344-017-9666-x.

Franke, W., 1982, Vitamin C in Sea Fennel (Crithmum maritimum), an Edible Wild Plant. *Econ. Bot.*, *36* (2), 163–165. https://doi.org/10.1007/BF02858711.

Fallovo, C., Rouphael, Y., Rea, E., Battistelli, A. and Colla, G., 2009, Nutrient Solution Concentration and Growing Season Affect Yield and Quality of Lactuca Sativa L. Var. Acephala in Floating Raft Culture. *J. Sci. Food Agric.*, *89* (10), 1682–1689. https://doi.org/10.1002/jsfa.3641.

Gago, C., Sousa, A. R., Juliao, M., Miguel, G. and Antunes, D. C., 2011, Sustainable Use of Energy in the Storage of Halophytes Used for Food. *Int. J. Energy Environ.*, *5* (4), 592–599.

Generalić Mekinić, I., Šimat, V., Ljubenkov, I., Burčul, F., Grga, M., Mihajlovski, M., Lončar, R., Katalinić, V. and Skroza, D., 2018, Influence of the Vegetation Period on Sea Fennel, *Crithmum maritimum* L. (Apiaceae), Phenolic Composition, Antioxidant and Anticholinesterase Activities. *Ind. Crops Prod.*, *124* (September), 947–953. https://doi.org/10.1016/j.indcrop.2018.08.080.

Gil, M. I., Selma, M. V., Suslow, T., Jacxsens, L., Uyttendaele, M. and Allende, A., 2015, Pre- and Postharvest Preventive Measures and Intervention Strategies to Control Microbial Food Safety Hazards of Fresh Leafy Vegetables. *Crit. Rev. Food Sci. Nutr.*, *55* (4), 453–468. https://doi.org/10.1080/10408398.2012.657808.

REFERENCES (continued)

Gil, M. I., Tudela, J. A., Martínez-Sánchez, A. and Luna, M. C., 2012, Harvest Maturity Indicators of Leafy Vegetables. *Stewart Postharvest Rev. 8* (1), 1–9. https://doi.org/10.2212/spr.2012.1.2.

Giuffrida, F., Agnello, M., Mauro, R. P., Ferrante, A. and Leonardi, C., 2018, Cultivation under Salt Stress Conditions Influences Postharvest Quality and Glucosinolates Content of Fresh-Cut Cauliflower. *Sci. Hortic. (Amsterdam).*, *236* (March), 166–174. https://doi.org/10.1016/j.scienta.2018.03.049.

Giménez, A., Fernández, J. A., Pascual, J. A., Ros, M., López-Serrano, M. and Egea-Gilabert, C., 2019, An Agroindustrial Compost as Alternative to Peat for Production of Baby Leaf Red Lettuce in a Floating System. *Sci. Hortic. (Amsterdam).*, *246* (June 2018), 907–915. https://doi.org/10.1016/j.scienta.2018.11.080.

Gonnella, M., Serio, F., Conversa, G. and Santamaria, P., 2003, Yield and Quality of Lettuce Grown in Floating System Using Different Sowing Density and Plant Spatial Arrangements. *Acta Hortic.*, *614* (November 2014), 687–692. https://doi.org/10.17660/ActaHortic.2003.614.102.

Gonnella, M., Serio, F., Conversa, G. and Santamaria, P., 2003, Yield and Quality of Lettuce Grown in Floating System Using Different Sowing Density and Plant Spatial Arrangements. *Acta Hortic.*, *614* (September), 687–692. https://doi.org/10.17660/ActaHortic.2003.614.102.

Grahn, C. M., Benedict, C., Thornton, T. and Miles, C., 2015, Production of Baby-Leaf Salad Greens in the Spring and Fall Seasons of Northwest Washington. *HortScience* **2015**, *50* (10), 1467–1471. https://doi.org/10.21273/hortsci.50.10.1467.

Guijarro-Real, C., Adalid-Martínez, A. M., Gregori-Montaner, A., Prohens, J., Rodríguez-Burruezo, A. and Fita, A., 2020, Factors Affecting Germination of Diplotaxis Erucoides and Their Effect on Selected Quality Properties of the Germinated Products. *Sci. Hortic. (Amsterdam).*, *261* (June 2019), 109013. https://doi.org/10.1016/j.scienta.2019.109013.

REFERENCES (continued)

Guil Guerrero, J. L., Giménez Martínez, J. J. and Torija Isasa, M. E., 1998, Mineral Nutrient Composition of Edible Wild Plants. *J. Food Compos. Anal.*, *11* (4), 322–328. https://doi.org/10.1006/jfca.1998.0594.

