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# Impact of Various Potassium Sources on the Color and Juice Quality of Valencia Orange Fruits

*Esam M. S. Allam*[1] *Osama A. I. Zagzog*[1*] *Nermeen I. El-Naggar*[1]
*El-Sayed M. H. A. Qaoud*[2]

***1-*** *Plant Prod. Depart, Fac. Tech. and Dev., Zagazig University.*
***2-*** *Depart. Hort. Fac. Agric. Suez Canal University*
**Correspondence to: Email: zagzog_1000@yahoo.com,*
*nielnagar@hotmail.com*
*s_qaou@yahoo.com*

**ABSTRACT**:

The field experiment was conducted on ten-year-old Valencia orange (*Citrus sinensis* L.) trees that were grafted onto Volcamarina rootstock throughout the 2020-2021 and 2021-2022 seasons. The chosen trees were planted in a private orchard in Egypt's Wadi Elmoulak, which is part of the Ismailia Governorate. The purpose of the research was to determine how foliar spraying Valencia oranges with various potassium sources (treatments) affected their peel and juice color, fruit waste weight, and juice characteristics.

The results of this study demonstrated that foliar application of different potassium sources significantly influenced the peel and juice color, fruit waste weight, and juice characteristics of Valencia oranges. Potassium citrate at 1.5 and 2.0% being particularly effective in enhancing peel color intensity and peel and juice being particularly effective in enhancing peel color intensity and peel and juice color parameters (L*, a*, b*, Chroma and hue angle) and juice density and quality. Regarding fruit quality, monopotassium phosphate at 1.5% improved juice weight, volume, and juice ratio in the first and second seasons, respectively.

*Conclusively,* from these results, it is recommend spraying different potassium sources improved peel color intensity and peel and juice color parameters and juice density and quality of Valencia Orange fruits.

**Keywords**: Valencia, mono potassium phosphate, potassium citrate, peel and juice

## INTRODUCTION

Citrus fruits hold a prominent position in the Egyptian agricultural sector, as they are among the most globally cultivated fruits. According to the latest data from the Food and Agriculture Organization (FAO, 2023), the total area under citrus cultivation currently stands at approximately 420,000 feddans. This area is anticipated to exceed 517,000 feddans, representing a 35% increase in production.

Around 2.3 million metric tons of Egypt's total agricultural land is allocated for fruit growing, and approximately 5 million metric tons of citrus are exported annually, which reinforces Egypt's position as a key producer and a major exporter of fruits in the global market.

Citrus juice is widely consumed due to its availability, high nutritional value, and desirable taste, odor, and color. According to Rampersaud *et al.* (2007), citrus juice is a combination of water, vitamins, minerals, sugars (primarily sucrose, fructose, and glucose), carbohydrates, acids, phytochemicals, and other organic components. Furthermore, according to Xu *et al.* (2008), citrus juices are a good source of bioactive substances such as flavonoids, carotenoids, and other phenolic compounds.

Potassium is highly mobile within plants at all levels, moving from xylem and phloem to individual cells. This cation is particularly critical in areas of pigment production, sugar buildup, and fruit ripening, making it essential for plant physiology. Moreover, potassium accelerates the ripening process, which subtly improves the color of both the juice and the peel (Tiwari and Ashraf, 2010). Potassium nitrate is a soluble version of two essential elements required by plants. It is commonly used as a fertilizer for high-value crops that need nitrate ($NO_3^-$) nutrition and a potassium (K+) source free of chloride ($Cl^-$). Fattahi *et al.* (2021) claim that foliar 500 mg/L foliar potassium nitrate improved the color of the peel and the buildup of sugar

Potassium citrate is the potassium salt of citric acid, which is considered one of the most important organic acids in the respiratory pathways into plant cells (Sadak and Orabi, 2015). Furthermore, KC plays a critical function in plant metabolism, allowing the citric acid cycle into the mitochondria and aiding in the manufacture of ATP, which is essential for a number of physiological and biochemical processes that ultimately promote fruit color and quality, (Taiz and Zeiger, 2002).

