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# Effect of Magnetic Water Irrigating on Fruit Quality and Storability of Valencia Orange

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## ABSTRACT

Egypt is considered the first universal in orange production or export, as Egyptian oranges are distinguished by taste and quality that are different from other oranges worldwide. The cultivated area increased year after year. However, the problem in the places that have been added to the cultivated area with oranges is sometimes the salinity of the soil and sometimes the salinity of the irrigation water. Irrigation by magnetic water is a method to reduce the impact of irrigation water that contains salinity. Many experiments have been conducted on irrigation by magnetic water, and the experiments have shown an affirmative impact on the quality and productivity of the crop. This investigation was carried out in the 2021 & 2022 seasons to investigate the impact of magnetic water irrigation on the goodness of fruits of cv. Valencia orange at harvest, through cold storage (7C$^{o}$) and storage at room temperature at 24 C$^{o}$. At harvest time trees treated by magnetic water irrigation, fruits had increased percentages of fruit weight, volume, firmness, peel thickness, and attribution of juice weight than was taken in normal water. During cold storage at 7C$^{o}$ and at room temperature at 24C$^{o}$, fruits treated with magnetic water had less weight loss, decay, and increase in TSS/acid ratio in all storage conditions than fruits treated with normal water.

**Keywords**: Magnetic water- Fruit quality-Valencia orange- Room temperature

## INTRODUCTION

Agriculture is the most important section of the Egyptian state and plays a serious function in ensuring food security for Egypt. The agricultural section contributes an estimated 10-15% of the gross domestic product, according to data from the Central Bank of Egypt. Egypt is one of the largest producers of oranges in the world, and its climate is conducive to citrus cultivation; oranges are grown in the Delta, Wadi El Natrun, and Eastern Desert regions, where sandy clay soil rich in organic matter is available, along with a good water drainage network, making it suitable for growing many types of oranges. These regions allow Egypt to cultivate different varieties of oranges, such as Baldy oranges, Washington navel oranges, and Valencia oranges. According to The Ministry of Agriculture and Land Reclamation and Agricultural Export Council, Egypt exports oranges to about 160 countries around the world with a total export production of about 2 million tons, as Egypt has a large number of sorting, packing, and packaging stations at the highest level, reaching about 200 stations with a total production capacity for packing and packaging of about 3 million tons of citrus fruits, which provides an opportunity for Egypt to increase its production volume and increase exports by about 50%.

Oranges are non-climacteric fruits, so there are no peaks in respiration and ethylene output, which leads to increased fruit maturity after harvesting. So, there is a long shelf life compared with other fruits (Ladaniya, 2010). Metabolic processes in fruits slow down during cold storage. Also, storage temperature and duration are affected fruit quality, such as increases in TSS, lowering sugars and, pH in oranges which could be stored at 10 $^{o}$C for 45 days, (Hussain et al., 2017),

Irrigation with saline well water is the main problem in new lands planted. With citrus fruits, this leads to a decrease in the crop in terms of yield and quality, because citrus fruits are susceptible to irrigation water in terms of quantity and quality. Soil osmosis is disturbed due to salinity, which affects the roots' absorption of water and leads to increased ion toxicity and

accumulation of sodium and chloride, which leads to a decrease in orange fruit production (Al-Yassin, 2005). So, farmers resort to utilizing magnetized water technology, through which water is passed into a magnetic device to treat water magnetically (MW). The shape of the hydrogen bonds between the molecules changes as a result of the water passing through the magnetic field, and this leads to a change in the water characteristics as electrical conductivity, oxygen rate, and dissolution in the water increase, increase in the efficiency of dissolving acids and salts, surface intensity, and a change in the speed chemical reaction with the retention of moisture and increased permeability, which makes the flow of water better than it was. (Al-Jbouri et al., 2006).

Previous studies have found the impact of irrigation with magnetized water on plants such as (Hamdy et al., 2015) in two varieties of mandarin indicated that magnetized water remarkably raised fruit weight (g), pulp weight (g), peel weight (g), fruit volume (cm3), and number of segments /fruit when compared with control treatment. (Aly et al., 2015) noticed that watered with normal water due to clear decreases in percentages of total soluble solids, acidity, ascorbic acid, and total sugar on Valencia Orange compared irrigation with magnetic water. The magnetic domain influences different plant agents like gene indication enzyme activities, and protein bio-structure, and causes different plant missions and plant members or tissue (Goodman et al., 1995 and Atak et al., 2003). The results from (Bondarenko et al., 1999) explained that the important effect of watering with magnetic water resulted in high-altitude energy such as atomic oxygen and free radicals carrying nitrogen, which were found in treated water.

Magnetic field when water is passed on it changes to small water molecules, which change water and nutrients to be more available for plant roots (Hilal et al., 2013) causing an increase in water permeability and movement of salt ions like chloride, sodium, and carbonate ions, on the root zone layers (Mostafa et al., 2012). Found that the structure of water, its density, its ability to retain salt, and the rate of settling of solid particles change when water passes through a magnetic field.

So, yield and fruit quality increased as recommended by (Hassan, 2022) that magnetic water irrigating due to rise also reduced the fruit set percentage and fruit subsidence, and progressed total yield (kg/tree) Similar results were found by (Aly et al., 2015) on Valencia orange (Hamdy et al., 2015), on Baldy and Fremont mandarin and (El-Dengawy et al., 2019) on Washington navel orange. (Bogdan et al., 2022) Suggesting that a magnetized field is a possible process for increasing crops, upgrading the quality of the crop, inhibiting pest damage and disease, and preventing fruit aging. Plants or fruits when put in a magnetic field is an environmentally friendly and safe method and also has a positive economic effect.

