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# High temperature decreases the vitamin C bioavailability in five fruits juice collected from Tripoli, Libya

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ABSTRACT

Citrus juices have long been considered a good source of vitamin C (Vit- C). The amount of Vit- C content of five fresh fruits, mango (*Mangifera indica*), guava (*Psidium guajava*), pineapple (*Ananas comosus*), orange (*Citrus sinensis*), and lime (*Citrus aurantifolia*) was determined under different high temperature conditions. These juices were extracted, and the Vit- C content was analyzed at room temperature (R.T) (25°C), 35, 45, 55, 65, and 75°C for different periods of 10, 15 and 20 minutes. by the iodometric titration method. The highest Vit- C content was observed in *C. sinensis*, whereas *M. indica* showed the lowest level at R.T. The results showed that the Vit- C content decreased after boiling. The rate at which Vit- C was decreased depends on the increase in temperature and the time of exposure. High temperature degree created conditions for the high degradation of Vit- C content. The present analysis verified that Vit- C is an unstable compound at higher temperatures.

**Keywords**:
Fruit samples, High temperature, Iodine titration, Vitamin C.

## 1. Introduction

Vitamins are essential organic substances that are important for normal physiological functions such as maintenance, growth, development, and production (Comb and Gerald, 2012). A vitamin is an organic compound, which means that it contains carbon. It is usually needed in minuscule quantities for the body to have optimal functionality. Deficiency syndrome happens when vitamins decrease (Kale et al., 2015). Humans have to obtain vitamins from an exogenous source, such as food, where the vitamin is one of its natural components and is found in small amounts (Comb and Gerald, 2012). Vitamin C (Vit- C), a water-soluble nutrient, plays a pivotal role in health maintenance and high temperatures, presents a challenge to the nutritional integrity of fruit juice products disease prevention. Vit- C (also referred to as L-ascorbic acid) is an odorless, white solid having the chemical formula $C_6H_8O_6$. Vit- C is L-enantiomeric ascorbic acid, which also encompasses the oxidation product of dehydroascorbic acid (Drouin et al., 2011). The function of Vit- C as a powerful antioxidant furthermore helps the body build new tissue and maintain connective tissue, including bones, blood vessels, and skin (Telang, 2013). Besides, it inhibits amine formation, collagen formation, reduction of plasma cholesterol level, and enhancement of the immune system (Moser and Chun, 2016). It participates in numerous biochemical reactions, suggesting that Vit- C is important for the body's process of repair (Iqbal et al., 2004).

Storage conditions are essential for the amount of Vit- C. If the surface of the fruit is damaged, there is a significant loss of ascorbic acid. Fruits with a low pH have lower losses of ascorbic acid, and fruits with a soft consistency, such as strawberries, are more sensitive to external influences (Zee et al., 1991). Vitamins in fruits and vegetables can be lost during handling, processing, and storage, which is known as stability. It is important to note that stability refers to the retaining ability of vitamins under chemical, physical, and/or thermal stress. To improve stability, proper handling and storage techniques should be employed (Giannakourou and Taoukis, 2021). The stability of Vit- C was studied by scientists, based on the percentage loss of the vitamin (Klimczak et al., 2007). Consequently, a low percentage loss indicates high stability of Vit- C, while a high percentage loss means low stability (Yan et al., 2021).

The present study aimed to measure the Vit- C content in five fruit juice samples, examine the impact of various hot temperatures on Vit- C, and correlate it with the stability.

## 2. Materials and Methods

### Sample collection and preparation

The tested samples were studied at the Pharmacy Department of the high Institute for Medical Sciences and Technology. Garabolli-Libya, and included samples collected from markets in Tripoli, mango (*Mangifera indica*), guava (*Psidium guajava*), pineapple (*Ananas comosus*), orange (*Citrus sinensis*) and lime (*Citrus aurantifolia*). Each sample was cut into small pieces and blended to obtain a homogeneous mixture. 200 g of the mixture was added to a glass beaker and homogenized with 500 ml of distilled water, individually. Each mixture was then incubated at 25°C in a dark place with gentle stirring overnight. To achieve a clear filtrate, the homogenate was passed through Whatman No. 1 filter paper. The resulting filtrate was then carefully transferred to a clean, sealed flask (Moorthy, 2020).