Monopotassium phosphate is a high-purity PK fertilizer that is inorganic, free-flowing, and crystalline (0-52-34). It is frequently used as a buffering agent, food additive, and fertilizer due to its extremely low sodium level. Foliar sprays of MKP at 1 and 1.5% at various intervals (every 10, 20, or 30 days) increased berry color juice of Ruby grapes, according to El Botaty *et al.* (2023).Monopotassium thiosulphate is a foliar fertilizer used in citrus to address potassium deficiency. It can potentially improve fruit quality and enhance nutrient uptake and tolerance to stress, with benefits for fruit coloration (El-Salhy *et al.* 2017).

Recently, numerous attempts have been made to spray potassium using different forms, which have shown a positive effect on the peel and juice color of citrus trees (Al-Sabbagh *et al.,* 2024). Many physiological and biochemical processes that are essential to quality and stress include potassium (Dutta, 2011). According to Eliwa *et al*, (2003), it also improved the fruit's coloring, total soluble solids, and total sugars. These effects may be attributed to potassium's role in enhancing stress tolerance and accelerating the rates at which sugars develop and accumulate (Hamza *et al,* 2015).

Therefore, the current study's goal is to find out how different potassium sources affect the physical characteristics, juice, and peel color of Washington navel orange trees grown in sandy soil with drip irrigation.

## MATERIALS AND METHODS

### 1. *Plant materials and experimental procedure*

In 2021 and 2022, ten-year-old Valencia orange (*Citrus sinensis* L.) trees were grafted onto Volcamarina rootstock for two growing seasons. The chosen trees were cultivated in a private orchard with drip irrigation in Wadi Elmoulak, Ismailia Governorate, Egypt. A 25-liter backpack power sprayer (Model HT-767; Taizhou Tianyi Agricultural and Forestry Machinery Co., Zhejiang, China) was also used to apply various potassium forms (potassium nitrate, potassium phosphate, potassium citrate, and monopotassium thiosulphate) as a foliar spray to the Valencia orange cultivar twice (late May and late July) in both seasons. These sources of potassium were acquired from the Sigma Aldrich Company, St. Louis, MO, USA. Spraying was done till runoff (7 L / tree spraying). However, each tree's spray solution was sprayed until dripping.

### *2. Experimental design and treatments*

This experiment included 117 uniform orange trees planted at a spacing of 4x6 meters (about 175 trees/fed) with similar size and vigor, in sandy soil under drip irrigation. The trees were subjected to agricultural practices, which are usually done in this area, and free of any physiological diseases or nutrient deficiencies. The trees selected were sprayed with 13 spray treatments. Treatments were placed in a randomized complete block design (RCBD) system with three replicates, and each replicate was represented by three trees. In both seasons, the same nine trees were subjected to the same treatment as follows:

Control (tap water), potassium nitrate ($KNO_3$ ) at concentrations of 1.0%, 1.5%, and 2.0%, mono-potassium phosphate at concentrations of 1.0%, 1.5%, and 2.0%, potassium citrate at concentrations of 1.0%, 1.5%, and 2.0%, and mono-potassium thio-sulphate at concentrations of 1.0%, 1.5%, and 2.0%.

### 3. *Responses of trees to the applied treatments were evaluated through the following parameters*:

#### 3.1. Peel and juice color:

At harvest time, four fruits were chosen from each replicate to evaluated fruit color at two opposite points of each fruit and estimated juice color after Squeezing utilizing Minolta CR10 colorimeter, Minolta crop, Japan CIE L, a, b, C* and h* color values were estimated. Where, (L*) "Lightness*" color value which measures the relative luminosity between black (0) and white (100), (a*) "Redness*" color value which indicates the relative green (-) to red (+), (b*)

"Yellowness*" color values which indicates the relative yellow (+) to blue (-), (C*) "Chroma*", which represents the color's saturation or intensity, calculated by the following equation:

$C^* = \sqrt{a*^2 + b^{*2}}$ and (h*) "Hue angle *", which describes the color's position on the color wheel. Calculated by the following equation: h*= arctan (b∗/a∗) and is expressed in degrees according to Francis (1980).

**3.2. Citrus Color Index (CCI):**

It emphasizes the relationship between the red-green (a*) and yellow-blue (b*) components, normalized by lightness (L*) of fruit peel color and calculated by using the formula: $CCI = \frac{1000 \times a*}{L* \times b*}$

Higher CCI values indicate a more intense orange to red color, which is associated with ripeness and lower CCI values suggest a greener or less ripe fruit, according to Jiménez-Cuesta *et al* . (1983).