Hall, M. K. D., Jobling, J. J. and Rogers, G. S., 2015, Effect of Nitrogen Supply and Storage Temperature on Vitamin C in Two Species of Baby Leaf Rocket, and the Potential of These Crops for a Nutrient Claim in Australia. *J. Plant Nutr*. *38* (2), 246–259. https://doi.org/10.1080/01904167.2013.873465.

Hamdani, F., Derridj, A. and Rogers, H. J., 2017, Diverse Salinity Responses in Crithmum maritimum Tissues at Different Salinities over Time. *J. Soil Sci. Plant Nutr.*, *17* (3), 716–734. https://doi.org/10.4067/S0718-95162017000300013.

Hamed, K. Ben, Biotechnologie, C. De, Messedi, D., Biotechnologie, C. De, Ranieri, A. and Abdelly, C., 2008, Biotechnologie, C. De. Biosaline Agriculture and High Salinity Tolerance. *Biosaline Agric. High Salin. Toler.* No. January 2016. https://doi.org/10.1007/978-3-7643-8554-5.

Hamed, K., Ben; Debez, A., Chibani, F. and Abdelly, C., 2004, Salt Response of Crithmum maritimum, an Oleagineous Halophyte. *Trop. Ecol.*, *45* (1 SPEC. ISS.), 151–159.

Hasanuzzaman, M., Nahar, K., Alam, M. M., Bhowmik, P. C., Hossain, M. A., Rahman, M. M., Prasad, M. N. V., Ozturk, M. and Fujita, M., 2014, Potential Use of Halophytes to Remediate Saline Soils. *Biomed Res. Int.*, *2014*. https://doi.org/10.1155/2014/589341.

Hayes, R. J., Trent, M. A., Mou, B., Simko, I., Gebben, S. J. and Bull, C. T., 2014, Baby Leaf Lettuce Germplasm Enhancement: Developing Diverse Populations with Resistance to Bacterial Leaf Spot Caused by Xanthomonas Campestris Pv. Vitians. *HortScience*, *49* (1), 18–24. https://doi.org/10.21273/hortsci.49.1.18.

Iammarino, M., Di Taranto, A. and Cristino, M., 2014, Monitoring of Nitrites and Nitrates Levels in Leafy Vegetables (Spinach and Lettuce): A Contribution to Risk Assessment. *J. Sci. Food Agric.*, *94* (4), 773–778. https://doi.org/10.1002/jsfa.6439.

REFERENCES (continued)

Iulia-Adriana, M. and Maria, B., 2015, Analysis of Aquaponic Organic Hydroponics from the Perspective of Setting Costs and of Maintenance on Substratum and Floating Shelves Systems. *For. Biotechnol.*, *19* (3), 73–76.

Jallali, I., Megdiche, W., M'Hamdi, B., Oueslati, S., Smaoui, A., Abdelly, C. and Ksouri, R., 2012, Changes in Phenolic Composition and Antioxidant Activities of the Edible Halophyte Crithmum maritimum L. With Physiological Stage and Extraction Method. *Acta Physiol. Plant.*, *34* (4), 1451–1459. https://doi.org/10.1007/s11738-012-0943-9.

Kandel, S. L., Mou, B., Shishkoff, N., Shi, A., Subbarao, K. V. and Klosterman, S. J., 2019, Spinach Downy Mildew: Advances in Our Understanding of the Disease Cycle and Prospects for Disease Management. *Plant Dis.*, *103* (5), 791–803. https://doi.org/10.1094/PDIS-10-18-1720-FE.

Kılıç, C. C. and Duyar, H. A., 2016, Research on Production of Baby Leaf Vegetables in Floating System. *Hungarian Agric. Eng.*, *7410* (29), 24–27. https://doi.org/10.17676/hae.2016.29.24.

Kianersi, F., Abdollahi, M. R., Mirzaie-asl, A., Dastan, D. and Rasheed, F., 2020, Identification and Tissue-Specific Expression of Rutin Biosynthetic Pathway Genes in Capparis Spinosa Elicited with Salicylic Acid and Methyl Jasmonate. *Sci. Rep.*, *10* (1), 1–15. https://doi.org/10.1038/s41598-020-65815-2.