This study aims to define the effect of magnetized water irrigation on the quality of Valencia orange fruits at harvest and when stored at room temperature (24ºC) and cold storage (7ºC) compared with the uptake of normal water.

## MATERIALS AND METHODS

This trial was carried out during (2021 and2022) seasons on orange (*Citrus sinensis* L.) fruits of cv. Valencia grafted on Volkamer lemon (*Citrus volkameriana*) rootstock. The trees were planted for 8 years in sandy loam soil, with 4×6 meters distances, irrigated with a drip irrigation system by River Nile water in a private orchard at Belbeis district in El Sharkia Governorate, Egypt.

Part of that farm was irrigated with magnetized water using a Delta Water device through drip irrigation, and part of it is still irrigated through drip irrigation without the device, as the farm was on its way to converting to magnetized irrigation. Samples from soils were taken from two parts and also, samples from water were taken before and after magnetizing. The results of the soil and

water sample analysis in **Tables (1 and 2)** were taken from the owner of the orchard, as he was the one who analyzed the water and soil before and after treatment with magnetized water.

**Table (1). Some changes in soil parameters before and after the use of magnetic water.**

| Particle size distribution | | | Soluble cations and anions (meq/ L) | | |
|---|---|---|---|---|---|
| **Parameters** | **Control soil** | **Magnetic soil** | **Parameters** | **Control soil** | **Magnetic soil** |
| **Sand (%)** | 76.5 | 73.6 | **Ca++** | 1.28 | 2.00 |
| **Salt (%)** | 16.85 | 17.9 | **Mg++** | 0.90 | 1.50 |
| **Clay (%)** | 6.65 | 8.50 | **Na+** | 1.85 | 3.90 |
| **Textural class** | Loamy sand | Loamy sand | **K+** | 30 | 37 |
| | | | **Cl-** | 1.90 | 2.70 |
| **Some chemical properties** | | | **SO4 =** | 0.83 | 2.77 |
| **PH** | 8.1 | 8.02 | **Available macronutrients(mg/kg)** | | |
| **EC dS/m** | 0.85 | 0.42 | **N** | 25.5 | 30.0 |
| **OM%** | 0.37 | 0.40 | **P** | 8.0 | 10.0 |
| **CEC Meq/100g** | 2.60 | 3.20 | **K** | 55.0 | 43.0 |

**Table (2).** Several parameters of water before and after magnetized.

| Parameters | PH | EC dS/m | $K^{++}$ | $Na^{+}$ | $Mg^{++}$ | $Ca^{++}$ | $SO_4^{=}$ | $Cl^{-}$ | $CO_3^{=}$ | $HCO_3^{-}$ | SAR |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Meg/L | | | | | |
| **Before** | 7.31 | 1.30 | 0.50 | 8.70 | 1.50 | 2.80 | 3.20 | 5.60 | 0.0 | 4.70 | 5.93 |
| **After** | 7.21 | 2.00 | 0.78 | 11.28 | 2.10 | 3.97 | 2.53 | 8.00 | 0.0 | 7.60 | 6.47 |

All horticultural practices were done for all trees in two parts. Harvest was started when fruits reached a maturity index of at least 12.0 according to Volpe et al. (2002). The trees for each part almost similar in growth were defined to collect the fruit's samples at harvest time to subject the fruit chemical and physical characteristics under the effect of irrigation and non-irrigation by magnetic water. After harvest the fruits were transported to the Experimental laboratory of Mansoura Research Station. Each part involves 2 treatments, each with three replicates. Fruits were washed and allowed to air dry with the assistance of a standing fan. Fruits were packaged in plastic boxes each box containing (2 kg) and divided into 2 groups the first group was held at room temperature (24 ± 2 C°, 65±5 % RH) and studied fruit quality properties under storage at room temperature. The second group was stored at (7 ±1 C°, 90% RH) and studied fruit quality properties at cold storage.

**Fruit physical properties:**

At harvest, some physical properties of fruits were measured such as fruit [weight (g), volume ($cm^3$), peel (gm), pulp (gm)], peel thickness (cm), and firmness ($Kg/cm^3$). Fruit quality properties were measured during storage. Measurements of the parameters were made at harvest day, 7-, 14-, 21-, and 28 days during storage.

**Lose in weight (%):** Loss in weight was decided by the following equation:

Loss in weight (%) = $[(W_1-W_2)/W_1] \times 100$

Where $W_1$ = the fruit weight at harvest day and $W_2$ = the fruit weight after storage intervals. (A.O.A.C., 2000)

**Decay (%):** Decay (%) = (decayed fruit weight/fruit weight before storage) X 100.

**Firmness ($Kg/cm^3$):** Firmness was measured at two different sites to measure the breakthrough force using a hand-held fruit firmness tester

**Fruit biochemical characteristics:**

**Juice weight (%):**

Juice weight (%) =weight of juice (ml) /weight of fruit which juice extract (gm) X100

**Total soluble solid (T.S.S):** Determined by using a hand refractometer on fruit juice according to (AOAC 2000).

**Total acidity** (%): Measured by using the titrating method according to (AOAC, 2000).

**Total soluble solids/acid ratio:** TSS/acid ratio was estimated by dividing the total soluble solids percentage over total acidity percentage.