### Iodometric titration to estimate Vit- C in five fruit samples

The mass of a single piece of freshly plucked fruit is recorded before collecting its juice using a sharp knife and cotton cloth. A few drops of a 0.5% starch indicator (0.25 g of soluble starch dissolved in 50 mL of nearly boiled distilled water) are added to the juice, which is then titrated with 0.005 M iodine solution (2 g of potassium iodide (KI) and 1.3 g iodine in 1L distilled water). A few drops of a 0.5% starch indicator (0.25 g of soluble starch dissolved in 50 mL of nearly boiled distilled water) are added to the juice, which is then titrated with 0.005 M iodine solution (2 g of I and 1.3 g iodine in 1 L distilled water). A few drops of a 0.5% starch indicator (0.25 g of soluble starch dissolved in 50 mL of nearly boiled distilled water) are added to the juice, which is then titrated with 0.005 M iodine solution (2 g of KI and 1.3 g iodine in 1 L distilled water). The endpoint of the titration is detected when the color of the starch-iodine complex turns into a permanent dark blue-black. Then, titrate 10 mL of the filtrate juice sample with 0.005 M iodine solution and 10 drops of 0.5% starch indicator (Moorthy, 2020).

## 3. Statistical analysis:

The experiments were conducted in triplicate and mean values with standard deviation were calculated using standard statistical procedures. The data obtained underwent statistical evaluation, and the coefficient of determination (R2) was calculated using Microsoft Excel 2010.

## 4. Results

The result of the initial values of amount of Vit- C clearly showed at room temperature are much better conditions than hot temperatures for the five citrus (C) juices samples. The experimental results are presented in (Fig. 1) found that *C. sinensis* (90 ± 20 mg / 100 ml) has more Vit- C content, followed by *C. aurantifolia* (75 ± 0.10 mg / 100 ml), P. *guajava* (70 ± 0.20 mg / 100 ml), *A. comosus* (65 ± 0.25 mg / 100 ml), and *M. indica* (55 ± 0.30 mg / 100 ml) in that order. The Vit- C content had been measured at five different heating temperatures 35°C, 45°C, 55°C, 65°C, and 75°C for 10, 15, and 20 minutes.

**Table 1.** Effect of heating at a temperature degree of 35°C on Vit-C bioavailability in tested juices

| Fruits | Temperature degrees 35°C | | |
|---|---|---|---|
| | Minutes | | |
| | 10 | 15 | 20 |
| *M. indica* | 54 ± 0.35 | 52 ± 0.30 | 50 ± 0.35 |
| *A.comosus* | 60 ±0.30 | 57 ± 0.30 | 55 ± 0.40 |
| *P. guajava* | 68 ± 0.50 | 67 ± 0.30 | 65 ± 0.34 |
| *C. sinensis* | 88 ± 0.38 | 86 ± 0.30 | 84 ± 0.27 |
| *C. aurantifolia* | 72 ± 0.4 | 70 ± 0.30 | 68 ± 0.30 |

**Table 2.** Effect of heating at a temperature degree of 45°C on Vit-C bioavailability in tested juices

| Fruits | Temperature degrees 45°C | | |
|---|---|---|---|
| | Minutes | | |
| | 10 | 15 | 20 |
| *M. indica* | 48 ± 0.37 | 47 ± 0.2 | 45 ± 0.20 |
| *A.comosus* | 55 ± 0.3 | 52 ± 0.30 | 50 ± 0.33 |
| *P. guajava* | 63 ± 0.30 | 60 ±0.35 | 58 ± 0.30 |
| *C. sinensis* | 84 ± 0.29 | 81 ±0.28 | 80 ± 0.18 |
| *C.aurantifolia* | 65 ± 0.20 | 61 ±0.3 | 60 ± 0.20 |

**Table 3.** Effect of heating at a temperature degree of 55°C on Vit-C bioavailability in tested juices

| Fruits | Temperature degrees 55°C | | |
|---|---|---|---|
| | Minutes | | |
| | 10 | 15 | 20 |
| *M. indica* | 43 ± 0.40 | 42 ± 0.15 | 40 ± 0.2 |
| *A.comosus* | 48 ± 0.35 | 48 ± 0.33 | 45 ± 0.30 |
| *P. guajava* | 56 ± 0.25 | 56 ± 0.28 | 56 ± 0.33 |
| *C. sinensis* | 77 ± 0.30 | 75 ± 0.31 | 72 ± 0.40 |
| *C. aurantifolia* | 58 ± 0.36 | 55 ± 0.20 | 53 ± 0.28 |