**3.3. Juice content % and fruit waste%:**

At harvest time 4 fruits were weighed and then cut in half to extract the juice by a manual juicer; fruit juice and waste weights were evaluated by using a digital scale and expressed as (g) and juice volume was estimated by a graduated laboratory and expressed as ($cm^3$). Fruit juice and fruit waste percentages were calculated by the following equations:

Juice % = Juice weight (g)/ fruit weight (g) ×100

Fruit waste%= Waste weight (g)/Fruit weight (g)×100, according to Sinha *et al.* (2012).

**3.4. Juice density (g /$cm^3$):**

It was calculated by the following equation Juice density (g /$cm^3$) = Juice weight (g) / Juice volume ($cm^3$) according to Sinha *et al* . (2012).

**4. *Statistical analysis***

Data were analyzed using the MSTAT-C statistical package in a randomized complete block design (RCBD) as described by Snedecor and Cochran (1980), and means were compared using mean comparison at 0.05 level (Duncan, 1955).

**RESULTS AND DISCUSSION**

***1. Fruit peel color***

Tables 1 and 2 express the fruit peel **color** assessment (I) in numerical terms along the lightness (L* value), the (a*) "redness" color value, which indicates the relative green (-) to red; the (b*) "yellowness" color value, which indicates the relative yellow (+) to blue; the Chroma (C*, intensity of color); and the hue angle (h°) within the CIELAB color sphere, which are usually mathematically combined to calculate the color indexes. Concerning the fruit

**Table 1:** Effect of foliar spraying with different sources of potassium on fruit peel color (L, A, and B) for Valencia orange in two seasons (2021/2022)

| Characters | Fruit Peel Color | | | | | |
|---|---|---|---|---|---|---|
| | L* | | a* | | b* | |
| Season / Treatments | 2021 | 2022 | 2021 | 2022 | 2021 | 2022 |
| **Control** | 57.603 f | 58.758 cde | 34.537 a | 33.442 a | 59.263 de | 61.375 ab |
| **Potassium nitrate at 1.0 %** | 59.370 e | 59.40 abcd | 31.620 cd | 31.367 d | 58.863 de | 56.375 g |
| **Potassium nitrate at 1.5 %** | 59.633 de | 60.333 a | 33.427 ab | 32.525 abc | 59.613 d | 60.242 bc |
| **Potassium nitrate at 2.0 %** | 60.56 abcd | 59.225 bcd | 31.377 d | 32.050 bcd | 62.103 c | 60.742 abc |
| **Mono Potassium phosphate at 1.0 %** | 59.94 cde | 56.833 f | 31.360 d | 31.108 d | 61.413 c | 58.750 de |
| **Mono Potassium phosphate at 1.5 %** | 59.303 e | 59.625 abc | 29.527 e | 31.217 d | 57.110 g | 59.633 cd |
| **Mono Potassium phosphate at 2 %** | 57.760 f | 59.40 abcd | 32.067 cd | 33.283 a | 55.377 h | 57.083 fg |
| **Potassium citrate at 1.0 %** | 61.087 ab | 58.583 cde | 30.010 e | 33.608 a | 58.110 efg | 57.633 efg |
| **Potassium citrate at 1.5 %** | 61.333 a | 60.258 ab | 29.020 e | 31.400 cd | 58.460 def | 58.325 ef |
| **Potassium citrate at 2.0 %** | 60.04 cde | 59.008 cde | 31.483 d | 31.383 cd | 66.653 a | 60.367 abc |
| **Mono Potassium thiosulphate at 1.0 %** | 60.74abc | 59.308 abcd | 32.737 bc | 31.658 bcd | 63.420 b | 61.617 a |
| **Mono Potassium thiosulphate at 1.5 %** | 60.260 bcde | 58.400 de | 32.503 bcd | 32.700 ab | 61.643 c | 60.775 abc |
| **Mono Potassium thiosulphate at 2.0 %** | 56.570 g | 58.042 e | 32.253 bcd | 33.617 a | 57.483 fg | 58.100 ef |

a, b, c…f Means are bearing different lettersin each column, differ significantly P < 0.05

color analyzed at the harvest time, it can be noticed that the applications used in this study led to lower averages for L* readings, indicating that the fruit of Valencia orange had a lighter coloration. In contrast, the highest average for L* reading was noticed in the control, showing that the color of the berries presented a lower intensity. The control treatments recorded the highest (a*) “redness” color value, while the potassium citrate at 1.5 % was the lowest; the other treatments were intermediate between these two. Besides, potassium citrate at 2.0% treatment recorded higher “yellowness*” color values than other treatments in the first season, and monopotassium thiosulphate at 1.0%

