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# A quantitative analysis of vitamin C in fruits, khat (*Catha edulis*), and pharmaceutical tablets using potassium iodate titration

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## Abstract

Vitamin C, or ascorbic acid, is an essential antioxidant in various resources, such as pharmaceutical tablets, fruits, and vegetables. The human body cannot synthesize it by itself. This research aims to measure the vitamin C content in 29 commonly assessable compressed tablets, effervescent tablets, fruits, and khat (*Catha edulis*) leaves that are found in the Yemeni local markets. This study used a redox titration method with potassium iodate. These results reveal confirmed European and American standards and no significant difference between the measured vitamin C content in the commercial tablet ($p < 0.05$) and the amount stated on the product label, as well as the highest amount of vitamin C content in fruits in guava (111.21 mg/100 g), while the lowest amount of vitamin C is in apple (8.72 mg/100 g).

**Keywords:** Tablets; Fruits; Potassium iodate; Redox titration; Quantitative analysis

## 1. Introduction

Vitamin C, also known as L-ascorbic acid (A.A), is a weak monobasic organic molecule with a molecular weight of 176 g/mol. It is the most crucial antioxidant vitamin for human health, commonly obtained from fruits, plants, pharmaceutical forms, and vegetables.[1] In general, ascorbic acid can be oxidized to L-dehydroascorbic acid (DHA), which can be turned into L-ascorbic acid via our bodies [1, 2]. Vitamin C in aqueous solutions is unstable due to oxidization into enol molecules, high pH, temperature, and metal ions promoting breakdown[3].

The A.A. content in fruits has fluctuated for numerous reasons, including temperature, soil nutrients, and climate changes[4]. The overall acidity of all the fruits exceeds the amount of ascorbic acid, indicating the presence of several acids in fruits. To confirm that, a sodium hydroxide solution is applied. The presence of other acids in the fruits might overlap with potassium iodate and reduce the sensitivity of this approach.

Khat, scientifically known as *Catha edulis*. It exists in Yemen, South Africa, and Ethiopia[5]. In Yemen, the people frequently chew khat leaves in the afternoon. This chewing is an extraction process. The khat leaves involve various photochemical compositions such as tannins[6, 7], alkaloids, triterpenoids, steroids, aromatic molecules, minerals, amino acids, and vitamin C [8].

In the newest research, vitamin C content was evaluated using high-performance liquid chromatography (HPLC), Ultra performance liquid chromatography (UPLC) [9], flow injection analysis, redox titration[10], and UV spectroscopy[11-13].

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The primary goal of this research was to detect the vitamin C content in certain fruits, pharmaceutical tablets, and khat leaves in Ibb city, Yemen using the redox titration method with potassium iodate solution.

## 2. Materials and Methods

### 2.1. Sample collection

Ten fresh fruit samples, fourteen tablet samples, and five kinds of khat leaves were purchased from different local markets and pharmacies in Ibb city, Yemen. The fruit samples used in this research involved Orange (*Citrus sinensi*), Papaya (*Carica papaya*), Guava (*Psidium guagava*), Strawberry (*Fragaria ananassa*) Lemon (*Citrus limon*), Tangerine (*Citrus reticulata*), Orange (*Citrus sinensi*), Kiwi (*Actinidia deliciosa*), Watermelon (*Citrullus lanatus*), Black grapes (*Vitis viifera*). The pharmaceutical tablets include Nat C, Ocean, Indovit, Juvamine, Vitacid, Efervit, Redoxon, Oran C, Cee Cal - 1000, Effernol-C, SALIX-200, APIVIT C 1000, Cal-C-Care, vitamin C-1000. Also, khat leaves were Al-Shuaibi, Al-Hushbi, Mawiyah, Al-Arhabi, and Al-Shami which were collected in winter.

### 2.2. Sample preparation

#### *2.2.1. The fruit sample preparation*

The fruit samples were completely cleaned using a distilled water well. The cleansing fruit samples were prepared by cutting them into small species. All samples were mixed completely, and then the samples were weighed separately at 100 g. Then the fruit samples were thoroughly squeezed with 250 ml of distilled water, left for an hour, filtered using filter paper, and stored at room temperature.