**Table 4.** Effect of heating at a temperature degree of 65°C on Vit-C bioavailability in tested juices

| Fruits | Temperature degrees 65°C | | |
|---|---|---|---|
| | Minutes | | |
| | 10 | 15 | 20 |
| *M. indica* | 40 ± 0.30 | 38 ± 0.28 | 37 ± 0.37 |
| *A.comosus* | 40 ± 0.20 | 40 ± 0.240 | 38 ± 0.29 |
| *P. guajava* | 50 ± 0.35 | 48 ± 0.41 | 45 ± 0.28 |
| *C. sinensis* | 70 ± 0.15 | 68 ± 0.43 | 65 ± 0.30 |
| *C. aurantifolia* | 50 ± 0.16 | 48 ± 0.20 | 46 ± 0.32 |

**Table 5.** Effect of heating at a temperature degree of 75°C on Vit-C bioavailability in tested juices

| Fruits | Temperature degrees 75°C | | |
|---|---|---|---|
| | Minutes | | |
| | 10 | 15 | 20 |
| *M. indica* | 36 ± 0.18 | 35 ± 0.28 | 35 ± 0.20 |
| *A.comosus* | 36 ± 0.40 | 35 ± 0.35 | 35 ± 0.37 |
| *P. guajava* | 42 ± 0.28 | 40 ± 0.30 | 38 ± 0.17 |
| *C. sinensis* | 62 ± 0.35 | 60 ± 0.28 | 55 ± 0.30 |
| *C. aurantifolia* | 45 ± 0.27 | 42 ± 0.30 | 40 ± 0.24 |

The concentration of *C. sinensis* decreased as the temperature and time of exposure increased. At 35°C, the concentration was 88 ± 0.38, 86 ± 0.30, and 84 ± 0.27mg /100 ml after 10, 15, and 20 minutes, respectively (Table. 1 and Fig. 2A). At 45°C, the concentration was 84 ± 0.29, 81 ± 0.28, and 80 ± 0.18 mg /100 ml after 10, 15, and 20 minutes, respectively (Table. 2 and Fig. 2A). At 55°C, the concentration was 77 ± 0.30, 75 ± 0.31, and 72 ± 0.40 mg /100 ml after 10, 15, and 20 minutes, respectively (Table. 3 and Fig. 2A). At 65°C, the concentration was 70 ± 0.15, 68 ± 0.43, and 65 ± 0.30 mg /100 ml after 10, 15, and 20 minutes, respectively (Table. 4 and Fig. 2A). At 75°C, the concentration was 62 ± 0.35, 60 ± 0.28, and 55 ± 0.30 mg /100 ml after 10, 15, and 20 minutes, respectively (Table. 5 and Fig. 2A).

The effects of different temperatures and time periods on *C. aurantifolia* were studied.

The findings showed that at 35°C, the concentration of Vit- C in *C. aurantifolia* was 72 ± 0.4, 70 ± 0.30, and 68 ± 0.30 mg /100 ml for 10, 15, and 20 minutes, respectively (Table. 1 and Fig. 2B). At 45°C, the concentration was 65 ± 0.20, 61 ± 0.30, and 60 ± 0.20 mg /100 ml after the same time periods (Table. 2 and Fig. 2B). At 55°C, the concentration was 58 ± 0.36, 55 ± 0.20, and 53 ± 0.28 mg /100 ml (Table. 3 and Fig. 2B), and at 65°C, it was 50 ± 0.16, 48 ± 0.20, and 46 ± 0.32 mg /100 ml (Table. 4 and Fig. 2B). The concentrations of 45 ± 0.27, 42 ± 0.30, and 40 ± 0.24 mg /100 ml were maintained at 75°C for 10, 15, and 20 minutes, respectively (Table. 5 and Fig. 2B).

The concentration 0f Vit- C in *P. guajava* at different temperatures and time intervals was measured. At 35°C, the concentration was 68 ± 0.50, 67 ± 0.30, and 65 ± 0.34 mg / 100 ml for 10, 15, and 20 minutes, respectively (Table. 1 and Fig. 2C). At 45°C, the concentration was 63 ± 0.30, 60 ± 0.35, and 58 ± 0.30 mg /100 ml after the same time intervals (Table. 2 and Fig. 2C). At 55°C, the concentration was 56 ± 0.25 mg / 100 (Table. 3 and Fig. 2 C). At 65°C, the concentration was 50 ± 0.35, 48 ± 0.41, and 45 ± 0.28 mg/100 ml for 10, 15, and 20 minutes, respectively (Table. 4 and Fig. 2 C). Finally, at 75°C, the concentration was 42 ± 0.28, 40 ± 0.30 and 38 ± 0.17 mg / 100 ml after the same time intervals (Table. 4 and Fig. 2 C).