Kianersi, F., Abdollahi, M. R., Mirzaie-asl, A., Dastan, D. and Rasheed, F., 2020, Biosynthesis of Rutin Changes in Capparis Spinosa Due to Altered Expression of Its Pathway Genes under Elicitors' Supplementation. *Plant Cell. Tissue Organ Cult.*, *141* (3), 619–631. https://doi.org/10.1007/s11240-020-01823-4.

Kim, H. J., Chen, F., Wang, X. and Rajapakse, N. C., 2006, Effect of Methyl Jasmonate on Secondary Metabolites of Sweet Basil (Ocimum Basilicum L.). *J. Agric. Food Chem.*, *54* (6), 2327–2332. https://doi.org/10.1021/jf051979g.

REFERENCES (continued)

Kittas, C., Katsoulas, N., Bartzanas, T. and Bakker, S., 2013, Greenhouse climate control and energy use. *Good Agricultural Practices for Greenhouse Vegetable Crops*: Principles for Mediterranean climate areas. E. Duffy, ed. (Rome, Italy: FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS), pp. 63-95.

Koike, S. T. and Henderson, D. M., 2001, Leaf Spot Disease of Spinach in California Caused by Stemphylium Botryosum. *Plant Dis.*, *85* (2), 126–130. https://doi.org/10.1094/PDIS.2001.85.2.126.

Kotsiras, A., Vlachodimitropoulou, A., Gerakaris, A., Bakas, N. and Darras, A. I., 2016, Innovative Harvest Practices of Butterhead, Lollo Rosso and Batavia Green Lettuce (Lactuca Sativa L.) Types Grown in Floating Hydroponic System to Maintain the Quality and Improve Storability. *Sci. Hortic. (Amsterdam).*, *201*, 1–9. https://doi.org/10.1016/j.scienta.2016.01.021.

Ksouri, R., Ksouri, W. M., Jallali, I., Debez, A., Magné, C., Hiroko, I. and Abdelly, C., 2012, Medicinal Halophytes: Potent Source of Health Promoting Biomolecules with Medical, Nutraceutical and Food Applications. *Crit. Rev. Biotechnol.*, *32* (4), 289–326. https://doi.org/10.3109/07388551.2011.630647.

Lara, L. J., Egea-Gilabert, C., Niñirola, D., Conesa, E. and Fernández, J. A., 2011, Effect of Aeration of the Nutrient Solution on the Growth and Quality of Purslane (Portulaca Oleracea). *J. Hortic. Sci. Biotechnol.*, *86* (6), 603–610. https://doi.org/10.1080/14620316.2011.11512810.

Lee, S. and Lee, J., 2015, Beneficial Bacteria and Fungi in Hydroponic Systems: Types and Characteristics of Hydroponic Food Production Methods. *Sci. Hortic. (Amsterdam).*, *195*, 206–215. https://doi.org/10.1016/j.scienta.2015.09.011.

Lenzi, A., Baldi, A. and Tesi, R., 2011, Growing Spinach in a Floating System with Different Volumes of Aerated or Non Aerated Nutrient Solution. *Adv. Hortic. Sci.*, *25* (1), 21–25. https://doi.org/10.13128/ahs-12780.

REFERENCES (continued)

Lenzi, A., Orlandini, A., Bulgari, R., Ferrante, A. and Bruschi, P., 2019, Antioxidant and Mineral Composition of Three Wild Leafy Species: A Comparison between Microgreens and Baby Greens. *Foods, 8* (10). https://doi.org/10.3390/foods8100487.

Li, C., Wang, P., Menzies, N. W., Lombi, E. and Kopittke, P. M., 2018, Effects of Methyl Jasmonate on Plant Growth and Leaf Properties. *J. Plant Nutr. Soil Sci., 181* (3), 409–418. https://doi.org/10.1002/jpln.201700373.

Lichtenthaler, H. K. and Buschmann, C., 2001, Chlorophylls and Carotenoids: Measurement and Characterization by UV-VIS Spectroscopy. *Curr. Protoc. Food Anal. Chem., 1* (1), F4.3.1-F4.3.8. https://doi.org/10.1002/0471142913.faf0403s01.

Loconsole, D., Cristiano, G. and De Lucia, B., 2019, Glassworts: From Wild Salt Marsh Species to Sustainable Edible Crops. *Agric., 9* (1). https://doi.org/10.3390/agriculture9010014.

López-Gálvez, F., Ragaert, P., Haque, M. A., Eriksson, M., van Labeke, M. C. and Devlieghere, F., 2015, High Oxygen Atmospheres Can Induce Russet Spotting Development in Minimally Processed Iceberg Lettuce. *Postharvest Biol. Technol., 100*, 168–175. https://doi.org/10.1016/j.postharvbio.2014.10.001.

