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# Evaluation of Washington Navel Orange Economic Indicators

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## Abstract

In Egypt, oranges are the most important citrus crops for local consumption or export. It represents approximately 72.2% of the total Egyptian citrus production in 2019/2020. The main cultivated variety of orange is the Washington navel orange and it is more popular because of its delicious taste, nutrition, and its seedless besides being rich in vitamin C. Washington navel orange is susceptible to fruit cracking, and it is a common physiological disorder that takes place during fruit development. This work aims to investigate the negative effect of fruit cracking in reducing the yield and quality of Washington navel orange produced in Egypt by studying major economic indicators and estimating an economical evaluation of using treatment of Washington navel orange during the period time of 2007/2008 until 2019/2020. Results showed that fruit areas and production of Washington navel orange represented about 52.9% and 53.2% of fruit areas and production of orange during the study period. However, the yield was unstable with a significant annual growth rate of about 1.1%. Also, the last mentioned treatment achieved a high price for farmers by about 5.1% and total revenue of about 3.2% during the study period. Nowadays, Egypt has become the largest exporter of oranges in the world within the last year and the achieved earnings reached $661 million in 2019/2020. In addition, results showed that evaluation of using a treatment to reduce the rate of Washington navel orange cracking was economical to be applied.

## Keywords

Washington Navel Oranges, Economic Indicators, Fruit Cracking, Revenue

## 1. Introduction

In Egypt, citrus has nutritional and economic values, whether for local consumption or for export, which represents the main source of foreign currencies. Citrus produced about 4.25 million tons from cultivated areas and reached about 0.42 million feddans[1] in 2019/2020 [1]. In 2019/2020, around 1.8 million tons were exported worth about $661 million [2].

Oranges are the most important citrus crops and produced about 3.1 million tons, representing about 72.2% of the total Egyptian citrus production in 2019/2020. [3] expected that orange domestic consumption will increase to reach 1.55 million tons in 2020/2021 as a result of the higher demand by consumers during the COVID-19 pandemic due to its high content of vitamin C. Egypt produces many varieties of orange. However, navel orange and valencia orange are the top Egyptian orange varieties for export which comprise the vast majority of citrus exports about 94% of the Egyptian citrus exported varieties [3] [4] [5].

Washington navel orange (*Citrus sinensis* (L.) Osbeck) is the main cultivated variety of navel orange and more popular citrus in Egypt because of its delicious taste, nutrition, and its seedless, besides being rich in vitamin C and minerals and low prices compared to other fruits [6] [7] [8] [9]. The maturity period for Washington navel orange starts from mid-October to March approximately [9]. The cultivated areas of Washington navel orange reached about 0.145 million feddans, representing about 49.7% of orange cultivated areas, producing about 1.6 million tons in 2019/2020 [1].

Fruit cracking is a common physiological disorder that takes place while the fruit is developing and it may be found in a variety of fruits, including pomegranate, plum, citrus, grape, sweet cherry, tomato, and apple [10]. Fruit cracking causes severe economic losses for many fruits due to surface cracks of the peel to reduce marketability [11] [12] because cracking has a negative impact on the appearance and quality of the fruit. Furthermore, during storage, cracked fruit is exposed to varying degrees of fungal and bacterial infections, which shortens the fruit's expiration date. Fruit cracking typically occurs during the rapid growth phase of the fruit or when it rains near harvest time [12].

Citrus fruit cracking is one of the most serious problems that suffered by growers, where the crack usually starts at the blossom end of the citrus, which is the weakest point in the peel [13]. In addition, [14] [15] reported that citrus fruit cracking is caused not only by genetic factors but also by environmental factors such as light, temperature, humidity, nutrient management, irregular water supply, and plant growth regulators, besides morphological factors which are the thickness of peel and rind hardness. The range of the fruit cracking incidence is from 10% to 35% [16].

Also, according to [17] navel oranges are the most susceptible to cracking. Furthermore, [13] [18] [19] reported that causes of fruit cracking are

[1]One feddan is 0.42 hectare.

represented in increased temperature, humidity unbalance, hot dry winds, heavy rain after a dry period, temperatures difference between day and night, and fertilizer levels.

Therefore, the problem of this work is to specify the negative effect of fruit cracking on reducing the yield and quality of Washington navel orange produced in Egypt.

So, this work aims to study major economic indicators and estimate an economical evaluation of using treatment of Washington navel orange to reduce fruit cracking during the period time of 2007/2008 until 2019/2020.