**Table 2:** Effect of foliar spraying with different sources of potassium on fruit peel color (Chroma, Hue angle and Citrus Color Index) for Valencia orange in two seasons (2021/2022)

| **Characters** | **Fruit Peel Color** | | | | | |
|---|---|---|---|---|---|---|
| | **Chroma** | | **Hue angle** | | **Citrus Color Index (CCI)** | |
| **Treatments** / **Season** | **2021** | **2022** | **2021** | **2022** | **2021** | **2022** |
| **Control** | 68.587 c | 69.902 a | 1.717 f | 1.837 bc | 10.120 a | 9.277 cde |
| **Potassium nitrate at 1.0 %** | 66.810 d | 64.519 g | 1.860 e | 1.798 cd | 9.050 bc | 9.374 bc |
| **Potassium nitrate at 1.5 %** | 68.340 c | 68.464 bc | 1.787 f | 1.853 bc | 9.403 b | 8.950 cdef |
| **Potassium nitrate at 2.0 %** | 69.577 c | 68.682 bc | 1.977 bc | 1.896 ab | 8.340 ef | 8.914 cdef |
| **Mono Potassium phosphate at 1.0 %** | 68.953 c | 66.483 ef | 1.960 bcd | 1.890 ab | 8.517 de | 9.323 bcd |
| **Mono Potassium phosphate at 1.5 %** | 64.293 f | 67.315 de | 1.937 cd | 1.911 ab | 8.717 cd | 8.786 ef |
| **Mono Potassium phosphate at 2 %** | 63.993 f | 66.078 f | 1.727 f | 1.715 d | 10.027 a | 9.817 ab |
| **Potassium citrate at 1.0 %** | 65.403 def | 66.719 ef | 1.937 cd | 1.715 d | 8.453 de | 9.956 a |
| **Potassium citrate at 1.5 %** | 65.263 ef | 66.242 ef | 2.013 b | 1.858 bc | 8.093 fg | 8.934 cdef |
| **Potassium citrate at 2.0 %** | 73.720 a | 68.038 cd | 2.120 a | 1.924 ab | 7.870 g | 8.810 def |
| **Mono Potassium thiosulphate at 1.0 %** | 71.367 b | 69.280 ab | 1.937 cd | 1.948 a | 8.500 de | 8.666 f |
| **Mono Potassium thiosulphate at 1.5 %** | 69.683 c | 69.014 abc | 1.897 de | 1.858 bc | 8.750 cd | 9.214 cde |
| **Mono Potassium thiosulphate at 2.0 %** | 65.917 de | 67.126 def | 1.783 f | 1.728 d | 9.920 a | 9.972 a |

a, b, c…f Means are bearing different lettersin each column, differ significantly $P < 0.05$

recorded higher "yellowness*" color values than other treatments in the second season, while monopotassium phosphate at 2 %gave the lowest "yellowness*" color values compared to other treatments.

### *3.2. Fruit peel color (Chroma, Hue angle and Citrus Color Index)*

The increased availability of color-measuring instruments now makes possible a more objective notation of specimen colors. The influence of the different applications on the assessment parameter color is presented in table 5. These scales were measured to illustrate the influence of the tested applications on the homogeneity of the fruit color of Valencia oranges. The results revealed that the effect of potassium citrate at 2.0% was superior to that of potassium forms concentrations on Chroma color in the first season, but in the second season, the control gave the highest value in Chroma color/fruit. The hue angle observed with potassium citrate at 2.0% was superior to that of potassium source concentrations on hue angle in the first season, but in the second season, the monopotassium thiosulphate at 1.0% gave the highest value in hue angle. The control treatment gave the lowest hue angle, underscoring the importance of potassium supplementation in citrus cultivation.