**Ascorbic acid content:** Determined by using the 2, 6- dichloroindophenol method (AOAC, 2000).

**Statistical analysis:**

A complete randomized block design was used to perform all physio-chemical parameters. Data throughout the two seasons were subjected to analysis of the SAS Computer Program (1998) according to Duncan's multiple ranges for every group separately. Comparisons among means were tested in this program. Different alphabetical letters in the column are significant at the level of 5% of significance.

## RESULTS AND DISCUSSIONS

**Effect of magnetic water irrigation on several physical properties of Valencia Orange at harvest in 2021 and 2022 seasons:**

At harvest date when comparing Valencia orange fruits irrigated by magnetic water and the other irrigated by nonmagnetic water, found, there were significant increases in fruit weight (g), fruit size (cm3), fruit peel (gm), fruit weight pulp (g), peel thickness, firmness, and weight of juice (%), of Valencia Orange in the two studied seasons as shown in **(Tables 3 and 4).** These rustles are in line with (Aly et al., 2015) on Valencia Orange, (Hamdy et al., 2015) on some mandarin species, and (Tarek, et, al., 2019) on Washington Navel Orange. These results may be caused by the magnetic water due to the alkalinity decreased in soil and the resolution of a few soluble salts such as phosphates, sulfates, and carbonates and increasing soil obtainability of Phosphorus and Nitrogen, while a reduction of Potassium under using the magnetic water. (Hilal et al., 2002). Thus, improving mineral availability to the plant caused increased plant growth and productivity (Maheshwari and Grewal, 2009). Increased representative growth resulting from the presence of internal energy in the plant similar to resonance stimulates fruit production with influences some physical characteristics such as fruit volume ($cm^3$), fruit pulp weight (g), and fruit peel weight (g) (Shabrangi and Majd, 2009). As confirmed by (Atak et al., 2003) magnetic range may change the component cell membrane causing variation in cell metabolism and assisting in pectin forming and Ca intake due to a rise in fruit firmness.

**Table (3). Impact of irrigation by magnetized water in several physical properties of Valencia orange at harvest in 2021 and 2022 seasons.**

| Measurements | Fruits weight (g) | | Fruit volume ($cm^3$) | | Fruit peel (gm) | | Fruit pulp (gm) | |
|---|---|---|---|---|---|---|---|---|
| Seasons / Treatments | 2021 | 2022 | 2021 | 2022 | 2021 | 2022 | 2021 | 2022 |
| **Non-magnetic water** | 189 b | 192 b | 238 b | 243 b | 79.3 b | 75.8 b | 87.3 b | 85.9 b |
| **Magnetic water** | 210 a | 228 a | 261 a | 275 a | 84.3 a | 90.6 a | 92.3 a | 95.4 a |

Means followed by the same letters within each column do not significantly differ using Duncan's Multiple Range Test at 5%.

**Table (4).** Impact of irrigation with magnetized water on fruit peel thickness, firmness**,** and Juice weight of Valencia orange at harvest in 2021 and 2022 seasons.

| Measurements | Peel thickness (cm) | | Firmness ($kg/cm^3$) | | Juice weight (%) | |
|---|---|---|---|---|---|---|
| Seasons / Treatments | 2021 | 2022 | 2021 | 2022 | 2021 | 2022 |
| **Non-magnetic water** | 0.37 **b** | 0.42 **b** | 11.7 **b** | 12.0 **b** | 60.4 **b** | 62.6 **b** |
| **Magnetic water** | 0.51 **a** | 0.53 **a** | 12.0 **a** | 12.3 **a** | 66.7 **a** | 68.0 **a** |

Means followed by the same letters within each column do not significantly differ using Duncan's Multiple Range Test at 5%.

**Impacts of irrigation by magnetized water on some biochemical properties of Valencia orange at harvest in 2021 and 2022 seasons:**

It is clear from **(Table 5)** that the application of magnetic water increased marketable fruits on Valencia orange properties as T.S.S, TSS/acid, and ascorbic

acid content but decreased acidity when compared with fruits irrigated by normal water in both study seasons. Similarly, (Abd El-Shafik et al., 2019) on Tomatoes, on Washington Navel Oranges (Hassan, 2022) also concerning T.S.S, (Selim, 2008) represents that increasing TSS (%) on the juice of tomatoes might be done by increasing mobility and uptake of ions under the condition of magnetic water which improves photosynthesis prompting plants that displayed amelioration of fruit properties. Meanwhile, (De Souza et al. 2006) said that TSS increases may be caused by the relationship between stomach behavior and photosynthesis, due to an increase in photosynthesis operation, which crossed as an outcome of bioenergetics structural irritation causing cell pumping and enzymatic stimulation. Photosynthesis rises due to the greater interception of light and the greater amount of assimilates available for vegetative growth. The same explanation was suggested by (Pietruszewski, 1999) for increasing TSS/acid ratio and decreases of acidity on the fruits at harvest time. Meanwhile (Aly et al., 2015) indicated that vitamin C increased as the outcome of magnetized water which gradually increases nutrient perception from the soil and increases the effectiveness of transpiration of these nutrients inside the plants. That is in harmony with (Moussa, 2011) who suggested that the increase in V.C (Ascorbic acid) in fruit juice at harvest time may be attributed to the increase in fruit weight and size and also to the increase in shoot growth and leaf area caused by magnetic treatment or may be due to irrigation with magnetized water caused antioxidant enzymes had a significant increase in the activities over the control plants.