The content of Vit- C of *A. comosus* were measured for the same different temperatures and time intervals, at 35°C the concentration was 60 ± 0.30, 57 ± 0.30, and 55 ± 0.40 mg / 100 ml after 10, 15, and 20 minutes, respectively (Table. 1 and Fig. 2 D). While at 45°C the concentration was 55 ±0.35, 52 ± 0.30, and 50 ± 0.33 mg / 100 ml for the same time intervals (Table. 2 and Fig. 2 D), at 55°C, 65°C and 75°C the concentration was 48 ± 0.35, 48 ± 0.33, and 45 ± 0.30 mg / 100 ml, 40 ± 0.20, 40 ± 0.24, and 38 ± 0.29 mg / 100 ml, 36 ± 0.40, 35 ± 0.35, and 35 ± 0.37 mg / 100 ml after 10, 15, and 20 minutes, respectively (Table. 3, 4 and 6).

The content of Vit- C in *M. indica* showed the lowest concentration between other citrus juices at the same different heating temperatures and the same time intervals (Fig. 2 E).

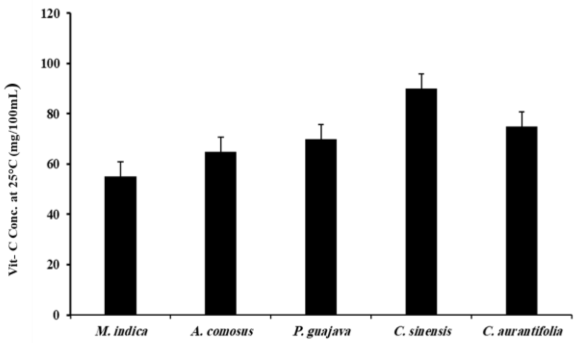
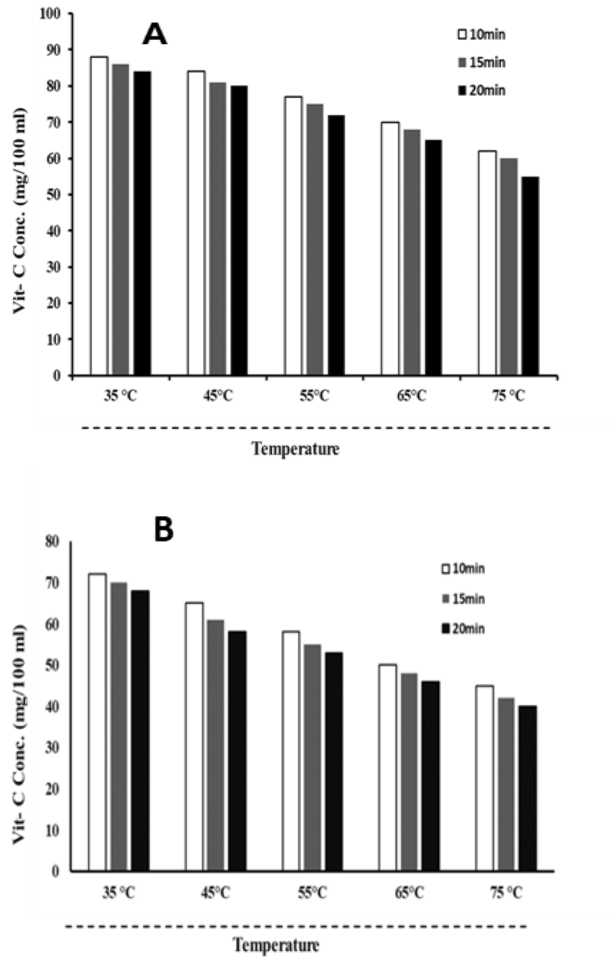
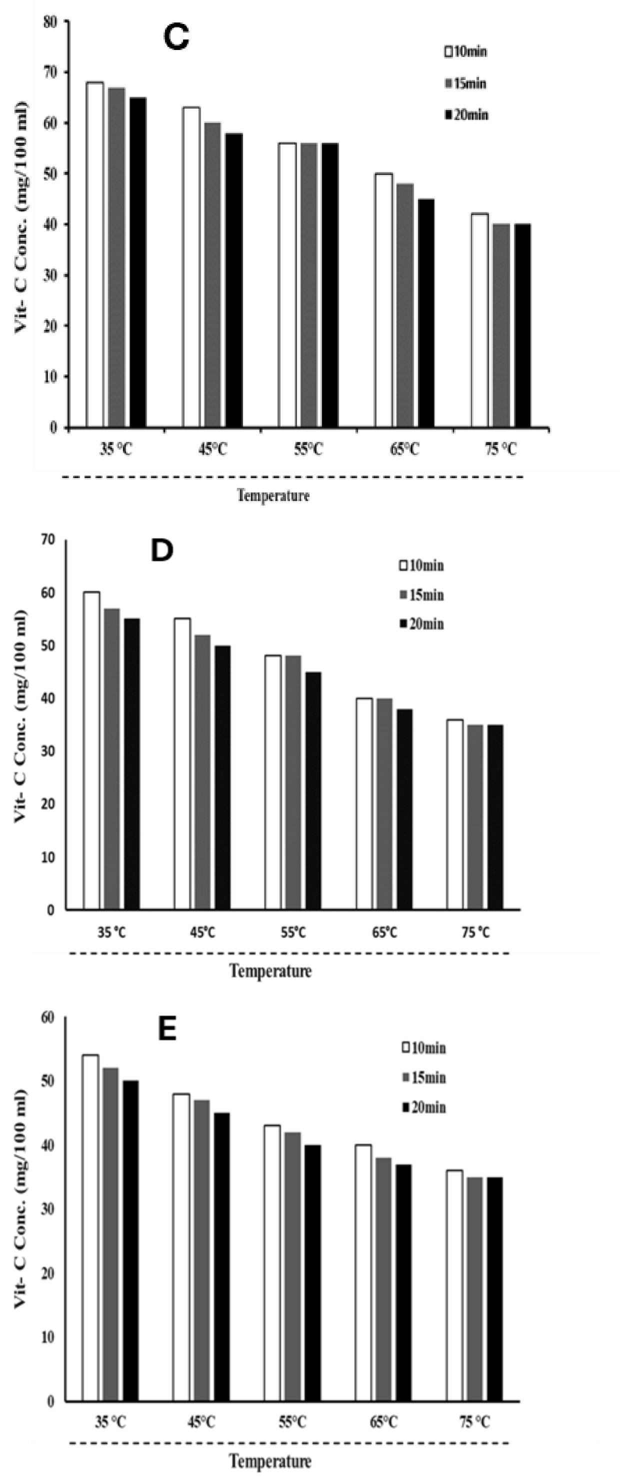