After careful analysis of the data, it was found that, compared to all treatments in the seasons, monopotassium phosphate at 2%, monopotassium thiosulphate at 2.0%, and the control were superior to that of other treatments on Citrus Color Index (CCI) in the first season, but in the second season, potassium citrate at 1.0% and monopotassium thiosulphate at 2.0% gave the highest value in Citrus Color Index (CCI), while potassium nitrate at 2.0% had the lowest Citrus Color Index (CCI) in both seasons.

***3. Fruit weight loss and fruit juice characteristics***

In the experiment, the physical characteristics of fruits (fruit weight loss and fruit juice characteristics) in Valencia oranges changed between 2021 and 2022 as a result of the foliar treatments of different potassium sources in Table (3). The data show that, in both seasons, all applied treatments significantly improved fruit waste weight as compared to the control. The treatment of monopotassium phosphate at 2% exhibited higher values in both seasons. On the other hand, the lowest fruit waste weight at harvest was obtained from untreated trees in both seasons. In addition, there were no significant differences between potassium nitrate at 1.0% and 1.5% in fruit waste weight in both seasons.

Regarding fruit juice weight, fruit juice volume, and fruit juice net ratio, the treatment of potassium nitrate at 1.5% exhibited higher values for fruit juice weight, fruit juice volume, and fruit juice net ratio in the first season, and monopotassium phosphate at 1.5% exhibited higher values for fruit juice weight, fruit juice volume, and fruit juice net ratio in the second season. On the other hand, the lowest fruit volume at harvest was obtained from untreated trees in both seasons.

Regarding the fruit juice specific gravity, the control gave the highest fruit juice specific gravity in the first season, and potassium citrate at 1.5% exhibited a higher fruit juice specific gravity in the second season, indicating denser and potentially higher-quality fruit. In addition, there were no significant differences between different potassium sources in fruit juice specific gravity in the first season, and there were also no significant differences between potassium citrate at 2.0% and potassium nitrate at 2.0% in fruit juice specific gravity in the second season. Also, there were no significant differences between monopotassium phosphate at 2% and monopotassium thiosulphate at 1.5% in fruit juice fruit juice specific gravity in the second season.

**Table 3:** Effect of foliar spraying with different sources of potassium on fruit waste weight and fruit juice characteristics for Valencia orange in two seasons (2021/2022)

| Characters | Fruit waste weight (g) | | Fruit juice weight (g) | | Fruit juice volume $(cm)^3$ | | Fruit Juice Net Ratio | | Fruit Juice Specific Gravity | |
|---|---|---|---|---|---|---|---|---|---|---|
| Season / Treatments | 2021 | 2022 | 2021 | 2022 | 2021 | 2022 | 2021 | 2022 | 2021 | 2022 |
| **Control** | 94.153 i | 96.183 f | 56.860 f | 59.289 f | 55.953 f | 59.111 e | 37.657 b | 38.135 a | 1.0167 a | 1.0030 k |
| **Potassium nitrate at 1.0 %** | 128.427 h | 137.233 e | 90.687 a | 76.950 b | 89.847 a | 76.180 b | 41.387 a | 35.927 b | 1.0097 ab | 1.0101 j |
| **Potassium nitrate at 1.5 %** | 127.243 h | 137.517 e | 91.073 a | 72.983 c | 90.677 a | 70.794 c | 41.717 a | 34.670 bc | 1.0043 b | 1.0309 e |
| **Potassium nitrate at 2.0 %** | 147.587 d | 156.342 b | 71.947 cd | 78.436 b | 71.607 cd | 75.848 b | 32.773 d | 33.389 c | 1.0050 b | 1.0341 d |
| **Mono Potassium phosphate at 1.0 %** | 134.013 g | 138.283 e | 84.310 ab | 74.861 bc | 83.693 ab | 71.792 c | 38.610 b | 35.116 b | 1.0073 b | 1.0428 c |
| **Mono Potassium phosphate at 1.5 %** | 139.437 e | 137.183 e | 81.573 b | 89.172 a | 81.460 b | 87.389 a | 36.900 bc | 39.391 a | 1.0013 b | 1.0204 h |
| **Mono Potassium phosphate at 2 %** | 166.487 a | 165.817 a | 66.043 de | 75.972 bc | 65.813 de | 72.706 bc | 28.320 e | 31.420 d | 1.0037 b | 1.0449 b |
| **Potassium citrate at 1.0 %** | 134.993 fg | 148.283 c | 70.213 cd | 65.267 de | 69.843 cd | 63.635 d | 34.193 d | 30.564 d | 1.0053 b | 1.0256 f |
| **Potassium citrate at 1.5 %** | 153.033 c | 154.825 b | 80.690 b | 68.653 d | 80.203 b | 64.877 d | 34.520 cd | 30.720 d | 1.0060 b | 1.0582 a |
| **Potassium citrate at 2.0 %** | 155.570 b | 165.317 a | 76.940 bc | 64.211 e | 76.497 bc | 62.092 de | 33.083 d | 27.976 e | 1.0063 b | 1.0341 d |
| **Mono Potassium thiosulphate at 1.0 %** | 137.087 ef | 144.542 d | 68.003 d | 49.919 g | 67.587 de | 48.771 g | 33.133 d | 25.670 f | 1.0063 b | 1.0235 g |
| **Mono Potassium thiosulphate at 1.5 %** | 152.113 c | 155.958 b | 56.800 f | 55.764 f | 56.587 f | 53.366 f | 27.103 e | 26.338 f | 1.0040 b | 1.0449 b |
| **Mono Potassium thiosulphate at 2.0 %** | 146.483 d | 163.750 a | 60.187 ef | 50.417 g | 55.953 f | 49.660 g | 29.123 e | 23.541 g | 1.0053 b | 1.0152 i |