**Table (5). Impact of irrigation with magnetized water on some chemical properties of Valencia orange at harvest in 2021 and 2022 seasons.**

| Measurements | T.S.S | | Acidity (%) | | TSS/acid ratio | | V.C (mg/k) | |
|---|---|---|---|---|---|---|---|---|
| Seasons / Treatments | 2021 | 2022 | 2021 | 2022 | 2021 | 2022 | 2021 | 2022 |
| **Non-magnetic water** | 9.8 **b** | 10.0 **b** | 0.77 **a** | 0.79 **a** | 12.72 **b** | 12.65 **b** | 44.0 **a** | 44.2 **a** |
| **Magnetic water** | 10.5 **a** | 11.0 **a** | 0.68 **b** | 0.72 **b** | 15.44 **a** | 15.27 **a** | 43.2 **a** | 43.5 **a** |

Means followed by the same letters within each column do not significantly differ using Duncan's Multiple Range Test at 5%.

**Effect of irrigation with magnetic water on some physical properties of Valencia orange during storage 2021 and 2022 seasons.**

As found in **(Table 6)** there were significant differences between the fruits resulting from irrigation with magnetized water and others resulting from irrigation with normal water. There was a clear difference after storage, whether at room temperature (24°C) or cold storage (7°C), despite the weight loss of all fruits, except that the control had a higher weight loss than those treated with magnetized water.

Whoever, at room temperature (24ºC) the control has the highest-level loss in weight percentage in the end storage (14.27), irrigation with magnetic water reduced loss in weight at room temperature. Storage fruits at 7ºC irrigated with magnetic water is clear for reducing loss in weight percentage (10.39), which is also done in the two studied seasons. As (Murr, 1963) confirmed the magnetic field (MF) effect linked with the polarization of organic radicals in the plant bio-systems and molecular stress can affect the plant's reactions. This consequence is in keeping the post-harvest quality of some fruits and lengthening of shelf life of the product (Maheshwari, et al., 2009 and Wang et al., 2008). Literature reports that electric fields give rise to gas ionization in a room environment, which shifts to the cross electrode at high promptness. It is non-thermal therapy beneficial in prolongation the shelf life of fruits (Maheshwari et al., 2009).

**Table (6). Effect of irrigation with magnetic water on loss in weight (%) of Valencia orange fruits during storage in 2021 and 2022 seasons.**

| Period in days | Loss in weight (%) | | | | | |
|---|---|---|---|---|---|---|
| | Room temperature | | | Cold storage | | |
| | Control | Magnetic water | Means | Control | Magnetic water | Means |
| | | | Season 2021 | | | |
| **0** | 0.0 **h** | 0.0 **h** | **0.0 E** | 0.0 **h** | 0.0 **h** | **0.0 E** |
| **7** | 3.65 **g** | 3.08 **g** | **3.36 D** | 2.06 **g** | 1.95 **g** | **2.00 D** |
| **14** | 6.73 **e** | 5.56 **f** | **6.14 C** | 5.74 **e** | 4.58 **f** | **5.16 C** |
| **21** | 10.28 **c** | 9.12 **d** | **9.70 B** | 8.26 **c** | 6.95 **d** | **7.61 B** |
| **28** | 14.27 **a** | 12.23 **b** | **13.25 A** | 12.00 **a** | 10.39 **b** | **11.19 A** |
| **Means** | **6.98 A** | **5.99 A** | | **5.61 A** | **4.77 A** | |
| | | | Season 2022 | | | |
| **0** | 0.00 **h** | 0.00 **h** | **0.0 E** | 0.00 **h** | 0.00 **h** | **0.0 E** |
| **7** | 3.57 **g** | 3.13 **g** | **3.35 D** | 2.29 **g** | 2.01 **g** | **2.15 D** |
| **14** | 6.41 **e** | 5.45 **f** | **5.93 C** | 5.21 **e** | 4.13 **f** | **4.67 C** |
| **21** | 10.31 **c** | 8.97 **d** | **9.64 B** | 8.23 **c** | 7.22 **d** | **7.72 B** |
| **28** | 13.93 **a** | 12.10 **b** | **13.01 A** | 11.89 **a** | 10.47 **b** | **11.18 A** |
| **Means** | **6.84 A** | **5.93 A** | | **5.52 A** | **4.76 A** | |

Means followed by the same letters within each column do not significantly differ using Duncan's Multiple Range Test at 5%.

In the same line fruit decay (%) gets larger with increasing storage time for all storage conditions. Also, decayed fruits decreased on fruits treated with magnetic water compared with those treated with normal water, which is clear in **(Table 7).** Fruits treated with magnetic water appeared to decay after 14 days under cold storage at (7ºC) and carry on to end storage but were accompanied by a lower rate than those treated with normal water or storage at room temperature. At room temperature (24ºC) control treatment had the highest decayed fruits (6.14% - 5.35%) at the end of storage in two seasons of study respectively. The best treatment was recorded for fruits irrigated with magnetized water and storage at (7ºC) (3.35% - 3.68%) in two seasons of study respectively. This decrease in decay for fruits treated with magnetic irrigation may be due to the increased peel thickness outcome from irrigation with magnetized water, which led to decreased respiration and increased firmness. These results agree with (Kharel and Hashinaga, 1996) on strawberries pointed out a surface electric field due to a reduction in the decay rate. Previous studies pointed out that the electric field affects the cell membrane permeability and impacts enzyme activity and the restraint of microbial activity (Zhao et al., 2011and Van et, al., 2002). An aura electric field may help to reduce decay and spore growth in stored ordnance by prevailing infection by fungi, inhibit *B. cinerea* from growing on strawberries, preserving the fruit's moisture content and freshness (Esehaghbeygi, et, al., 2021).