Mahmud, S., Sharmin, S., Chowdhury, B. L. Das, Hossain, M. A. and Bhuiyan, M. J. H., 2016, Mitigation of Salt Stress in Rice Plant at Germination Stage by Using Methyl Jasmonate. *Asian J. Med. Biol. Res., 2* (1), 74–81. https://doi.org/10.3329/ajmbr.v2i1.27572.

Maleš, Ž., Žuntar, I., Nigović, B., Plazibat, M. and Vundać, V. B., 2003, Quantitative Analysis of the Polyphenols of the Aerial Parts of Rock Samphire - Crithmum maritimum L. *Acta Pharm., 53* (2), 139–144.

Manaa, A., Ben Ahmed, H., Valot, B., Bouchet, J. P., Aschi-Smiti, S., Causse, M. and Faurobert, M., 2011, Salt and Genotype Impact on Plant Physiology and Root Proteome Variations in Tomato. *J. Exp. Bot., 62* (8), 2797–2813. https://doi.org/10.1093/jxb/erq460.

REFERENCES (continued)

Manan, A., Ayyub, C. M., Pervez, M. A. and Ahmad, R., 2016, Methyl Jasmonate Brings about Resistance against Salinity Stressed Tomato Plants by Altering Biochemical and Physiological Processes. *Pakistan J. Agric. Sci.*, *53* (1), 35–41. https://doi.org/10.21162/PAKJAS/16.4441.

Manuela, J. and Santos, S., 2014, Minimally Processed Baby Leaf Vegetables: Phytonutrient Characterization and Nutritional Stability. Faculdade de Pharmacia Universidade De Porto for Doctor Degree in Pharmaceutical Sciences - Nutrition and Food Science Specialty . Submitted.

Martínez-Ballesta, M. C., López-Pérez, L., Hernández, M., López-Berenguer, C., Fernández-García, N. and Carvajal, M., 2008, Agricultural Practices for Enhanced Human Health. *Phytochem. Rev.*, *7* (2), 251–260. https://doi.org/10.1007/s11101-007-9071-3.

Martínez-Sánchez, A., Luna, M. C., Selma, M. V., Tudela, J. A., Abad, J. and Gil, M. I., 2012, Baby-Leaf and Multi-Leaf of Green and Red Lettuces Are Suitable Raw Materials for the Fresh-Cut Industry. *Postharvest Biol. Technol.*, *63* (1), 1–10. https://doi.org/10.1016/j.postharvbio.2011.07.010.

Meot-Duros, L. and Magné, C., 2008, Effect of Salinity and Chemical Factors on Se(1) Meot-Duros, L.; Magné, C. Effect of Salinity and Chemical Factors on Seed Germination in the Halophyte Crithmum maritimum L. Plant Soil 2008, 313 (1–2), 83–87. Https://Doi.Org/10.1007/S11104-008-9681-6.Ed G. *Plant Soil*, *313* (1–2), 83–87. https://doi.org/10.1007/s11104-008-9681-6.

Meot-Duros, L. and Magné, C., 2009, Antioxidant Activity and Phenol Content of Crithmum maritimum L. Leaves. *Plant Physiol. Biochem.*, *47* (1), 37–41. https://doi.org/10.1016/j.plaphy.2008.09.006.

Meot-Duros, L., Cérantola, S., Talarmin, H., Le Meur, C., Le Floch, G. and Magné, C., 2010, New Antibacterial and Cytotoxic Activities of Falcarindiol Isolated in Crithmum maritimum L. Leaf Extract. *Food Chem. Toxicol.*, *48* (2), 553–557. https://doi.org/10.1016/j.fct.2009.11.031.

REFERENCES (continued)

Mola, I. Di, Ottaiano, L., Cozzolino, E., Senatore, M., Giordano, M., El-nakhel, C., Sacco, A., Rouphael, Y. and Colla, G., 2019, Plant-Based Biostimulants Influence the Agronomical, Physiological , and Qualitative Responses of Baby Rocket Leaves under Diverse Nitrogen Conditions.Plants 8,522. 1–15. doi:10.3390/plants8110522.

Montesano, F. F., D'Imperio, M., Parente, A., Cardinali, A., Renna, M. and Serio, F., 2016, Green Bean Biofortification for Si through Soilless Cultivation: Plant Response and Si Bioaccessibility in Pods. *Sci. Rep.*, *6* (July), 1–9. https://doi.org/10.1038/srep31662.