## 2. Materials and Methods

### 2.1. Data Collection

Data were obtained from published and unpublished recourses such as the Egyptian Ministry of Agriculture and Lands Reclamation (Agricultural Statistics Bulletin; 2007/2008-2019/2020), Central Agency for Public Mobilization and Statistics (CAPMAS; 2007/2008-2019/2020), Food and Agriculture Organization of the United Nations Statistical (FAOSTAT; 2007/2008-2019/2020) and the data of the International Network, as well as previous studies related to the study's topic.

### 2.2. Analytical Methods

This study estimates and describes major economic indicators of Washington navel orange during the study period (2007/2008-2019/2020) using descriptive analysis such as mean, maximum, minimum, growth rate and relative importance using the SPSS program version 25. In addition, this study attempted to evaluate a treatment for Washington navel oranges that was used to reduce fruit cracking in the season of 2019/2020 in order to determine whether this treatment is effective.

## 3. Results and Discussion

### 3.1. Relative Importance of Citrus and Orange

In Egypt, citrus is produced mainly in arid and semiarid areas [9]. Total and fruit areas of citrus reached about 480 and 407 thousand feddans, represented by about 31.4% and 31.8% of total and fruit areas of fruit crops, respectively during 2007/2008-2019/2020. Also, citrus produced by about 3.96 million tons represented about 39.5% of the production of fruit crops.

Table 1 confirmed that fruit areas of citrus increased from 344 to 450 thousand feddans with a significant annual growth rate of approximately 1.9% and from 3.1 to 4.65 million tons with significant annual growth rate of citrus production of about 2.9%. But fruit cracking of citrus is a serious problem in the hot and moist areas of Egypt. Climatic conditions cause high fruit cracking percentages, which lead to the development of thin, smooth fruit rinds [20]. Also, [21] reported that temperature is a significant climatic factor in determining citrus fruit yield and quality, with a significant positive correlation between diurnal

**Table 1.** Descriptive statistics of orange and total citrus during (2007/2008-2019/2020).

| Crop | | Mean | Standard Deviation | Minimum | Maximum | Growth Rate % | % from total Oranges | % from total Citrus |
|---|---|---|---|---|---|---|---|---|
| **Oranges** | **Fruit area** (1000 Feddans) | 272 | 34.1 | 213 | 313 | 2.9*** | 100 | 67.0 |
| | **Production** (1000 ton) | 2762 | 416 | 2055 | 3351 | 3.6*** | 100 | 69.6 |
| **Total Citrus** | **Fruit area** (1000 Feddans) | 407 | 35.8 | 344 | 450 | 1.9*** | - | 100 |
| | **Production** (1000 ton) | 3966 | 492 | 3134 | 4647 | 2.9*** | - | 100 |

(***) statistically significant difference at the 0.001. Source: Collected and calculated from Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Agricultural Statistics Bulletin, Egypt (2007/2008-2019/2020) and output using SPSS 25.

temperature and total sugar content, vitamin C content and ratio of total soluble solids (TSS).

Table 1 also shows that fruit areas of orange reached about 272 thousand feddans, which increased from 213 to 313 thousand feddans with significant annual growth rate of approximately 2.9% and these areas represented around 67% of total fruit areas of citrus. Additionally, oranges were produced for about 2.8 million tons, which increased from 2.1 to 3.4 million tons with a significant annual growth rate of approximately 3.6% and represented around 69.6% of the total Egyptian citrus production during the study period.

### 3.2. Economic Indicators of Washington Navel Orange

**Fruit Areas:** Washington navel orange is the most cultivated variety in Egyptian lands, where fruit areas of Washington navel orange represented about 35.4% and 52.9% of fruit areas of citrus and orange during the study period. Table 2 shows that these areas reached about 144 thousand feddans, which increased from 122 to 158 thousand feddans with a significant annual growth rate of approximately 1.6%. According to [7] [8], the navel orange ranks first among citrus crops because it is considered as the most popular fresh citrus fruit for Egyptians due to its seedless, high-quality fruit, desirable taste and low prices when compared to other fruits.