Fruit firmness data tabled in **(Table 8)** revealed that, there are no significant differences between the treatments, whether the irrigation water is treated with magnets or under different storage conditions. Firmness slightly decreased in the prolonged storage period, which was clearer in the second season than in the first one. In this regard, in Persimmon fruits treated between the two magnetic plates (Jaisue et al.,2020 and Liu et al., 2017) found an increase in firmness, respiration, and antioxidant activity. While (Wang et al., 2008) supposed that treated tomato fruit at 2 kV/cm electrostatic field could worthily dodge decreases in the color and firmness. The results by, (Shivashankara et al., 2004) declared that

pre-treatment a favorable HVEF (1.5 kV/cm) did not have a trace on the color and firmness of mango fruit. Treating with a magnetized field or an electric progress the structural substance on the fruit and prevents water loss in the tissues. Electric and magnetic fields substantially lateness the fruit softening tissue and raise the fruit firmness (Nyakane et al., 2019).

In **Table (9)** juice weight increased after harvest for 2 weeks of storage after that it decreased with the augmentation storage period either irrigated magnetized water or irrigated normal water and storage in different conditions, which is clear in the second season. The decrease in the weight of the juice is due to evaporation occurring during storage, due to the continued respiration during storage.

**Table (7). Effect of irrigation with magnetic water in decay (%) of Valencia orange during storage on 2021 and 2022 seasons.**

| Decay (%) | | | | | | |
|---|---|---|---|---|---|---|
| **Period in days** | **Room Temperature** | | | **Cold Storage** | | |
| | **Control** | **Magnetic water** | **Means** | **Control** | **Magnetic water** | **Means** |
| | | | **Season 2021** | | | |
| **0** | 0.00 **d** | 0.00 **d** | **0.00 D** | 0.00 **c** | 0.00 **c** | **0.00 C** |
| **7** | 0.00 **d** | 0.00 **d** | **0.00 D** | 0.00 **c** | 0.00 **c** | **0.00 C** |
| **14** | 1.80 **c** | 0.33 d | **1.06 C** | 0.60 **c** | 0.00 **c** | **0.30 C** |
| **21** | 3.73 **b** | 2.45 **c** | **3.09 B** | 1.20 **b** | 1.08 **b** | **1.14 B** |
| **28** | 6.14 **a** | 4.15 **b** | **5.14 A** | 3.91 **a** | 3.35 **a** | **3.63 A** |
| **Means** | **2.33 A** | **1.38 B** | | **1.14 A** | **0.88 A** | |
| | | | **Season 2022** | | | |
| **0** | 0.00 **g** | 0.00 g | **0.00 D** | 0.00 d | 0.00 d | **0.00 C** |
| **7** | 0.00 **g** | 0.00 **g** | **0.00 D** | 0.00 **d** | 0.00 d | **0.00 C** |
| **14** | 1.51 **e** | 0.69 **f** | **1.10 C** | 0.55 **c** | 0.00 d | **0.27 C** |
| **21** | 3.45 **c** | 2.83 **d** | **3.14 B** | 1.48 **b** | 1.35 **b** | **1.41 B** |
| **28** | 5.35 **a** | 4.18 **b** | **4.76 A** | 4.33 **a** | 3.68 **a** | **4.00 A** |
| **Means** | **2.06 A** | **1.54 A** | | **1.27 A** | **1.00 A** | |

Means followed by the same letters within each column do not significantly differ using Duncan's Multiple Range Test at 5%.

**Table (8). Effect of irrigation with magnetic water on the Firmness of Valencia orange during storage in 2021 and 2022 seasons.**

| Firmness | | | | | | |
|---|---|---|---|---|---|---|
| **Period in days** | **Room temperature** | | | **Cold Storage** | | |
| | **Control** | **Magnetic water** | **Means** | **Control** | **Magnetic water** | **Means** |
| | | | **Season 2021** | | | |
| **0** | 11.8 **a** | 12.0 **a** | **11.9 A** | 11.8 **a** | 12.0 **a** | **11.9 A** |
| **7** | 11.6 **a** | 11.9 **a** | **11.7 A** | 11.7 **a** | 12.0 **a** | **11.8 A** |
| **14** | 11.1 **a** | 11.6 **a** | **11.3 A** | 11.3 **a** | 11.7 **a** | **11.5 A** |
| **21** | 10.7 **a** | 11.0 **a** | **10.8 A** | 11.0 **a** | 11.4 a | **11.2 B** |
| **28** | 10.0 **b** | 10.5 **b** | **10.2 B** | 10.5 **a** | 10.8 **a** | **10.6 B** |
| **Means** | **11.04 A** | **11.40 A** | | **11.26 A** | **11.58 A** | |
| | | | **Season 2022** | | | |
| **0** | 12.0 **a** | 12.3 **a** | **12.1 A** | 12.0 **a** | 12.3 **a** | **12.1 A** |
| **7** | 11.5 **b** | 12.0 **a** | **12.6 A** | 11.7 **a** | 12.1 **a** | **11.9 A** |
| **14** | 11.2 **b** | 11.6 **b** | **11.6 A** | 11.2 **a** | 11.8 **a** | **11.5 A** |
| **21** | 10.6 **c** | 11.0 **b** | **10.9 B** | 10.5 **b** | 11.5 **b** | **11.0 A** |
| **28** | 9.7 **d** | 10.2 **c** | **9.9 B** | 10.0 **c** | 11.0 **c** | **10.5 B** |
| **Means** | **11.00 A** | **11.42 A** | | **11.08 A** | **11.74 A** | |

Means followed by the same letters within each column do not significantly differ using Duncan's Multiple Range Test at 5%.