Montesano, F. F., Gattullo, C. E., Parente, A., Terzano, R. and Renna, M., 2018 Cultivation of Potted Sea Fennel, an Emerging Mediterranean Halophyte, Using a Renewable Seaweed-Based Material as a Peat Substitute. *Agric.*, *8* (7), 1–12. https://doi.org/10.3390/agriculture8070096.

Moraes, L. A., Calori, A. H., Factor, T. L., Patrício, F. R., Ghini, R., Abreu, M., F. and Purquerio, L. F., 2016, Baby Leaf Lettuce Production in Trays with Reused and Solarized Substrate. *Hortic. Bras.*, *34* (4), 463–469. https://doi.org/10.1590/s0102-053620160403.

Nabet, N., Boudries, H., Chougui, N., Loupassaki, S., Souagui, S., Burló, F., Hernández, F., Carbonell-Barrachina, Á. A., Madani, K. and Larbat, R., 2017, Biological Activities and Secondary Compound Composition from Crithmum maritimum Aerial Parts. *Int. J. Food Prop.*, *20* (8), 1843–1855. https://doi.org/10.1080/10942912.2016.1222541.

Nicoletto, C., Maucieri, C., Schmautz, Z., Borin, M., Sambo, P. and Junge, R., 2018, Babyleaf NFT Production and Water Management in Aquaponic System. *Acta Hortic.*, *1215*, 159–164. https://doi.org/10.17660/ActaHortic.2018.1215.30.

Niñirola, D., Fernández, J. A., Conesa, E., Martínez, J. A. and Egea-Gilabert, C., 2014, Combined Effects of Growth Cycle and Different Levels of Aeration in Nutrient Solution on Productivity, Quality, and Shelf Life of Watercress (Nasturtium Officinale R. Br.) Plants. *HortScience*, *49* (5), 567–573. https://doi.org/10.21273/hortsci.49.5.567.

REFERENCES (continued)

Özcan, M., Akgül, A., Başcr, K. H. C., Özck, T. and Tabanca, N., 2001, Essential Oil Composition of Sea Fennel (Crithmum maritimum) Form Turkey. *Nahrung - Food*, *45* (5), 353–356. https://doi.org/10.1002/1521-3803(20011001)45:5<353::AID-FOOD353>3.0.CO;2-4.

Öztekin, G. B., Uludağ, T., Tüzel, Y. and Tepecik, M., 2019, Turkish Journal of Agriculture - Food Science and Technology Effects of Different Nutrient Solutions on Yield and Quality Parameters of Rocket Grown in Floating Water Culture Farklı Besin Solüsyonlarının Yüzen Su Kültüründe Rokanın Verim ve Kalite Özellik, *7* (2), 258–265.

Pachepsky, Y., Shelton, D. R., McLain, J. E. T., Patel, J. and Mandrell, R. E., 2011, *Irrigation Waters as a Source of Pathogenic Microorganisms in Produce. A Review*, 1st ed.; Elsevier Inc.,; Vol. 113. https://doi.org/10.1016/B978-0-12-386473-4.00007-5.

Pandey, R., Jain, V. and Singh, K. P., 2009, Hydroponics Agriculture : Its Status, Scope and Limitations. *Researchgate.net*, No. January, 20–29.

Pardossi, A., Carmassi, G., Diara, C., Incrocci, L., Maggini, R., Massa, D., Pardossi, A., Carmassi, G., Diara, C., Incrocci, G. et al., 2011, Fertigation and Substrate Management in Closed Soilless Culture. Dipartimento di Biologia delle Piante Agrarie (DBPA) No. August, 63. http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.501.28&rep=rep1&type=pdf

Pardossi, A., Incrocci, L., Incrocci, G., Malorgio, F., Battista, P., Bacci, L., Rapi, B., Marzialetti, P., Hemming, J. and Balendonck, J., 2009, Root Zone Sensors for Irrigation Management in Intensive Agriculture. *Sensors*. MDPI *9* (4), 2809–2835.

Pauwelyn, E., Vanhouteghem, K., Cottyn, B., De Vos, P., Maes, M., Bleyaert, P. and Höfte, M., 2011, Epidemiology of Pseudomonas Cichorii, the Cause of Lettuce Midrib Rot. *J. Phytopathol.*, *159* (4), 298–305. https://doi.org/10.1111/j.1439-0434.2010.01764.x.