#### *2.2.2. Pharmaceutical tablet preparation*

Five tablets were crushed into a homogenous fine powder. The powder tablets were weighed and classified into five classes. Each class was dissolved in 200 ml of distilled water.

#### *2.2.3. Khat leaves preparation*

Khat leaves were purchased from different Yemeni markets in Ibb city, Yemen. The gathered samples were thoroughly washed and then dried away from sunlight for five days, and stored in a dark container. The dried khat samples were ground, 100 g of dried sample was weighed, and 200 ml of di-ionized water was added. After waiting for 30 minutes, the solution was filtered. The extracted solution was maintained in a dark container before measuring vitamin C.

### 2.3. Standard solution preparation

1.00 g of dried ascorbic acid was transferred into a cleansing volumetric flask. The powder was thoroughly dissolved in 100 ml of deionized water.

### 2.4. Preparation of chemicals

This process involved the preparation of different solutions, including 0.00413 M potassium iodate ($KIO_3$) was prepared, weighing 0.442 g of dried $KIO_3$, then transferred into a conical flask of 500 ml, and then dissolved using distilled water until it reached a calibrated line. 10% potassium iodide (KI) was prepared by weighing 10 g of dried potassium iodide and dissolving it using appropriate distilled water. To prepare a 5% starch solution, weighed 5.00 g of dried starch powder which is dissolved using 95 ml of boiling distilled water. Hydrochloric acid (HCl, 1.00 M) solution was prepared by transferring 11.6 ml of concentrated solution (33% %) into a cleansing volumetric flask of 100 ml. The solution was filled up until it reached the calibrate line.

### 2.5. Determination of ascorbic acid in prepared samples

The filtered fruit solutions were exactly 10.00 ml, while the corresponding 5.00 ml from each of the filtered drug solutions were taken into a cleansing conical flask. The solution was added using 30 ml of deionized water, 2 ml of potassium iodide (10%), 2 ml of diluted hydrochloric acid (1.00 M) solution, and five drops of starch as an indicator. The mixture was thoroughly stirred and then titrated with 0.00423 M of potassium iodate solution until it obtained a blue-black color. The fruit samples were titrated as mentioned under the determination of the ascorbic acid procedure. The consumed volumes were noted, a table was created, and the mg of ascorbic acid content in each original sample was calculated.

### 2.6. Statistical analysis

The means and standard deviation (SD) were conducted using Microsoft Excel 2019.

## 3. Result and discussion

### 3.1. Mechanism of the redox titration method

The primary principle of this titration is oxidation-reduction titration, which involves the transfer of electrons between iodine and A. A. In other words, a diol is transformed into a dione using a halide, such as iodine ($I_2$). Since ascorbic acid (A. A) can be oxidized when prepared in an aqueous solution, hence you might consider preparing an iodine solution in A. A solution.

First, the iodine solution is formed instantly during the reaction between potassium iodate (titrant) and potassium iodide (KI), as illustrated in the below equation.

$$2IO_3^- + 10\ I^- + 12H^+ \rightarrow 6I_2 + 6H_2O$$

After iodine is formed, it reacts with ascorbic acid in an acidic medium ($H^+$) to produce dehydroascorbic acid (DHA).

$$\text{Ascorbic acid} + \text{Iodine } (I_2) \rightarrow 2\ I^- + \text{dehydroascorbic acid}$$

When all the vitamin C is finished, the access of iodine reacts with starch, resulting in a blue-dark color as the endpoint.

$$\text{Starch} + \text{iodine} \rightarrow \text{blue-black complex}$$

### 3.2. Calculation of Ascorbic acid content

$$2IO_3^- + 10\ I^- + 12H^+ \rightarrow 6I_2 + 6H_2O$$

$$\text{Ascorbic acid} + \text{Iodine } (I_2) \rightarrow 2\ I^- \text{ (iodide)} + \text{dehydroascorbic acid}$$

