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# Effect of Organic Fertilization with Moringa Oleifera Seeds Cake and Compost on Storability of Valencia Orange Fruits

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**Abstract**

This study was carried out during two successive seasons 2017/2018 and 2018/2019 at the experimental research station of National Research Centre at Nubaria, El Behera governorate, Egypt. The work aimed to test the effect of moringa seeds cake and compost on Valencia orange (*Citrus sinensis* L. Osbeck) fruit quality during cold storage. Treatments included; moringa seed cake 100% (3 tons/fed), compost 100% (3 tons/fed), 1 moringa seed cake: 1 compost, 1 moringa seed cake: 2 compost, 2 moringa seed cake: 1 compost and control without moringa seed cake or compost. Results showed that, application of Valencia orange trees by moringa seeds cake at 100% or in combination with compost at 2:1 ratio significantly improved fruit quality at the harvest. In addition, these treatments significantly reduced weight loss percentage and firmness deterioration of fruits during storage. Moreover, delayed the changes of fruit weight loss percentage, color values (L* and h°), firmness, juice percentage, TSS: TA ratio, ascorbic acid and carotene content. Therefore, it could be recommended that fertilizing with moringa seeds cake as a natural organic fertilizer source for substitution of some chemical fertilizers, besides its positive role in improving the fruit quality at the harvest and during storage period.

*Keywords*: Valencia orange, organic fertilization, moringa seed cake, compost, fruit quality and cold storage.

## 1. Introduction

Citrus is considered as one of the premier fruit crops all over the world, both in terms of planting area and production. Egypt is ranking as the sixth largest producer of orange throughout the world after Brazil, China, US, EU, and Mexico according to Ministry of Agriculture and Land Reclamation [1], also considered the largest exporter of orange in the world [2]. The cultivated area reached to (204095 ha) representing about 29 % of the total fruit area (700854 ha), the total fruitful area of citrus reached about (175734 ha) approximately, which produce about 4272886 metric tons, from which around 1.34 million tons are exported according to the report prepared by the Ministry of Agriculture and Land Reclamation of Egypt, 2018.

Valencia orange trees (*Citrus sinensis* L. Osbeck) have high economic values and considered one of the most important suitable cultivars for exportation and industry in Egypt, because it is medium size with excellent quality and usually matures from February to July [3].

Fertilization is the most important inputs which directly affect the tree growth, yield and fruit quality. Citrus tree needs to fertilizers in large amounts but fairly expensive to supply. Using mineral fertilizers causes serious environmental problems that lead to pollution of soil and water due to the easily loss in the field. In addition, the accumulation of harmful residual substances in fruits which reflected on human health, so organic sources and natural raw materials have received much attention from growers and researchers. Recent approaches have included the use of organic material such as organic manures, compost, biofertilizers and plants extracts to improve productivity and access to safe fruits for local consumer and high exportation potential as well as reduce the costs. Several studies were done for producing citrus fruits through avoid application of all or part of chemical fertilizers and encouraging the

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application of organic [4, 5, 6, 7]. Fertilization has influence on the chemical content of citrus fruit and its storability. A few studies were done to study the effect of organic fertilizers applications on orange fruit quality during cold storage [8, 9, 10, 11].

Therefore, the purpose of this study was to test the effect of moringa seeds cake and/or compost on Valencia orange fruit quality during cold storage at 5 ± 1°C and RH 90-95%

## 2. Experimental

### *2.1. Plant material*

This study was carried out during 2017/2018 and 2018/2019 seasons on 12-year-old Valencia orange trees (*Citrus sinensis* L. Osbeck) budded on Volkamer lemon (*Citrus volkameriana* L.) rootstock. Trees were planted at 3 x 4 m (350 trees fed $^{-1}$) grown in sandy soil under drip irrigation system at the experimental research station of National Research Centre at Nubaria, El Behera governorate, Egypt. Mechanical and chemical properties of the experimental soil are presented in Table (1).