REFERENCES (continued)

Pereira, C. G., Barreira, L., da Rosa Neng, N., Nogueira, J. M. F., Marques, C., Santos, T. F., Varela, J. and Custódio, L., 2017, Searching for New Sources of Innovative Products for the Food Industry within Halophyte Aromatic Plants: In Vitro Antioxidant Activity and Phenolic and Mineral Contents of Infusions and Decoctions of Crithmum maritimum L. *Food Chem. Toxicol., 107*, 581–589. https://doi.org/10.1016/j.fct.2017.04.018.

Pérez-Balibrea, S., Moreno, D. A. and García-Viguera, C., 2011, Improving the Phytochemical Composition of Broccoli Sprouts by Elicitation. *Food Chem., 129* (1), 35–44. https://doi.org/10.1016/j.foodchem.2011.03.049.

Persley, D., and Gambley, C., 2010, Viruses in Vegetable Crops in Australia. Integrated Virüs Disease Management. The State of Queensland, Department of Employment, Economic Development and Innobvation.Agri-Science Queensland. Horticulture Australia Limited project VGO 7128-Integrated management of viral diseases in vegetables. https://www.soilwealth.com.au/imagesDB/news/35.Viruses-in-vegies.pdf.

Pests, I. K. and Vegetables, A., 2009, Vegenotes-AUSVEGVIC.11, 4.

Petropoulos, S., Karkanis, A., Fernandes, Â., Barros, L., Ferreira, I. C. F. R., Ntatsi, G., Petrotos, K., Lykas, C. and Khah, E., 2015, Chemical Composition and Yield of Six Genotypes of Common Purslane (Portulaca Oleracea L.): An Alternative Source of Omega-3 Fatty Acids. *Plant Foods Hum. Nutr., 70* (4), 420–426. https://doi.org/10.1007/s11130-015-0511-8.

Polit, U., 2013, Halophytic Crops for a Salinising World. *Bull. Univ. Agric. Sci. Vet. Med. Cluj-Napoca - Hortic., 70* (1), 1–9. https://doi.org/10.15835/buasvmcn-hort:9349.

Renna, M. and Gonnella, M., 2012, The Use of the Sea Fennel as a New Spice-Colorant in Culinary Preparations. *Int. J. Gastron. Food Sci., 1* (2), 111–115. https://doi.org/10.1016/j.ijgfs.2013.06.004.

Renna, M., 2018, Reviewing the Prospects of Sea Fennel (Crithmum maritimum L.) as Emerging Vegetable Crop. *Plants, 7* (4). https://doi.org/10.3390/plants7040092.

REFERENCES (continued)

Renna, M., Gonnella, M., Caretto, S., Mita, G. and Serio, F., 2017, Sea Fennel (*Crithmum maritimum* L.): From Underutilized Crop to New Dried Product for Food Use. *Genet. Resour. Crop Evol.*, *64* (1), 205–216. https://doi.org/10.1007/s10722-016-0472-2.

Ruberto, G., Baratta, M. T., Deans, S. G. and Dorman, H. J. D., 2000, Antioxidant and Antimicrobial Activity of Foeniculum Vulgare and Crithmum maritimum Essential Oils. *Planta Med.*, *66* (8), 687–693. https://doi.org/10.1055/s-2000-9773.

Saini, R. K., Ko, E. Y. and Keum, Y. S., 2017, *Minimally Processed Ready-to-Eat Baby-Leaf Vegetables: Production, Processing, Storage, Microbial Safety, and Nutritional Potential*;; Vol. 33. https://doi.org/10.1080/87559129.2016.1204614.

Salimi, F., Shekari, F. and Hamzei, J., 2016, Methyl Jasmonate Improves Salinity Resistance in German Chamomile (Matricaria Chamomilla L.) by Increasing Activity of Antioxidant Enzymes. *Acta Physiol. Plant.*, *38* (1), 1–14. https://doi.org/10.1007/s11738-015-2023-4.

Sánchez-Romera, B., Ruiz-Lozano, J. M., Li, G., Luu, D. T., Martínez-Ballesta, M. D. C., Carvajal, M., Zamarreño, A. M., García-Mina, J. M., Maurel, C. and Aroca, R., 2014, Enhancement of Root Hydraulic Conductivity by Methyl Jasmonate and the Role of Calcium and Abscisic Acid in This Process. *Plant, Cell Environ.*, *37* (4), 995–1008. https://doi.org/10.1111/pce.12214.