Overall reaction:

$$IO_3^- + 3\ C_6H_8O_6 \rightarrow 3\ C_6H_6O_6 + I^- + 3H_2O$$

based on the above equation, the molar ratio between ascorbic acid and titrant (potassium iodate) is 1:3, therefore

mmole of vitamin C = 3 x mmole of potassium iodate $KIO_3$

$$\frac{\text{mg of vitamin C}}{\text{M. wt. of vitamin C}} = 3 \text{ x Molarity of } KIO_3 \text{ x Volume of } KIO_3$$

$$\text{mg of vitamin C} = 3 \text{ x Molarity of } KIO_3 \text{ x Volume of } KIO_3 \text{ x M. wt. of vitamin C}$$

$$\text{mg of vitamin C} = \text{Molarity of } KIO_3 \text{ x Volume of } KIO_3 \text{ x } 528$$

Therefore, for total analyzed sample so,

$$\text{mg of vitamin C} = \frac{\text{Consumed volume of } KIO_3 \text{ x M of } KIO_3 \text{ x } 528 \text{ x Volume of total sample}}{\text{Volume of taken sample}}$$

The research explains that the iodate ($IO_3^-$) solution reacts indirectly with vitamin C to produce iodine ($I_2$) in an acidic medium ($H^+$). The iodine formulation directly reacts with vitamin C to result in dehydroascorbic acid. According to the obtained results as shown in Table 1, the vitamin C amount ranged significantly from 7.63 mg/100 g to 111.21 mg/100 g in the fruit samples as illustrated in Fig. 1. Guava contained the most vitamin C at 111.21 mg/100 g. Black grapes had the lowest content at 7.63 mg/100 g. Based on the results exhibited, it was found that there is consistency with the published data[14] with slight variations in some fruit samples. The main explanation for the variation is most likely a difference in resources between the original fruit samples; differences in organic molecules such as phenols, triose, and

ions such as ferrous or sulfite might interact with vitamin C [15, 16] as well as the different temperatures of the studied samples [4] All the studied fruit samples were handled using the same ascorbic acid content measurement approach.

**Table 1** Vitamin C content in fresh fruits using an indicator titration method with means with standard deviation

| Fruits | Consumed volume of titrant (ml) | | | | | | Vitamin C content (mg)/ 100 g |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | Means $\pm$ *SD* | |
| Papaya | 0.5 | 0.6 | 0.6 | 0.5 | 0.6 | $0.56 \pm 0.06$ | 30.52 |
| Guava | 1.9 | 2.1 | 2.2 | 2 | 2 | $2.04 \pm 0.11$ | 111.21 |
| Strawberry | 1.6 | 1.5 | 1.6 | 1.5 | 1.5 | $1.54 \pm 0.05$ | 83.95 |
| Lemon | 1.5 | 1.6 | 1.4 | 1.5 | 1.6 | $1.52 \pm 0.08$ | 82.86 |
| Tangerine | 1.2 | 1.3 | 1.4 | 1.2 | 2.1 | $1.44 \pm 0.38$ | 78.50 |
| Orange | 1.2 | 1.3 | 1.3 | 1.1 | 1.2 | $1.22 \pm 0.08$ | 66.51 |
| Kiwi fruit | 1.5 | 1.2 | 1.6 | 1.5 | 1.4 | $1.44 \pm 0.15$ | 78.50 |
| Apple | 0.2 | 0.1 | 0.2 | 0.1 | 0.2 | $0.16 \pm 0.05$ | 8.72 |
| Watermelon | 0,2 | 0.3 | 0.2 | 0.3 | 0.2 | $0.25 \pm 0.12$ | 13.63 |
| Black grapes | 0.1 | 0.2 | 0.1 | 0.1 | 0.2 | $0.14 \pm 0.05$ | 7.63 |