Twenty four trees uniform in vigour growth and fertilized by farmyard manure at the rate of 3 tons/fed (recommended rate of the organic fertilization program in the station) and received the same horticultural practices commonly adopted on the orchard, except for the purpose of this study. The experiment followed complete randomized block design, each treatment replicated four times with one tree per replicate.

### *2.2. Treatments*

The experiment included six organic fertilization treatments as follows:

1. Moringa seed cake (MC) 100% (3 tons/fed).
2. Compost (COM)100% (3 tons/fed)
3. 1 Moringa seed cake (MC): 1 Compost (COM).
4. 1 Moringa seed cake (MC): 2 Compost (COM).
5. 2 Moringa seed cake (MC): 1 Compost (COM).
6. Control: None moringa seed cake and none compost.

Farmyard manure, compost and moringa seed cake were added in December of both seasons in trenches close to the root system under the tree canopy after mixed with part of surface soil and followed by irrigation. Physical and chemical properties of moringa seed cake, compost and farmyard manure are shown in (Table 2).

At harvest time, fruits uniform in shape, weight, colour and size were picked from each replicate separately by clipper to reduce any mechanical injuries and packed in plastic boxes and transported directly to laboratory of Agriculture Development Systems (ADS) project at Faculty of Agriculture, Cairo University. Fruits were washed with tap water to remove the adherent particles of the dirt and foreign materials and dipped in 1% Clorox solution and air dried then packed in carton boxes (3 Kg each and measures 43×33×9 cm) in one layer and each treatment represented by four boxes. All boxes were stored at 5±1°C and 90-95% relative humidity (RH). The fruit quality parameters were evaluated every 2 weeks of cold storage till 8 weeks.

### *2.3. Parameters*

#### *2.3.1. Fruit weight loss percentage (FWL %)*

The boxes of fruits were weighed before cold storage to get the initial weight, and then weighed after each period of cold storage. Fruits weight was recorded and then percentages of weight loss were calculated according to the following equation

$$FWL\% = \frac{(Wi - Ws)}{Wi}\ x\ 100$$

Where Wi = fruit weight at initial period and Ws = fruit weight at sampling period.

#### *2.3.2. Fruit color*

Lightness (L*) and hue angle (h°) were estimated using Minolta Calorimeter (Minolta Co. Ltd.,Osaka, Japan) as described by Mc Gire [12].

#### *2.3.3. Fruit firmness (Lb\in$^2$)*

Fruit firmness was determined as Lb/in$^2$ by using fruit pressure tester model FT 327 (327 Lbs).

#### *2.3.4. Juice percentage*

Fresh fruits were ground in an electric juice extractor for freshly prepared juice, then juice weight and percentage of juice was evaluated.

#### *2.3.5. Total soluble solids (TSS): Titratable acidity (TA) ratio*

Total soluble solids percentage was determined in fruit juice using Digital refractometer PR32 (Atago Palete ATago.CO .LTD. Japan); titratable acidity percentage was determined by titrating the juice against 0.1 N sodium hydroxide using phenolphthalein as an indicator and expressed as gm of citric acid /100 ml juice according to AOAC [13] and then the TSS: TA ratio was calculated.

#### *2.3.6. Ascorbic acid content (vitamin C)*

Ascorbic acid content was determined by using 2.6 dichlorophenol indophenol dye 2% oxalic as subtract. Vitamin C content was calculated as mg /100 ml juice according to AOAC [13].

#### *2.3.7. Carotene content (mg/100 ml juice)*

Carotene content of fruits juice was extracted by direct dipping of 10 gm of blended fruit pulp into solution containing (40 ml acetone, 60 ml hexane and 0.1 g Mg $Co_3$ and blended for 5 minutes. It was determined by colorimeter according to according to AOAC [13].