Santamaria, P., Gonnella, M., Elia, A., Parente, A. and Serio, F., 2001, Ways of Reducing Rocket Salad Nitrate Content. *Acta Hortic.*, *548* (March), 529–536. https://doi.org/10.17660/ActaHortic.2001.548.64.

Santos, J., Oliva-Teles, M. T., Delerue-Matos, C. and Oliveira, M. B. P. P., 2014, Multi-Elemental Analysis of Ready-to-Eat "Baby Leaf" Vegetables Using Microwave Digestion and High-Resolution Continuum Source Atomic Absorption Spectrometry. *Food Chem.*, *151*, 311–316. https://doi.org/10.1016/j.foodchem.2013.11.083.

REFERENCES (continued)

Selma, M. V., Luna, M. C., Martínez-Sánchez, A., Tudela, J. A., Beltrán, D., Baixauli, C. and Gil, M. I., 2012, Sensory Quality, Bioactive Constituents and Microbiological Quality of Green and Red Fresh-Cut Lettuces (Lactuca Sativa L.) Are Influenced by Soil and Soilless Agricultural Production Systems. *Postharvest Biol. Technol.*, *63* (1), 16–24. https://doi.org/10.1016/j.postharvbio.2011.08.002.

Sheikh, B. A., 2006, Hydroponics: Key to Sustain Agriculture in Water Stressed and Urban Environment. *Pakistan J. Agric. Agric. Eng. Vet. Sci.*, *22* (2), 53–57.

Singh, A., Dwivedi, P. and Padmanabh Dwivedi, C., 2018, Methyl-Jasmonate and Salicylic Acid as Potent Elicitors for Secondary Metabolite Production in Medicinal Plants: A Review. *J. Pharmacogn. Phytochem.*, *7* (1), 750–757.

Singleton, V. L. and Rossi, J. A. J., 1965, Colorimetry to Total Phenolics with Phosphomolybdic Acid Reagents. *Am. J. Enol. Vinic.*, *16* (48), 144–158.

Smoleń, S., Lukasiewicz, A., Klimek-Chodacka, M. and Baranski, R., 2020, Effect of Soil Salinity and Foliar Application of Jasmonic Acid on Mineral Balance of Carrot Plants Tolerant and Sensitive to Salt Stress. *Agronomy*, *10* (5). https://doi.org/10.3390/agronomy10050659.

Son, K. H. and Oh, M. M., 2013, Leaf Shape, Growth, and Antioxidant Phenolic Compounds of Two Lettuce Cultivars Grown under Various Combinations of Blue and Red Light-Emitting Diodes. *HortScience*, *48* (8), 988–995. https://doi.org/10.21273/hortsci.48.8.988.

Souid, A., Gabriele, M., Longo, V., Pucci, L., Bellani, L., Smaoui, A., Abdelly, C. and Ben Hamed, K., 2016, Salt Tolerance of the Halophyte Limonium Delicatulum Is More Associated with Antioxidant Enzyme Activities than Phenolic Compounds. *Funct. Plant Biol.*, *43* (7), 607–619. https://doi.org/10.1071/FP15284.

Sundriyal, M., Sundriyal, R. C. and Url, S., 2001, Wild Edible Plants of the Sikkim Himalaya : Nutritive Values of Selected Species. Econ Bot 55 (3), 377-390.

REFERENCES (continued)

Suslow, T. V, 2009, Ph, D. Produce Safety Project Issue Brief : Produce Safety Project Issue Brief : *Sci. York*, 1–17.

Talalay, P. and Fahey, J. W., 2001, Phytochemicals from Cruciferous Plants Protect against Cancer by Modulating Carcinogen Metabolism. *J. Nutr.*, *131* (11 SUPPL.), 3027–3033. https://doi.org/10.1093/jn/131.11.3027s.

Tarazona-Díaz, M. P., Viegas, J., Moldao-Martins, M. and Aguayo, E., 2011, Bioactive Compounds from Flesh and By-Product of Fresh-Cut Watermelon Cultivars. *J. Sci. Food Agric.*, *91* (5), 805–812. https://doi.org/10.1002/jsfa.4250.

Tesoriero, L., 2009, Integrated Management Strategies for Diseases and Pests of Asian Vegetables. Australian Government Rural Industries Research and Development Corporation, (RIRDC) Project Number: PRJ-000512. ISSN 1440-6845.

Tesoriero, L., Rajakulendran, V., Forsyth, L., Carrus, R., Collins, D., Brunton, V., Dang, H., Fong, C., Dimsey, R., Vujovic, S. and Zirnsak, L., 2009, Managing Diseases and Pests of Asian Vegetables. Australian Government - Rural Industries Research and Development Corporation (RIRDC). Publication No 09/136 RIRDC Project No. PRJ-000512 ISBN 1 74151 935 7. ISSN 1440-6845.