a, b, c…f Means are bearing different lettersin each column, differ significantly $P < 0.05$.

### *4. Fruit juice color*

Table 4 expresses the fruit juice color assessment (I) in numerical terms along the lightness (L* value); the (a*) “redness” color value, which indicates

**Table 4:** Effect of foliar spraying with different sources of potassium on fruit juice color (L*, a*, and b*) for Valencia orange in two seasons (2021/2022)

| Characters | Fruit Juice Color | | | | | |
|---|---|---|---|---|---|---|
| | L* | | a* | | b* | |
| Treatments \ Season | 2021 | 2022 | 2021 | 2022 | 2021 | 2022 |
| **Control** | 36.78 a | 35.95 a | -3.12 ef | -2.67 de | 14.48 a | 15.18 a |
| **Potassium nitrate at 1.0 %** | 33.62 b | 34.42 ab | -2.15 abc | -2.23 bcd | 12.93 abcd | 14.33 ab |
| **Potassium nitrate at 1.5 %** | 34.58 b | 34.07 abc | -2.00 abc | -2.07 bc | 14.23 a | 14.07 ab |
| **Potassium nitrate at 2.0 %** | 34.43 b | 34.40 abc | -2.40 cd | -2.77 e | 14.33 a | 14.60 ab |
| **Mono Potassium phosphate at 1.0 %** | 34.50 b | 35.05 ab | -1.78 ab | -2.42 cde | 13.93 ab | 14.68 ab |
| **Mono Potassium phosphate at 1.5 %** | 34.58 b | 33.97 abc | -1.98 abc | -2.37 cde | 12.92 abcd | 14.07 ab |
| **Mono Potassium phosphate at 2 %** | 34.02 b | 33.52 bc | -1.87 ab | -1.78 ab | 13.35 abcd | 13.87 b |
| **Potassium citrate at 1.0 %** | 34.12 b | 33.80 abc | -2.70 de | -2.20 bcd | 13.82 abc | 13.53 bc |
| **Potassium citrate at 1.5 %** | 34.12 b | 33.52 bc | -3.27 f | -2.57 de | 13.42 abcd | 11.95 d |
| **Potassium citrate at 2.0 %** | 33.85 b | 33.28 bc | -2.28 bcd | -1.82 ab | 12.65 bcd | 11.47 d |
| **Mono Potassium thiosulphate at 1.0 %** | 34.18 b | 32.23 c | -1.65 a | -1.57 a | 12.20 d | 11.77 d |
| **Mono Potassium thiosulphate at 1.5 %** | 33.88 b | 34.28 abc | -2.08 abc | -2.00 abc | 12.28 cd | 12.33 cd |
| **Mono Potassium thiosulphate at 2.0 %** | 33.95 b | 33.42 bc | -2.28 bcd | -2.00 abc | 12.55 bcd | 11.52 d |

a, b, c…f Means are bearing different lettersin each column, differ significantly P < 0.05.