Statistical analysis

The treatments were arranged as experiment in a randomized complete design. All data were subjected to statistical analysis according to the procedures reported by Snedecor and Cochran [14] and means were compared by Duncan's multiple range tests at the 5 % level of probability according to Duncan [15] in the two seasons of experimentation.

**Table 1: Mechanical and chemical properties of the experimental soil**

| Mechanical analysis % | | | | | |
|---|---|---|---|---|---|
| **Sand** | **Silt** | **Clay** | **Texture** | | |
| 84.2 | 11.8 | 4.0 | Loamy sand | | |
| **Chemical soil characteristics** | | | | | |
| **pH** | **EC $dSm^{-1}$** | **$CaCO_3$ %** | **O.M. %** | | |
| 7.79 | 1.6 | 2.0 | 3.54 | | |
| **Available macronutrients (%)** | | | **Available micronutrients (ppm)** | | |
| N | P | K | Fe | Zn | Mn |
| 0.78 | 0.32 | 0.46 | 8.8 | 4.2 | 3.2 |
| **Soluble cations (me/l of soil past extract)** | | | **Soluble anions (me/l of soil past extract)** | | |
| **$Ca^{++}$** | **$Mg^{++}$** | **$Na^{+}$** | **$K^{+}$** | **$CO_3^{--}+HCO_3^{-}$** | **$Cl^{-}$** | **$So_4^{--}$** |
| 8.7 | 4.0 | 2.3 | 1.0 | 0.52 | 11.48 | 4.0 |

**Table 2: Physical and chemical properties of moringa seed cake, compost and farmyard manure**

| Properties | Moringa seed cake | Compost | Farmyard manure |
|---|---|---|---|
| **Moisture content (%)** | 4.9 | 25 | 29.5 |
| **pH** | 5.5 | 7.5 | 6 |
| **EC (dS/m)** | 1.3 | 1.5 | 1.4 |
| **Organic matter (%)** | 92.7 | 57 | 25.5 |
| **C/N ratio** | 7.08 | 18.01 | 13.20 |
| **Macro element (%)** | | | |
| **Total Nitrogen** | 3.8 | 1.4 | 0.85 |
| **Phosphorus** | 0.61 | 2.82 | 0.14 |
| **Potassium** | 0.7 | 0.3 | 0.22 |
| **Magnesium** | 0.31 | 0.47 | 0.25 |
| **Micro element (ppm)** | | | |
| **Zinc** | 18.8 | 378.8 | 18 |
| **Iron** | 12.5 | 26 | 15 |
| **Manganese** | 40 | 30 | 37 |

## 3. Results

*3.1. Fruit weight loss percentage*

Results in Table (3) cleared that, the weight loss percentage increased with extending cold storage periods. Normally this occurs during the fruit storage due to respiratory process, the transference of humidity and some processes of oxidation [16]. After 8 weeks of storage, the application of moringa seed cake and compost at 2: 1 ratio recorded the lowest significant percentage of fruit weight loss (5.10 and 4.82 %) in both seasons, respectively as compared with control which had the highest percentage of fruit weight loss (8.78 and 6.49%) in the first and second seasons, respectively.

*3.2. Fruit color*

*3.2.1. Lightness (L*)*

Results in Table (4) show that, the lightness (L*) was gradually decreased towards at the end of the storage period (after 8 weeks). At the end of storage period, the application of moringa seed cake and compost at 2: 1 ratio and moringa seed cake and compost at 1:2 ratio gave the highest values of L* in the first and second seasons, respectively. On the other hand, moringa seed cake 100% treatment exhibited the lowest value of L* in the both seasons.

*3.2.2. Hue angle (hº):*

The hue angle (hº) was decreased (increase density of orange colour) with the advance in cold storage period. At the end of storage period, significant differences between all treatments were observed in the two seasons. Treatment with moringa seed cake and compost at 2: 1 ratio gave the lowest value of hº

(high density of orange colour) in the two seasons. On the other hand, the highest values were recorded with control in both seasons (Table 5).