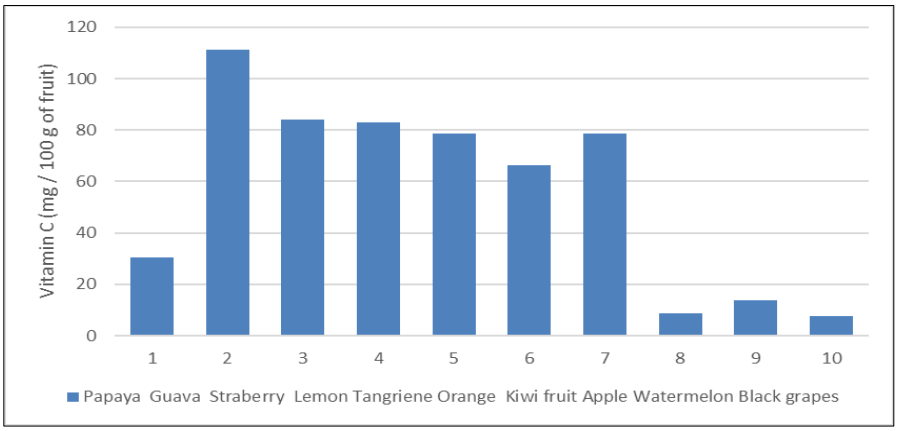


**Figure 1** Amount of vitamin C contents in fresh fruits using the indicator titration method

**Table 2** Vitamin C content in khat leaves using an indicator titration method with means with a standard deviation

| Qatte | Consumed volume of titrant (ml) | | | | | | Vitamin C content (mg) / 100 g |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | Means $\pm$ *SD* | |
| 1 | 0.4 | 0.4 | 0.3 | 0.3 | 0.3 | $0.34 \pm 0.05$ | 29.66 |
| 2 | 0.2 | 0.3 | 0.2 | 0.3 | 0.3 | $0.26 \pm 0.05$ | 22.68 |
| 3 | 0.3 | 0.2 | 0.3 | 0.1 | 0.2 | $0.22 \pm 0.08$ | 19.20 |
| 4 | 0.1 | 0.2 | 0.2 | 0.1 | 0.1 | $0.14 \pm 0.05$ | 12.21 |
| 5 | 0.5 | 0.3 | 0.4 | 0.6 | 0.6 | $0.48 \pm 0.12$ | 41.87 |

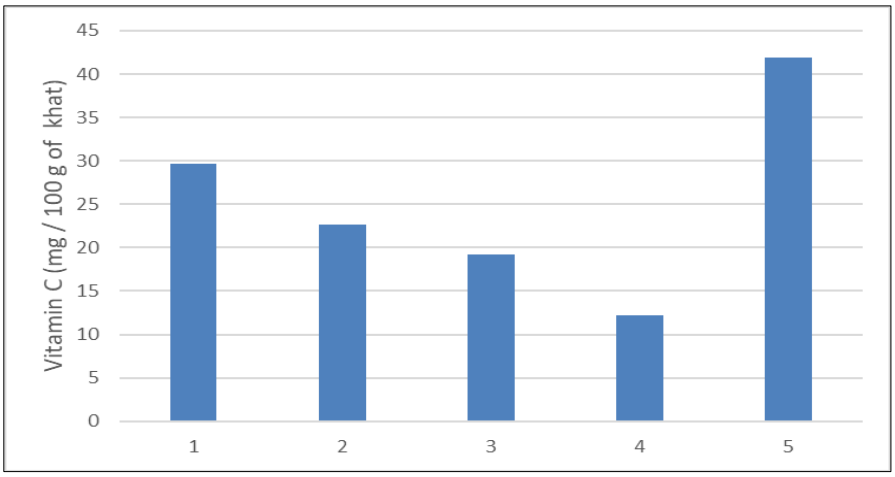


**Figure 2** Amount of vitamin C contents in khat leaves using the indicator titration method

The extracted khat leaves contain various large molecules such as steroids, alkaloids, and triterpenoids, which can interact with potassium iodate. This interaction is the primary reason for the discrepancies between this study and the published research [17]. The quantity of vitamin C in the khat leaves ranged from 19.20 mg/100 g to 41.87 mg/100 g as described in Table 2 and Fig. 2.

Also, these results reveal no significant difference between the measured vitamin C content in the commercial tablet ($p < 0.05$) and the amount stated on the product label as shown in Tables 3 and 4. Moreover, they conform to European and American standards.