the relative green (-) to red; and the (b*) "yellowness" color value, which indicates the relative yellow (+) to blue. Concerning the fruit juice color analyzed at the harvest time, it can be noticed that the applications used in this study led to lower averages for L* readings, indicating that the fruit juice of Valencia orange had a lighter coloration. In contrast, the highest average for L* reading was noticed in the control, showing that the color of the juice fruits presented a lower intensity. Additionally, all treatments with averages for L* reading during the first season showed no discernible effects, with the exception of the control.

Mono Potassium thiosulphate at 1.5% treatments recorded the highest (a*) "redness" color value, while the control was the lowest; the other treatments were intermediate between these two. In addition, there were no significant differences between different potassium nitrate at 1.0% and 2% and monopotassium thiosulphate at 1.5% in the (a*) "redness" color value in the first season, and there were also no significant differences between monopotassium phosphate at 1.0% and 1.5% in the (a*) "redness" color value in the second season.

Besides, the control treatment recorded higher "(b*) "yellowness" color values than other treatments in both seasons, while monopotassium thiosulphate at 1.0% gave the lowest "yellowness*" color values in the first season, and potassium citrate at 2.0% gave the lowest "yellowness*" color values in the second season.

Citrus juice is widely consumed due to its availability, high nutritional values, and desirable taste, odor, and color. Citrus juice contains water, vitamins, minerals, sugars (mainly sucrose, fructose & glucose), carbohydrates, acids, phytochemicals, and other organic compounds (Rampersaud and Valim, 2017).Furthermore, citrus juices are known as a good source of bioactive compounds such as various phenolic compounds, carotenoids, and flavonoids ( Xu *et al* . 2008). Mainly the content of anthocyanin's, carotenoids, pulps and some other chemicals determines and influences the color and turbidity of the juices.Consumers buy with their eyes" (Sandoval *et al* ., 2018). which means that the color is the first aspect of food products affecting the consumer's attraction; therefore, color is a determining factor in the food industry (Cortés *et al.*, 2008).

Potassium, one of the most significant macroelements, is highly mobile in plants. The beneficial effects of potassium as a foliar spray may be due to its ability to increase photosynthesis, decrease transpiration, increase energy compounds, stabilize cell membranes, encourage cell division and elongation, raise antioxidant levels, and increase the water potential and nutrient bioavailability of leaves (Tiwari, 2005). Through improving fruit peel color, fruit juice features, fruit juice color, fruit size, color, and juice content, as well as lowering fruit waste weight, potassium enhances the quality of fruit (Tiwari, 2005 and Ashraf *et al.*, 2010).

The results revealed that the effect of potassium citrate at 2.0% was superior to that of potassium form concentrations on chroma and hue angle. Peel color is one of the most important quality attributes of citrus fruit as a key factor for consumer acceptance. Peel color in citrus species and cultivars is the result of three main groups of pigments, including chlorophylls, carotenoids, and anthocyanins. The second group of pigments is carotenoids, providing yellow color in oranges and mainly restricted to the peel and flesh. The change of color and expression of color and carotenoid content genes in orange fruit was potassium forms. The positive effect of potassium citrate on the fruit peel color, fruit juice characteristics, and percentage of fruit juice and reduced fruit waste weight is due to the fact that citric acid plays a vital role in the plant metabolism (Sadak and Orabi, 2015).

Potassium sources in both seasons produced the highest fruit peel color and fruit juice characteristics at harvest. Abd El-Kader *et al.* (2010) reported that foliar sprays of potassium at a recommended rate increased fruit peel color and fruit juice characteristics of Clementine mandarin in a Mediterranean climate

The highest fruit peel color and fruit juice characteristics were produced by potassium sources in both seasons at harvest. Abd El-Kader *et al.* (2010) found that in a Mediterranean climate, foliar sprays of potassium at a recommended rate improved the color and characteristics of Clementine mandarin fruit peels and fruit juice. Potassium foliar spraying, especially at higher concentrations of potassium citrate, can improve Valencia oranges' fruit peel color, fruit juice properties, percentage of fruit juice, and specific gravity. Protecting plants from harm can extend the shelf life of fruits and improve the qualities of fruit juice. It is a non-enzymatic antioxidant that chelates free radicals (Awad *et al.* 2024). The increase in fruit juice volume with potassium fertilizer application can be associated with the vital roles of K in plants, in particular the role it plays in cell expansion that leads to the formation of a large central vacuole in fruit cells (Talaie, 2008).