**Table 3: Effect of organic fertilization with Moringa oleifera seeds cake and compost on weight loss percentage of Valencia orange fruits during cold storage at 5 ± 1°C and RH 90-95%**

Where: MC (Moringa seed cake) and COM (Compost).

| Treatments | First season | | | | | Second season | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Storage periods (weeks) | | | | | Storage periods (weeks) | | | | |
| | 0 | 2 | 4 | 6 | 8 | 0 | 2 | 4 | 6 | 8 |
| **100% MC** | 0 | 2.37B | 4.01B | 5.86B | 7.20B | 0 | 1.47D | 2.63D | 4.08D | 5.06C |
| **100% COM** | 0 | 2.16C | 3.53C | 5.03C | 5.97C | 0 | 1.82B | 3.26B | 5.00B | 6.11B |
| **1 MC: 2 COM** | 0 | 1.97D | 3.31D | 4.95C | 5.96C | 0 | 2.01A | 3.38B | 4.73C | 6.11B |
| **1 MC : 1 COM** | 0 | 1.78E | 3.08E | 4.60D | 5.53D | 0 | 1.61C | 2.86C | 4.20D | 5.08C |
| **2 MC :1 COM** | 0 | 1.62F | 2.79F | 4.17E | 5.10E | 0 | 1.62C | 2.75CD | 4.07D | 4.82D |
| **control** | 0 | 3.03A | 4.83A | 6.27A | 8.78A | 0 | 2.06A | 3.56A | 5.34A | 6.49A |

**Table 4: Effect of organic fertilization with Moringa oleifera seeds cake and compost on L* of Valencia orange fruits during cold storage at 5 ± 1°C and RH 90-95%**

| Treatments | First season | | | | | Second season | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Storage periods (weeks) | | | | | Storage periods (weeks) | | | | |
| | 0 | 2 | 4 | 6 | 8 | 0 | 2 | 4 | 6 | 8 |
| **100% MC** | 67.82C | 67.41C | 66.90A | 58.22D | 55.55E | 69.00C | 66.83BC | 65.61B | 59.19D | 58.72C |
| **100% COM** | 65.94D | 65.72E | 64.85D | 62.41C | 62.08CD | 66.53D | 65.35D | 64.88B | 64.70A | 61.89AB |
| **1 MC: 2 COM** | 66.12D | 65.73E | 63.10E | 62.07C | 62.00D | 67.21D | 66.18C | 65.13B | 64.71A | 61.08B |
| **1 MC : 1 COM** | 69.12B | 67.83B | 65.13CD | 62.44C | 62.24C | 78.18A | 70.98A | 64.15C | 63.17B | 62.24A |
| **2 MC :1 COM** | 67.97C | 66.93D | 66.37B | 66.00A | 65.18A | 66.67D | 66.17C | 63.76C | 60.74C | 55.20D |
| **control** | 72.71A | 70.18A | 65.51C | 64.86B | 62.45B | 70.17B | 66.96B | 66.38A | 59.40D | 58.94C |

Where: MC (Moringa seed cake) and COM (Compost).

**Table 5: Effect of organic fertilization with Moringa oleifera seeds cake and compost on hº of Valencia orange fruits during cold storage at 5 ± 1°C and RH 90-95%**

| Treatments | First season | | | | | Second season | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Storage periods (weeks) | | | | | Storage periods (weeks) | | | | |
| | 0 | 2 | 4 | 6 | 8 | 0 | 2 | 4 | 6 | 8 |
| **100% MC** | 80.72B | 75.71D | 73.27E | 71.19D | 64.46C | 83.15B | 80.42A | 74.71C | 74.09B | 69.76D |
| **100% COM** | 81.24A | 78.37B | 74.48C | 74.36B | 67.9B | 80.22D | 76.74D | 76.00B | 75.65A | 70.38C |
| **1 MC: 2 COM** | 79.34D | 76.72C | 75.50B | 75.43A | 68.32B | 82.82C | 79.69C | 73.47D | 72.20E | 66.87E |
| **1 MC : 1 COM** | 80.66B | 75.23D | 74.34CD | 69.16E | 67.77B | 79.1E | 74.80F | 73.58D | 73.57C | 71.06B |
| **2 MC :1 COM** | 78.32E | 76.31C | 76.27A | 75.27A | 64.06C | 77.66F | 75.20F | 74.69C | 71.74F | 63.91F |
| **control** | 80.18C | 78.95A | 74.14D | 73.57C | 70.94A | 83.30A | 80.08B | 77.05A | 73.05D | 73.00A |