**Table (9). Effect of irrigation with magnetic water on juice weight of Valencia Orange during storage in 2021 and 2022 seasons.**

| Period in days | Juice Weight | | | | | |
|---|---|---|---|---|---|---|
| | Room temperature | | | Cold Storage | | |
| | Control | Magnetic water | Means | Control | Magnetic water | Means |
| | | | Season 2021 | | | |
| **0** | 60.4 **e** | 66.7 **d** | **63.5 C** | 60.4 d | 66.7 **b** | **63.5 B** |
| **7** | 70.2 **c** | 72.2 **b** | **71.2 B** | 66.8 **b** | 69.4 **a** | **68.1A** |
| **14** | 73.4 **b** | 75.4 **a** | **74.4 A** | 69.4 **a** | 71.3 **a** | **70.3 A** |
| **21** | 69.1 **c** | 71.9 **b** | **70.5 B** | 67.8 **b** | 70.1 **a** | **68.9 A** |
| **28** | 64.7 **d** | 63.1 **d** | **63.9 C** | 64.8 **c** | 66.7 **b** | **65.7 A** |
| **Means** | **67.56 B** | **79.86 A** | | **65.84 B** | **68.84 A** | |
| | | | Season 2022 | | | |
| **0** | 62.6 **f** | 68.0 **d** | **65.3 D** | 62.6 **e** | 68.0 **c** | **65.3 C** |
| **7** | 71.4 **c** | 73.2 **b** | **72.3 B** | 65.5 **d** | 66.2 **d** | **65.8 C** |
| **14** | 75.7 **a** | 76.8 **a** | **76.2 A** | 70.9 **b** | 72.5 **a** | **71.7 A** |
| **21** | 67.7 **e** | 71.1 **c** | **69.4 C** | 68.6 **c** | 70.6 **b** | **69.6 B** |
| **28** | 66.4 **e** | 69.6 **d** | **68.1 C** | 63.8 **e** | 66.4 **d** | **65.1 C** |
| **Means** | **70.30 B** | **72.67 A** | | **67.20 A** | **68.92 A** | |

Means followed by the same letters within each column do not significantly differ using Duncan's Multiple Range Test at 5%.

**Effect of irrigation with magnetic water on some biochemical properties of Valencia orange during storage 2021 and 2022 seasons**

Data in **Table (10)** showed that despite there being an increase in T.S.S in fruits irrigated with magnetized water than control treatment at harvest time there are no significant differences between fruits irrigated by magnetized water nor non-magnetized water at the end of storage in all conditions there is an increase on T.S.S almost at a similar rate. The results are in harmony with (Esehaghbeygi et al., 2021) on strawberry fruit, established to decrease the loss in weight of fruit, even alteration in pH, titratable acidity, and increase in soluble solid content (SSC). (Bogdan, et al., 2022) Stated that alternating magnetic fields (AMF) impact plant growth characteristics like leaf area, yield, fruit weightiness, also minerals in leaves such as Ca, Mg, N, K, Mn, Zn and Fe. That affects fruit quality and its shelf life, mainly due to increases in ripening rate, firmness, fructose content sugar concentration, and a decrease in acidity and respiration rate. While TSS increased with prolonged storage, the acidity percentage of fruits was significantly decreased with progress storage the decreases started after 7 days and showed a significant difference at the end of storage.

That is tabled in **(Table 11)** with no differences between fruit control or fruit irrigated magnetic water in the end storage. Though, the TSS/Acid ratio of fruits increased by raised storage it began small (after 7 days) and grew to rise to the highest value in the end storage that was done with two treatments and under all condition's storage in the two seasons of study, that shown in **(Table 12).** These agree with **(**Al-Shrouf, 2014) on cucumber; (Aly et al., 2015) on Valencia orange, and (Mahmoud et al., 2018) on Washington orange. Investigation on the role of cryptochrome (El-Assal et al., 2004and Fruhwirth et al., 2012) evidenced that CryB does not only impact photosynthesis gene code but also genes for the non-photosynthetic energy like oxidative phosphorylation and Krebs cycle that is in line with the data which displayed a significant increasing in TSS

% and ascorbic acid with magnetic water treatments as the stabilization in acidity with little values.That lined with (Hamdy et al., 2015) on Mandarin and (Wang et al., 2008) on tomatoes stated that the increases in Vitamin C might be done by the magnetic field due to increases in the activities of the antioxidant enzymes over the treated plants.