Monopotassium phosphate is a reasonably priced fertilizer that may be used quickly to produce P and K (Barranco *et al.,* 2010). Pomegranate fruit output, fruit peel color, and fruit juice qualities were all improved by K and P fertilizers, whereas foliar K sprays had a significant effect. Mono-potassium thiosulphate is a foliar fertilizer used in citrus to correct potassium deficit and increase fruit quality. It has a good influence on fruit yield, fruit peel color, and fruit juice qualities (El-Salhy *et al.,* 2017).

Omaima-Hafez *et al.* (2017) found that the fruit's improved peel color and juice content were enhanced in Washington Navel orange trees due to potassium foliar application, which obtained results in this study by using different forms of potassium. It suggested that K activates about 60 enzymes that are involved directly/indirectly in many different physiological processes such as $CO_2$ assimilation, ATP synthesis, and photosynthesis (Lester *et al.,* 2010). These findings are supported by previous research highlighting potassium's role in fruit's peel color , juice content, and physical characteristics of fruits, which also increases citrus fruit quality (Wen *et al* . 2021, Mohamed *et al* . 2022, Barlas 2023, Awad *et al* . 2024, and Al-Sabbagh *et al.,* 2024).

**In conclusion**

Foliar application of different potassium sources significantly enhanced Valencia orange quality. Specifically, potassium citrate at 1.5% and 2.0% effectively improved peel and juice color parameters. Furthermore, monopotassium phosphate at 1.5% enhanced juice weight, volume, and juice ratio in both seasons.

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## تأثير مصادر البوتاسيوم على جودة اللون والعصير في البرتقال الفالنشيا

عصام محمد صلاح علام[١] - أسامة أحمد إبراهيم زقزوق[١] – نرمين اسماعيل النجار[١] - السيد حسن مصطفى قاعود[٢]

١- قسم الإنتاج النباتي، كلية التكنولوجيا والتنمية ، جامعة الزقازيق

٢- قسم البساتين، كلية الزراعة، جامعة قناة السويس

أجريت التجربة الحقلية خلال موسمي ٢٠٢١/٢٠٢٠ و٢٠٢٢/٢٠٢١ على أشجار برتقال فالنشيا عمرها ١٠ سنوات مطعمة على أصل فولكامارينا. زُرعت الأشجار المختارة في بستان خاص يقع في وادي الملاك بمحافظة الإسماعيلية - مصر. كان الغرض من البحث هو تحديد كيفية تأثير الرش الورقي لبرتقال فالنشيا بمصادر مختلفة

من البوتاسيوم على لون القشرة والعصير ووزن مخلفات الثمار وصفات عصير الثمار. أظهرت نتائج هذه الدراسة أن الرش الورقي لمصادر مختلفة من البوتاسيوم أثر بشكل كبير على لون القشرة والعصير ووزن مخلفات الثمار وكذا صفات عصير ثمار برتقال فالنشيا. كانت المعاملة بسترات البوتاسيوم بنسبة ١.٥ و ٢.٠٪ فعالة بشكل خاص في تحسين شدة لون القشرة ومعايير لون القشرة والعصير( Lو a و b وزاوية اللون والكروما) وكثافة العصير وجودته. ، كما أدى إضافة فوسفات أحادي البوتاسيوم بتركيز ١.٥% إلى تحسين وزن العصير وحجمه ونسبة العصير في الموسمين الأول والثاني على التواليا.

**التوصية:** من نتائج هذة التجربة نوصى برش مختلف مصادر البوتاسيوم على اشجار البرتقال الفالنشيا لتحسين لون وكثافة لون قشرة الثمرة وإيضا جودة الثمار

**كلمات مفتاحية:**البرتقال فالنشيا، مونوبوتاسيوم فوسفات،سترات البوتاسيوم، . القشرة،العصير