Where: MC (Moringa seed cake) and COM (Compost).

*3.3. Fruit firmness*

Data shown in Table (6) illustrated that fruit firmness declined towards the end of storage period. After 8 weeks of storage, the highest firmness values were obtained by moringa seed cake 100% and moringa seed cake and compost at 2:1 ratio in the first season without different significant between them and moringa seed cake and compost treatment at 1:1 ratio in the second seasons. On contrast, the least values of firmness recorded by control (11.30 Lb\inch$^2$) during the first and the second seasons.

*3.4. Juice percentage*

Juice percentage of stored fruits as shown in Table (7) decreased significantly with the extended of storage periods during two seasons. At the end of storage period (8 weeks) as previously fruits treated by moringa seed cake and compost at 1:2 detected the

highest juice percentage in the both seasons. On the contrary, control had the lowest value of juice % as compared with the other treatments during first and second seasons.

**Table 6: Effect of organic fertilization with Moringa oleifera seeds cake and compost on fruit firmness of Valencia orange fruits during cold storage at 5 ± 1°C and RH 90-95%**

| Treatments | First season | | | | | Second season | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Storage periods (weeks) | | | | | Storage periods (weeks) | | | | |
| | 0 | 2 | 4 | 6 | 8 | 0 | 2 | 4 | 6 | 8 |
| **100% MC** | 25.10C | 24.80B | 19.00C | 14.30C | 12.10A | 26.70A | 25.20B | 16.00D | 13.90C | 11.60C |
| **100% COM** | 26.00A | 25.30A | 25.30A | 15.20A | 11.40C | 26.00B | 24.30D | 21.00B | 14.60B | 11.40D |
| **1 MC: 2 COM** | 25.60B | 25.40A | 19.00C | 14.70B | 11.70B | 26.10B | 25.10B | 20.00C | 15.00A | 12.10A |
| **1 MC : 1 COM** | 26.10A | 24.90B | 21.00B | 14.10D | 11.60B | 25.40D | 25.40A | 20.00C | 12.10D | 11.80B |
| **2 MC :1 COM** | 24.80D | 24.80B | 18.00D | 14.80B | 12.10A | 25.70C | 25.10B | 22.00A | 13.90C | 11.40D |
| **control** | 25.40B | 25.40A | 21.00B | 15.10A | 11.30C | 25.70C | 24.80C | 20.00C | 14.60B | 11.30E |

Where: MC (Moringa seed cake) and COM (Compost).

**Table 7: Effect of organic fertilization with Moringa oleifera seeds cake and compost on juice percentage of Valencia orange fruits during cold storage at 5 ± 1°Cand RH 90-95%**