**Table (10). Effect of irrigation with magnetic water on T.S.S of Valencia Orange fruits during storage in 2021 and 2022 seasons.**

| Period in days | T.S.S. (%) | | | | | |
|---|---|---|---|---|---|---|
| | Room temperature | | | Cold Storage | | |
| | Control | Magnetic water | Means | Control | Magnetic water | Means |
| | | | Season 2021 | | | |
| **0** | 9.8 **b** | 10.5 **a** | **10.1 A** | 9.8 **c** | 10.5 **b** | **10.1 A** |
| **7** | 10.0 **b** | 10.6 **a** | **10.3 A** | 10.5 **b** | 11.2 **a** | **10.8 A** |
| 14 | 10.1 **b** | 10.9 **a** | **10.5 A** | 10.6 **b** | 11.5 **a** | **11.0 A** |
| **21** | 10.3 **a** | 11.1 **a** | **10.7 A** | 10.8 **b** | 11.5 **a** | **11.1 A** |
| **28** | 10.4 **a** | 11.3 **a** | **10.8 A** | 11.1 **a** | 11.8 **a** | **11.4 A** |
| **Means** | **10.12 A** | **10.88 A** | | **10.56 b** | **11.30 a** | |
| | | | Season 2022 | | | |
| **0** | 10.0 **b** | 11.0 **a** | **10.5 B** | 10.0 **b** | 11.0 **b** | **10.5 B** |
| **7** | 11.0 **a** | 11.5 **a** | **11.2 A** | 10.9 **b** | 11.3 **a** | **11.1 A** |
| **14** | 11.1 **a** | 11.8 **a** | **11.4 A** | 11.0 **b** | 11.5 **a** | **11.2 A** |
| **21** | 11.4 **a** | 12.1 **a** | **11.7 A** | 11.3 **a** | 11.8 **a** | **11.5 A** |
| **28** | 11.6 **a** | 12.3 **a** | **11.9 A** | 11.5 **a** | 12.0 **a** | **11.7 A** |
| **Means** | **11.02 A** | **11.74 A** | | **10.94 A** | **11.52 A** | |

Means followed by the same letters within each column do not significantly differ using Duncan's Multiple Range Test at 5%.

**Table (11). Effect of irrigation with magnetic water on acidity percentage of Valencia Orange fruits during storage in 2021 and 2022 seasons.**

| Period in days | Acidity (%) | | | | | |
|---|---|---|---|---|---|---|
| | Room temperature | | | 7 C° | | |
| | Control | Magnetic water | Means | Control | Magnetic water | Means |
| | | | Season 2021 | | | |
| **0** | 0.77 **a** | 0.68 **a** | **0.72 A** | 0.77 **a** | 0.68 **b** | **0.72 A** |
| **7** | 0.70 **a** | 0.66 **a** | **0.68 A** | 0.75 **a** | 0.67 **b** | **0.71 A** |
| **14** | 0.64 **a** | 0.64 **a** | **0.64 A** | 0.73 **a** | 0.66 **b** | **0.69 A** |
| **21** | 0.58 **b** | 0.61 **a** | **0.59 B** | 0.70 **a** | 0.64 **b** | **0.67 A** |
| **28** | 0.55 **b** | 0.58 **b** | **0.56 B** | 0.67 **b** | 0.62 **b** | **0.64 B** |
| **Means** | **0.65 a** | **0.63 a** | | **0.72 a** | **0.65 a** | |
| | | | Season 2022 | | | |
| **0** | 0.79 **a** | 0.72 **a** | **0.75 A** | 0.79 **a** | 0.72 **a** | **0.75 A** |
| **7** | 0.77 **a** | 0.70 **a** | **0.73 A** | 0.77 **a** | 0.72 **a** | **0.74 A** |
| **14** | 0.73 **a** | 0.67 **a** | **0.70 A** | 0.75 **a** | 0.70 **a** | **0.72 A** |
| **21** | 0.69 **a** | 0.63 **a** | **0.66 A** | 0.71 **a** | 0.67 **b** | **0.69 A** |
| **28** | 0.65 **a** | 0.60 **b** | **0.62 B** | 0.68 **b** | 0.64 **b** | **0.66 B** |
| **Means** | **0.72 A** | **0.66 A** | | **0.74 A** | **0.69 A** | |

Means followed by the same letters within each column do not significantly differ using Duncan's Multiple Range Test at 5%.

**Table (12). Effect of irrigation with magnetic water on TSS /acid ratio percentage of Valencia orange at 2021 and 2022 seasons.**

| T.S.S / acid ratio | | | | | | |
|---|---|---|---|---|---|---|
| Period in days | Room temperature | | | 7 C° | | |
| | Control | Magnetic water | Means | Control | Magnetic water | Means |
| **Season 2021** | | | | | | |
| **0** | 12.72 **e** | 15.44 **d** | **14.08 E** | 12.72 **f** | 15.44 **d** | **14.08 D** |
| **7** | 14.28 **e** | 16.06 **c** | **15.17 D** | 14.00 **e** | 16.71 **c** | **15.35 C** |
| **14** | 15.78 **d** | 17.03 **b** | **16.40 C** | 14.52 **e** | 17.42 **b** | **15.97 C** |
| **21** | 17.16 **b** | 18.19 **a** | **17.67 B** | 15.42 **d** | 17.96 **b** | **16.69 B** |
| **28** | 18.90 **a** | 19.48 **a** | **19.19 A** | 16.56 **c** | 19.03 **a** | **17.79 A** |
| **Means** | **15.76 b** | **17.24 a** | | **14.64 b** | **17.31 a** | |
| **Season 2022** | | | | | | |
| **0** | 12.65 **e** | 15.27 **d** | **13.96 D** | 12.65 **e** | 15.27 **c** | **13.96 D** |
| **7** | 14.28 **d** | 16.42 **c** | **15.35 C** | 14.15 **d** | 15.69 **c** | **14.92 C** |
| **14** | 15.20 **d** | 17.61 **b** | **16.40 B** | 14.66 **d** | 16.42 **b** | **15.54 C** |
| **21** | 16.52 **c** | 19.20 **a** | **17.86 B** | 15.91 **c** | 17.61 **a** | **16.76 B** |
| **28** | 17.84 **b** | 20.50 **a** | **19.17 A** | 16.91 **b** | 18.75 **a** | **17.83 A** |
| **Means** | **15.29 B** | **17.80 A** | | **14.85 B** | **16.74 A** | |

Means followed by the same letters within each column do not significantly differ using Duncan's Multiple Range Test at 5%.