**Fig. 1.** Vit- C concentration (mg/100 ml) for tested juices.




**Figs. 2 (A and B).** Effect of different heating temperatures and time on Vit-C bioavailability in *C. sinensis* (A) and C. *aurantifolia* (B).




**Figs. 2 (C-E).** Effect of different heating temperatures and time on Vit-C bioavailability in *P. guajava* (C), A. *comosus* (D) and *M. indica* (E).

## 4. Discussion

The findings showed that as the temperature increased, the concentration of vitamin C (Vit-C) decreased and there was a loss of Vit- C content in different types of the tested juices. The rate at which Vit- C is lost during boiling depends on the temperature and time. Boiling and cooking subject Vit- C to degradation (Moorthy, 2020). This analysis confirmed the fact that vitamin C is an unstable compound at higher temperatures. This is consistent with many studies showings that the percentage of ascorbic acid loss increases with increasing temperature and duration of the heating process (Mansor, 2022). High temperatures can also affect the color and taste of fresh juice. The Maillard reaction between amino acids and reducing sugars can lead to browning and changes in flavor characteristics, especially in juices with a higher sugar content (Shin et al., 2007). The nutrients in fresh juice continue to break down over time, even at freezing temperatures. This is due to continuous enzymatic and chemical reactions (Assiry et al., 2003). Longer storage times increase the risk of oxidation, leading to undesirable color, flavor, and nutritional value changes. Juices with a high polyphenol content, such as fruit and vegetable blends, are particularly susceptible to oxidation (Assiry et al., 2003). The accumulation of ascorbic acid in fruits can be effectively regulated by genetic engineering, and its accumulation is influenced by environmental factors (Kumar et al., 2016). In conclusion, high temperatures accelerate the loss of nutrients, changes in color and taste, and the growth of microorganisms in fresh juice, while time promotes the breakdown, oxidation, and separation of nutrients. The effect of hot temperature on fruit juice samples during storage can be summarized as follows: Storage temperature affects the Vit- C content of citrus juice samples. A warm environment creates the conditions for rapid degradation of Vit- C content, while a room environment creates conditions for slow degradation.

**Recommendations**

The study provides valuable information to the juice industry to help ensure product quality and safety and minimize losses due to thermal degradation. This confirmed the critical nature of temperature control in preserving the Vit- C content of fruit juices. Juice producers and consumers are encouraged to consider the heat sensitivity of ascorbic acid and take appropriate temperature control measures to extend the shelf life and health benefits of the products they consume.

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**Conflict of interest**

The author declared that there was no conflict of interest.

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