| Treatments | First season | | | | | Second season | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Storage periods (weeks) | | | | | Storage periods (weeks) | | | | |
| | 0 | 2 | 4 | 6 | 8 | 0 | 2 | 4 | 6 | 8 |
| **100% MC** | 61.12E | 58.33B | 49.61B | 37.37D | 35.34D | 65.24C | 53.11D | 49.66E | 42.15F | 35.06E |
| **100% COM** | 64.65C | 57.60C | 54.04A | 44.06B | 39.48B | 66.71B | 55.00C | 49.60E | 43.33D | 39.32B |
| **1 MC: 2 COM** | 61.98D | 55.20D | 47.95C | 47.47A | 39.83A | 66.05B | 60.30A | 54.22B | 50.12A | 47.47A |
| **1 MC : 1 COM** | 51.52F | 52.68F | 39.52F | 38.87C | 38.36C | 55.97D | 55.18C | 50.99D | 42.86E | 38.98C |
| **2 MC :1 COM** | 66.96B | 54.89E | 46.54D | 44.19B | 38.57C | 68.46A | 58.01B | 52.11C | 43.55C | 35.48D |
| **control** | 68.54A | 58.56A | 40.22E | 35.66E | 35.06E | 68.00A | 60.10A | 55.17A | 49.11B | 34.43F |

Where: MC (Moringa seed cake) and COM (Compost).

*3.5. SSC: TA ratio in fruit juice*

Regarding the changes in SSC: TA ratio during cold storage period, the results revealed that there was an increase until the 6$^{th}$ week storage and then steadily decreased up to 8 week in two seasons (Table 8). SSC: TA ratio was affected significantly as result of pre-harvest treatments. After 8 weeks of storage, Valencia orange fruits from trees treated with moringa seed cake and compost at 2: 1 and moringa seed cake 100% treatments gave the highest significant differences in the two seasons, respectively. While treatment with compost 100% and control treatments recorded the least values in the first and second seasons, respectively.

**Table 8: Effect of organic fertilization with Moringa oleifera seeds cake and compost on SSC: TA ratio ofValencia orange fruits during cold storage at 5 ± 1°C and RH 90-95%**

| Treatments | First season | | | | | Second season | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Storage periods (weeks) | | | | | Storage periods (weeks) | | | | |
| | 0 | 2 | 4 | 6 | 8 | 0 | 2 | 4 | 6 | 8 |
| **100% MC** | 11.11B | 10.54D | 14.00A | 18.04B | 10.27CD | 11.33A | 11.74C | 12.43C | 18.75C | 11.83A |
| **100% COM** | 11.77A | 11.11C | 14.04A | 18.23B | 10.07D | 9.76C | 12.63B | 13.26B | 22.88A | 10.58C |
| **1 MC: 2 COM** | 9.89D | 12.17B | 13.23B | 15.16D | 10.38C | 9.45D | 12.50B | 14.92A | 16.38D | 10.95B |
| **1 MC : 1 COM** | 9.01F | 12.05B | 12.60C | 18.88A | 10.88B | 10.52B | 13.24A | 14.63A | 14.85E | 10.94B |
| **2 MC :1 COM** | 10.20C | 12.50A | 13.86A | 18.16B | 11.46A | 10.50B | 11.75C | 13.51B | 20.60B | 10.42C |
| **control** | 9.72E | 11.00C | 12.73C | 16.73C | 11.07B | 10.63B | 12.63B | 12.73C | 15.00E | 9.37D |

Where: MC (Moringa seed cake) and COM (Compost).

*3.6. Ascorbic acid content*

Ascorbic acid content (vitamin C) degradation with advance cold storage duration, because unstable under the inclement storage conditions in terms of light, temperature, humidity and diseases [17]. It is clear from the tabulated data in Table (9) that Ascorbic acid content decreased with the advance in cold storage period. The highest value (51.22 and 54.45 %) was recorded in Valencia orange fruits from trees treated with moringa seed cake and compost at 2:1 in the first season and moringa seed cake 100% treatment in the second season. On the other hand, Valencia orange fruits from trees treated with compost 100% treatment exhibited least values (41.37 and 46.44 %) in the two seasons, respectively.