**Production and Yield:** Washington navel orange production represented about 37% and 53.2% of the total citrus and orange production during the study period. However, Table 2 shows that the Washington navel orange production was unstable during the study period, and it was about 1.47 million tons. In 2007/2008, production increased from 1.17 million tons to 1.69 million tons in 2015-2016, while in 2016/2017 decreased to 1.49 million tons and then increased to 1.59 million tons in 2019/2020. In general, during the study period, the production of Washington navel orange increased with a significant annual growth rate was approximately 2.7%. That might happen because navel orange

Table 2. Descriptive statistics of Washington navel orange during (2007/2008-2019/2020).

| Crop | | Mean | Standard Deviation | Minimum | Maximum | Growth Rate % | % from Total Oranges | % from Total Citrus |
|---|---|---|---|---|---|---|---|---|
| Washington Navel Orange | **Fruit area** (1000 Feddans) | 144 | 11.6 | 122 | 158 | 1.6** | 52.9 | 35.4 |
| | **Production** (1000 ton) | 1469 | 173 | 1167 | 1697 | 2.7*** | 53.2 | 37.0 |
| | **Yield** (ton/feddan) | 10.17 | 0.58 | 9.35 | 10.96 | 1.1** | - | - |
| | **Farm price** L.E./ton | 1393 | 322 | 954 | 1893 | 5.1*** | - | - |
| | **Total Revenue** L.E./feddan | 10,435 | 1328 | 8379 | 12,467 | 3.2*** | - | - |

(***) statistically significant difference at the 0.001. (**) statistically significant difference at the 0.01. Source: Collected and calculated from Ministry of Agriculture and Land Reclamation, Economic Affairs Sector, Agricultural Statistics Bulletin, Egypt (2007/2008-2019/2020) and output using SPSS 25.

faces pre- or post-harvest many rind disorders such as creasing, cracking, peel pitting and senescence which may affect the optimum fruit production and quality of the citrus industry [14] [22] [23].

Table 2 also shows that yield of Washington navel orange represents an indicator of the success of agricultural production. But the yield was unstable during the study period, between low and high values, which reached about 10.2 tons per feddan. It increased from 9.35 to 10.96 tons per feddan with a significant annual growth rate of about 1.1%. Abobatta, 2018 reported that proper nutrient management is critical for optimizing navel orange yield and productivity while reducing environmental danger.

**Farm Price:** Farm price is the most significant element that affects the producers' decisions [2]. Table 2 shows that farm prices reached about L.E 1.4 thousand which increased from L.E 0.95 thousand to L.E 1.9 thousand with a significant annual growth rate of approximately 5.1% during the study period.

**Total Revenue:** Table 2 shows revenue of Washington navel orange reached about L.E 10.4 thousand which increased from L.E 8.4 thousand to L.E 12.5 thousand with a significant annual growth rate of approximately 3.2% during the study period. [7] found that Washington orange tree intercropping systems significantly increased total return. Also, [8] confirmed that for citrus growers in the Delta region, Washington navel orange is the primary source of early season income.

**Export of Oranges:** Orange is an important export fruit crop and a source of national income in Egypt [9], especially during the latest period of time because of the COVID-19 pandemic. Most of Egypt exports are from navel orange during its export season compared with other verities [8] [24]. Otherwise, the quantity of export increased to 1.8 million tons in 2019/2020. That increase led to

Egypt has become the largest exporter of oranges in the world within the last year according to the International Trade Center report [25] and achieved earnings reached $661 million in 2019/2020.

Table 3 shows that the quantity of export reached about one million tons during the study period, which increased from 0.27 to 1.8 million tons, recording a significant annual growth rate was approximately 13.4%. Also, the value of export reached about $424 million during the study period, which increased from $94 million to $666 million, recording a significant annual growth rate of approximately 15%.

According to Financial Times [26], the vast majority of Egyptian's orange exports come from newly reclaimed lands established over the last three decades, rather than the old fertile lands of the Delta and Nile Valley, where landholdings are fragmented and farmers cannot afford the level of investment required to produce for export.

Otherwise, the navel orange export season in Egypt runs from mid-November to mid-February [4] [22] and for a high economic return, navel oranges tend to extend the harvest period by leaving the fruit on the trees for longer periods of time in order to extend the marketing season. This procedure causes the aforementioned disorders to appear, reducing its shelf life and marketing ability. So, [22] [27] [28] [29] found that growth regulators such as gibberellic acid could reduce cracking when used properly, pre-harvest allows citrus growers to extend the marketing period without sacrificing fruit quality after harvesting.

### 3.3. The Potential Economic Impact of Fruit Cracking on Washington Navel Orange: Case Study in Season of 2019/2020

Undoubtedly, there are many problems facing fruit trees growers that affect the productivity and fruit quality of navel orange trees [30]. Fruit cracking is one of these problems because it has a negative impact on the production and revenue of Washington navel orange. So, this study evaluates revenue from Washington navel orange during and after fruit cracking happened based on previous studies. Therefore, this section aimed to estimate an economical evaluation of using a treatment to reduce the rate of Washington navel orange cracking and makes revenue.