Data in **(Table 13)** revealed that meanwhile, ascorbic acid (Vitamin C) in fruit juice significantly increased under irrigated by magnetic water it reduced with increasing storage life in all storage temperatures, which is true for two seasons of study. That was done by (El-Dengawy et al., 2015) Washington navel orange fruits, and (Niu, 2021) who stated that the increases in Vitamin C might be done by the magnetic field due to augmentation activities of the antioxidant enzymes over the treated plants.

**Table (13). Effect of irrigation with magnetic water on V.C percentage of Valencia orange at 2021 and 2022 seasons**.

| V.C (gm / 100ml) | | | | | | |
|---|---|---|---|---|---|---|
| Period in days | Room temperature | | | 7 C° | | |
| | Control | Magnetic water | Means | Control | Magnetic water | Means |
| **Season 2021** | | | | | | |
| **0** | 44.0 **a** | 43.2 **a** | **43.6 A** | 44.0 **a** | 43.2 **a** | **43.7 A** |
| **7** | 42.9 **a** | 43.2 **a** | **43.0 A** | 43.6 **a** | 43.8 **a** | **43.7 A** |
| **14** | 41.0 **b** | 41.8 **b** | **41.4 B** | 42.6 **a** | 42.9 **a** | **42.7 A** |
| **21** | 38.5 **c** | 39.7 **c** | **39.1 C** | 40.8 **b** | 41.4 **b** | **41.1 B** |
| **28** | 35.1 **d** | 36.6 **d** | **35.8 D** | 38.2 **c** | 39.4 **c** | **38.8 C** |
| **Means** | **40.30 A** | **40.90 A** | | **41.84 A** | **42.26 A** | |
| **Season 2022** | | | | | | |
| **0** | 44.2 **a** | 43.5 **a** | **43.85 A** | 44.2 **a** | 43.5 **a** | **43.8 A** |
| **7** | 42.1 **a** | 42.6 **a** | **42.3 A** | 42.9 **a** | 43.2 **a** | **43.0 A** |
| **14** | 40.2 **b** | 41.1 **b** | **40.6 B** | 41.7 **b** | 42.5 **a** | **42.1 A** |
| **21** | 37.2 **c** | 38.3 **c** | **37.7 C** | 39.6 **c** | 41.3 **b** | **40.4 B** |
| **28** | 33.7 **e** | 35.2 **d** | **34.4 D** | 36.7 **d** | 39.6 **c** | **37.8 C** |
| **Means** | **39.48 A** | **40.14 A** | | **41.02 A** | **42.02 A** | |

Means followed by the same letters within each column do not significantly differ using Duncan's Multiple Range Test at 5%.

## Conclusion

This paper studied the effect of irrigation with magnetic water on the quality of Valencia orange fruits during storage at room temperature (24°C) and cold storage (7ºC). The study found that, at harvest time fruits irrigated with magnetic water were increased in fruit weight and volume, fruit peel thickness, firmness, and fruit weight percentage. During cold storage at 7ºC and at room temperature 24ºC fruit treated with magnetic water had less weight loss, decay, and keep other quality than fruits treated with normal

water. This happened due to the influence of the magnetic field, which appeared to affect the polarization of organic radicals' cell membrane permeability, ion mobility, cell well hydrolysis, and manipulation of molecules.

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**الملخص العربى**

**تأثير الري بالمياه المغناطيسية على جودة الثمار والقدرة التخزينة لبرتقال الفالنسيا**

**ماجدة محمود و منى هلال**

**معهد بحوث البساتين – مركز البحوث الزراعية – الجيزة**

تعتبر مصر الأولى عالميا من حيث إنتاج وتصدير البرتقال حسب بيانات وزارة الزراعة و استصلاح الاراضي والمجلس التصديري. حيث يتميز البرتقال المصري بطعم وجودة مختلفة عن غيره من البرتقال حول العالم، وقد زادت المساحة المزروعة في السنوات الأخيرة، إلا أن المشكلة في المساحات المضافة لزراعة البرتقال تتمثل احيانا في وجود ملوحة للتربة وأحيانا وجود ملوحة في مياه الري التي التي تروي بها الاشجار نتيجة وجود ملوحه في آبار المياه ، والري بالمياه المغناطيسية من الطرق المعروفة لتقليل تأثير مياه الري المحتوية على ملوحة، وقد أجريت العديد من التجارب على الري بالمياه المغناطيسية، وقد أظهرت التجارب تأثيرا إيجابيا على جودة وإنتاجية المحصول، وقد أجريت هذه الدراسة في عامي 2021 و2022 لدراسة تأثير الري بالمياه المغناطيسية على جودة ثمار البرتقال صنف فالنسيا أثناء التخزين سواء في درجة حرارة الغرفة أو عند 7 درجات مئوية، وقد أظهرت الثمار المروية بالمياه المغناطيسية قدرة تخزين عالية، تقترب أحيانا من تلك المروية بالمياه العادية، وقد ظهر ذلك قبل التخزين مع زيادة سمك القشرة وزيادة حجم الثمار .خلال التخزين حدث انخفاض في فقدان الوزن ومعدل الاعفان وزيادة في الصلابة.