**Table 9: Effect of organic fertilization with Moringa oleifera seeds cake and compost on Ascorbic acid content of Valencia orange fruits during cold storage at 5 ± 1°C and RH 90-95%**

| Treatments | First season | | | | | Second season | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Storage periods (weeks) | | | | | Storage periods (weeks) | | | | |
| | 0 | 2 | 4 | 6 | 8 | 0 | 2 | 4 | 6 | 8 |
| **100% MC** | 68.20C | 67.20D | 59.60C | 49.14D | 43.34D | 70.38C | 70.20A | 56.76B | 56.10B | 54.45A |
| **100% COM** | 68.20C | 65.10E | 50.31E | 41.72E | 41.37E | 71.91B | 66.00C | 62.70A | 58.50A | 46.44E |
| **1 MC: 2 COM** | 71.40B | 71.30A | 68.54A | 54.99A | 45.31C | 73.44A | 62.70D | 54.18C | 47.52E | 46.80D |
| **1 MC : 1 COM** | 71.40B | 68.20C | 59.60C | 51.48C | 45.31C | 71.91B | 66.00C | 56.73B | 52.65C | 49.50B |
| **2 MC :1 COM** | 77.78A | 69.30B | 66.65B | 53.82B | 51.22A | 71.91B | 69.30B | 54.18C | 47.85D | 47.52C |
| **control** | 71.30B | 67.20D | 53.64D | 51.22C | 49.14B | 70.38C | 58.50E | 49.50D | 47.85D | 47.42C |

Where: MC (Moringa seed cake) and COM (Compost).

*3.7. Carotene contents*

As clear in Table (10), carotene contents of stored orange fruits were not significantly affected by treatments in the most cases. Treatment with moringa seed cake and compost at 2:1 exhibited the highest values in the two seasons, while the control treatment exhibited the lowest values in the both seasons.

## 4. Discussion

In this work, pre-harvest organic fertilization by moringa oleifera seeds cake and compost resulted in a significant maintaining quality of Valencia orange fruits tell 8 weeks under cold storage compared to control, especially moringa seeds cake at 100% or combined application of moringa seeds cake and compost at 2:1 ratio. This may be due to the contents of moringa cake, which is obtained after extracting the moringa oil from seeds by the method of cold pressing. It is rich in protein content about 60% and contains all the essential amino acids; phenylalanine, valine, threonine, tryptophan, isoleucine, methionine, leucine, leucine, cysteine (or sulfur-containing amino acids), tyrosine (or aromatic amino acids), histidine and arginine [18].

**Table 10: Effect of organic fertilization with Moringa oleifera seeds cake and compost on Carotene contents of Valencia orange fruits during cold storage at 5 ± 1°Cand RH 90-95%**

| Treatments | First season | | | | | Second season | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Storage periods per weeks | | | | | Storage periods per weeks | | | | |
| | 0 | 2 | 4 | 6 | 8 | 0 | 2 | 4 | 6 | 8 |
| **100% MC** | 0.144A | 0.119AB | 0.110A | 0.044A | 0.032A | 0.157A | 0.122AB | 0.090B | 0.077A | 0.050A-C |
| **100% COM** | 0.145A | 0.125AB | 0.091BC | 0.054A | 0.033A | 0.151AB | 0.132A | 0.096AB | 0.082A | 0.054A-C |
| **1 MC: 2 COM** | 0.142A | 0.109B | 0.099AB | 0.054A | 0.034A | 0.145AB | 0.111BC | 0.099AB | 0.072A | 0.044BC |
| **1 MC : 1 COM** | 0.158A | 0.126AB | 0.112A | 0.058A | 0.037A | 0.159A | 0.131A | 0.110A | 0.080A | 0.059AB |
| **2 MC :1 COM** | 0.159A | 0.137A | 0.112A | 0.057A | 0.038A | 0.160A | 0.133A | 0.111A | 0.081A | 0.064A |
| **control** | 0.141A | 0.112B | 0.078C | 0.044A | 0.029A | 0.138B | 0.101C | 0.088B | 0.065A | 0.037C |

Where: MC (Moringa seed cake) and COM (Compost).