**Table 3.** Descriptive statistics of orange export during (2007/2008-2019/2020).

| Export | Mean | Standard Deviation | Minimum | Maximum | Growth Rate% |
|---|---|---|---|---|---|
| **Export Quantity (1000 ton)** | 1001 | 446 | 272 | 1817 | 13.4*** |
| **Export Value (million$)** | 424 | 195 | 94 | 666 | 15*** |

(***) statistically significant difference at the 0.001. Source: http://www.faostat.fao.org and output using SPSS 25.

Table 4 shows that in season 2019/2020, production of Washington navel orange reached about 1.6 million tons and yield reached to 10.65 ton/feddan, by total revenue of about L.E. 2991 million.

Also, total trees in the same season reached about 25.4 million tree, where average infected trees represent about 9% of total trees according to [6] [31] [32], thus the number of infected trees was calculated by about 2.3 million trees and cracked fruits value by about L.E.271 million. The revenue after cracking was estimated by about L.E. 2720 million.

Many studies reported that spraying some fruit trees including orange trees with different stimulating substances such as active dry yeast extract, Gibberellic acid (GA3), calcium chloride, calcium nitrate and propolis at the different concentrations enhanced vegetative growth, increased fruit set consequently and increased productivity [6] [27] [28] [30] [31] [33] [34].

Also, [22] [28] confirmed that these treatments had a positive impact on extending the harvest season without compromising navel orange fruit characteristics and growers can gain the economic advantage of harvesting early.

So, this work focused on using some of these chemical materials that are applied in many studies such as (calcium chloride, calcium nitrate and calcium chelate) to estimate the revenue of treated fruit. In addition, several experimental studies reported that the average proportion of cracking decreased from

Table 4. Revenue of Washington navel orange during and after fruit cracking in 2019/2020.

| Variables | Value/Number |
|---|---|
| Total trees N. | 25,369,440 tree |
| Production | 1,588,579 ton |
| Yield | 10.65 ton/feddan |
| Average fruit weight/tree | 63 Kilo |
| **Total Revenue** | **L.E. 2991 million** |
| Infected trees N. | 2,283,250 tree |
| Cracked fruits value | L.E. 271 million |
| **Revenue after cracking** | **L.E. 2720 million** |
| Tree N. after treatment | 761,083 tree |
| **Cracked fruits value after treatment** | **L.E. 90.3 million** |
| **Cost of treatment*** | |
| Cost of material | L.E. 11.46 feddan |
| Number of acres infected | 13,431 feddan |
| **Cost of treatment** | **L.E. 462 thousand** |

Notes: Calculated by authors. Fruit cracking/tree = 9%, Fruit cracking/tree after treatment = 3%. The average number of trees = 170 trees/Feddan. Total area of Washington navel orange (2019/2020) = 149,232 Feddan. Price (2019/2020) = L.E. 1883 ton. Average of cost of calcium chloride (3%) = L.E. 132 kilo, calcium nitrate (3%) = L.E. 120 kilo and calcium chelate (3%) = L.E. 130 kilo. All treatments were sprayed three times.

about 9% to about 3% of Washington navel orange after treatment [6] [31] [32]. Besides, [29] confirmed that spraying either GA3 at 50 ppm or $CaCl_2$ at 2% effectively reduced cracking and improve the yield and fruit quality of pomegranate.

Table 4 also, shows that the number of trees applied to treatment was about 761 thousand trees and by calculating fruits value after treatment reached about L.E. 90.3 million. Besides, the cost of the mentioned material calculated about L.E. 462 thousand acres infected was sprayed three times.

Lastly, a comparison between the cost of treatment and the fruit value after treatment to ensure this treatment caused benefits. This cost value was less than the treated fruit value and it means that the treatment process was economical to be applied.

## 4. Conclusion

The purpose of this study was to estimate major economic indicators of Washington navel orange from 2007/2008 to 2019/2020. According to their higher economic indicators during the study period, Washington navel orange is the most important variety of orange cultivated in Egypt. It also demonstrates that after evaluating a treatment to reduce the rate of Washington navel orange cracking. This treatment is effective because the treatment cost less than the value of the treated fruit. As a result, this study recommends using a treatment that includes calcium chloride, calcium nitrate, and calcium chelate to reduce fruit cracking and increase the yield and quality of Washington navel oranges.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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