Tomás-Callejas, A., Martínez-Hernández, G. B., Artés, F. and Artés-Hernández, F., 2011, Neutral and Acidic Electrolyzed Water as Emergent Sanitizers for Fresh-Cut Mizuna Baby Leaves. *Postharvest Biol. Technol.*, *59* (3), 298–306. https://doi.org/10.1016/j.postharvbio.2010.09.013.

Tomasi, N., Pinton, R., Dalla Costa, L., Cortella, G., Terzano, R., Mimmo, T., Scampicchio, M. and Cesco, S., 2014, New "solutions" for Floating Cultivation System of Ready-to-Eat Salad: A Review. *Trends Food Sci. Technol.*, *46* (Part B), 267–276. https://doi.org/10.1016/j.tifs.2015.08.004.

University of Florida, I. E., 2015, Nutrient Management of Vegetable and Row Crops Handbook (SP500), (February), 199.

REFERENCES (continued)

Wagstaff, C., Clarkson, G. J. J., Rothwell, S. D., Page, A., Taylor, G. and Dixon, M. S., 2007, Characterisation of Cell Death in Bagged Baby Salad Leaves. *Postharvest Biol. Technol.*, *46* (2), 150–159. https://doi.org/10.1016/j.postharvbio.2007.04.013.

Walker, T. S., Pal Bais, H. and Vivanco, J. M., 2002, Jasmonic Acid-Induced Hypericin Production in Cell Suspension Cultures of Hypericum Perforatum L. (St. John's Wort). *Phytochemistry*, *60* (3), 289–293. https://doi.org/10.1016/S0031-9422(02)00074-2.

Wang, S. Y., Bowman, L. and Ding, M., 2008, Methyl Jasmonate Enhances Antioxidant Activity and Flavonoid Content in Blackberries (Rubus Sp.) and Promotes Antiproliferation of Human Cancer Cells. *Food Chem.*, *107* (3), 1261–1269. https://doi.org/10.1016/j.foodchem.2007.09.065.

Wasternack, C. and Parthier, B., 1997, Jasmonate-Signalled Plant Gene Expression. *Trends Plant Sci.* **1997**, *2* (8), 302–307. https://doi.org/10.1016/S1360-1385(97)89953-0.

Xie, Q., Yan, F., Hu, Z., Wei, S., Lai, J. and Chen, G., 2019, Accumulation of Anthocyanin and Its Associated Gene Expression in Purple Tumorous Stem Mustard (Brassica Juncea Var. Tumida Tsen et Lee) Sprouts When Exposed to Light, Dark, Sugar, and Methyl Jasmonate. *J. Agric. Food Chem.*, *67* (3), 856–866. https://doi.org/10.1021/acs.jafc.8b04706.

Yen, S. K., Chung, M. C., Chen, P. C. and Yen, H. E., 2001, Environmental and Developmental Regulation of the Wound-Induced Cell Wall Protein WI12 in the Halophyte Ice Plant. *Plant Physiol.*, *127* (2), 517–528. https://doi.org/10.1104/pp.010205.

Yoon, J. Y., Hamayun, M., Lee, S. K. and Lee, I. J., 2009, Methyl Jasmonate Alleviated Salinity Stress in Soybean. *J. Crop Sci. Biotechnol.*, *12* (2), 63–68. https://doi.org/10.1007/s12892-009-0060-5.

Yuan, F., Liang, X., Li, Y., Yin, S. and Wang, B., 2019, Methyl Jasmonate Improves Tolerance to High Salt Stress in the Recretohalophyte Limonium Bicolor. *Funct. Plant Biol.*, *46* (1), 82–92. https://doi.org/10.1071/FP18120.

REFERENCES (continued)

Zheng, Y., Wang, L. and Dixon, M., 2007, An Upper Limit for Elevated Root Zone Dissolved Oxygen Concentration for Tomato. *Sci. Hortic. (Amsterdam).*, *113* (2), 162–165. https://doi.org/10.1016/j.scienta.2007.03.011.

Zhishen, J., Mengcheng, T. and Jianming, W., 1999, The Determination of Flavonoid Contents in Mulberry and Their Scavenging Effects on Superoxide Radicals. *Food Chemistry*., 555–559 pp. https://doi.org/10.1016/S0308-8146(98)00102-2.

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