In addition, the moringa seed cake acts as a coagulant due to positively charged, water-soluble proteins, which bind with negatively charged particles (silt, clay, some minerals, bacteria, etc.) allowing soil regeneration and improving plant fertilization through releasing the nutrients into the soil in a form that plants can easily absorb, activating soil microorganisms and increasing microbes that can increase soil aeration, which will help the decomposition processes of organic matter which will

promote higher plant growth within a short period of its application as compared to other organic matters from animal manure and plant compost that require long periods for decomposition and cautious use [19]. It is generally accepted that moringa seed cake increased the mineral content of the soil. These results are on the line with Emmanuel et al. [20]. This in turn increased the quality of Valencia orange fruits at harvesting and continues keeping fruits in good quality along the storage periods. The combination of compost and moringa seed cake led to beneficial effects on the physical, chemical, biochemical and biological properties of the soil. It helped in increasing the efficiency of the moringa seed cake on improving the quality fruit of treated trees not only through increase the organic matter in the soil and an improved moisture-holding capacity of the soil [21], but also by increase the available phosphorus and the exchangeable potassium, calcium and the other micro-elements, through its effect on soil pH, encourages proliferation of soil microorganisms, increases microbial population and activity of microbial enzymes [22].

The loss of water from fresh fruit after harvest is a serious problem, causing shrinkage and fruit weight loss and influence on its storability. The results indicated that combined application of moringa seed cake plus compost was more effective in reducing fruit weight loss percentage of Valencia orange fruits during storage at 5±1°C with 90 – 95 % RH for 8 weeks may be due to the integration of compost and moringa seed cake, which might have accelerated the better uptake and accumulation of Ca and P. It has been observed that when organic status of the soil was increased, it would also have helped to certain extent the maintenance of cell wall turgidity as the Ca is one of the important constituents of cell wall. This reduce dehydration in fruits, reduce water loss, retain the shrivelling of the fruit skin, delay the fruit ripening, and thereby delay the decline in fruit quality. The obtained results are in line with those found by Ennab et al. [6]; Candir et al. [10]; El Sayed and El Sherif [23] who reported that, organic fertilization before harvest producing fruit with high quality at harvest time and help to maintaining the quality of Washington navel oranges during cold storage.

There is now a growing demand for sound, ecologically compatible and environmental friendly techniques in agriculture, capable of providing enough food for the increasing human population; retaining soil quality and improving the quality and quantity of agricultural produce [24, 25, 26, 27]. Moreover, in organic systems, soil management involves the use of mowed or tilled cover crops, animal manures, composts and the application of organic fertilizers which increase soil-organic matter whilst provide a steady release of nutrients to the crops as the organic matter breaks down. Exogenous organic matter applications are known to improve chemical and physical properties of sand soil, soil water retention and biological functions [28, 29]. This may be interprets the positive role of organic fertilization with moringa seed cake and compost in improving of fruits quality at harvest and during storage period.

Moringa oleifera seed cake is one of such alternative, being investigated to ascertain its effect on growth and yield of crops and thus can be promoted among farmers as a possible supplement or substitute to inorganic fertilizers [30] and attains zero waste in agriculture production and thus better soils management [31]. Also, it can be added to inorganic materials to replenish the soil and improve plant fertilization and obtain on healthier crops and better yield. The process also reduces the quantity of chemical fertilizer which will be used thereby leading to lower production cost and indirectly increase income, but this needs to be studied.

## 5. Conclusions

Through the previous results it could be concluded that the fertilization of Valencia orange with moringa oleifera seeds cake and compost led to improve soil chemical and physical properties. This reflected on improving fruit quality and maintaining fruit colour, firmness, juice percentage, SSC: AT ratio, carotene contents and Ascorbic acid in the highest levels and reducing weight loss percentage during cold storage period till 8 weeks especially combined application of moringa seeds cake and compost at 2:1 ratio.

## 6. Conflicts of interest

The authors declare that they have no conflict of interest.

## 7. Formatting of funding sources

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## 8. References

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