**Table 3** Vitamin C content in compressed tablets using an indicator titration method with means with a standard deviation

| Compressed tablet | Consumed volume of titrant (ml) | | | | | | Vitamin C content (mg)/ tablet | Claimed content/ tablet |
|---|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | Means $\pm$ *SD* | | |
| Tablet 1 | 11.4 | 11.7 | 11.6 | 11.6 | 11.5 | $11.56 \pm 0.10$ | 1008.33 | 1000 |
| Tablet 2 | 11.2 | 11.4 | 11.5 | 12.1 | 11.2 | $11.48 \pm 0.33$ | 1001.35 | 1000 |
| Tablet 3 | 11.2 | 11.4 | 11.5 | 11.3 | 11.5 | $11.38 \pm 0.12$ | 992.63 | 1000 |
| Tablet 4 | 11.6 | 11.6 | 11.4 | 11.7 | 11.5 | $11.56 \pm 0.10$ | 1008.33 | 1000 |
| Tablet 5 | 11.6 | 11.8 | 11.6 | 11.7 | 11.6 | $11.66 \pm 0.08$ | 1017.10 | 1000 |
| Tablet 6 | 11.5 | 11.7 | 11.8 | 11.3 | 11.6 | $11.58 \pm 0.17$ | 1010.10 | 1000 |
| Tablet 7 | 11.8 | 11.6 | 11.6 | 11.7 | 11.5 | $11.64 \pm 0.10$ | 1015.31 | 1000 |
| Standard | 11.2 | 11.5 | 11.6 | 11.4 | 11.5 | $11.44 \pm 0.13$ | 997.86 | 1000 |

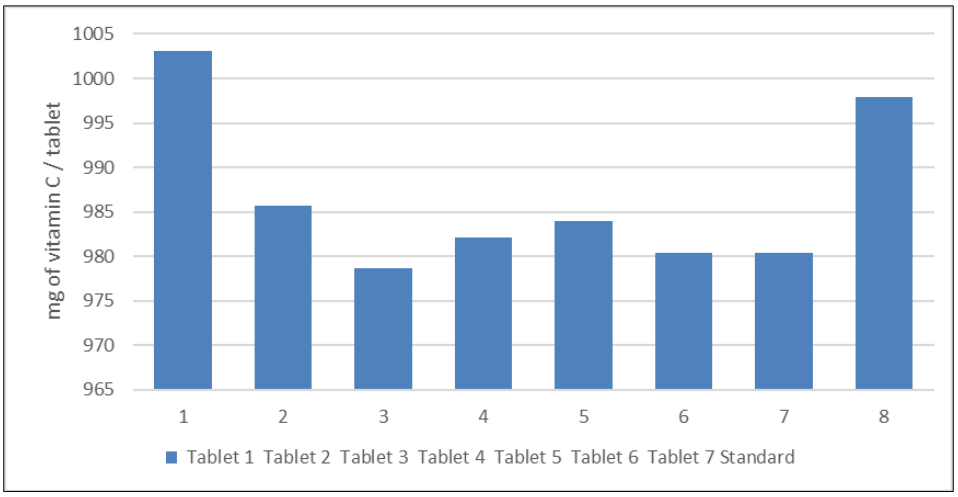


**Figure 3** Amount of vitamin C contents in effervescent tablets using the indicator titration method

**Table 4** Vitamin C content in effervescent tablets using an indicator titration method with means with a standard deviation

| Effervescent tablet | Consumed volume of titrant (ml) | | | | | | Vitamin C content(mg)/ tablet |
|---|---|---|---|---|---|---|---|
| | I | II | III | IV | V | Means $\pm$ *SD* | |
| Tablet 1 | 11.2 | 11.5 | 11.6 | 11.7 | 11.5 | 11.5 $\pm$ 0.17 | 1003.10 |
| Tablet 2 | 11.4 | 11 | 11.3 | 11.2 | 11.6 | 11.3 $\pm$ 0.2 | 985.65 |
| Tablet 3 | 11.2 | 11.3 | 11.1 | 11.4 | 11.1 | 11.22 $\pm$ 0.12 | 978.67 |
| Tablet 4 | 11.4 | 11.5 | 11.5 | 10.6 | 11.3 | 11.26 $\pm$ 0.34 | 982.16 |
| Tablet 5 | 11 | 11.6 | 11.5 | 11.1 | 11.2 | 11.28 $\pm$ 0.23 | 983.90 |
| Tablet 6 | 11.2 | 11.4 | 11.1 | 11.3 | 11.2 | 11.24 $\pm$0.10 | 980.42 |
| Tablet 7 | 11.4 | 11 | 11 | 11.5 | 11.3 | 11.24 $\pm$0.21 | 980.42 |
| Standard | 11.2 | 11.5 | 11.6 | 11.4 | 11.5 | 11.44 $\pm$0.14 | 997.86 |

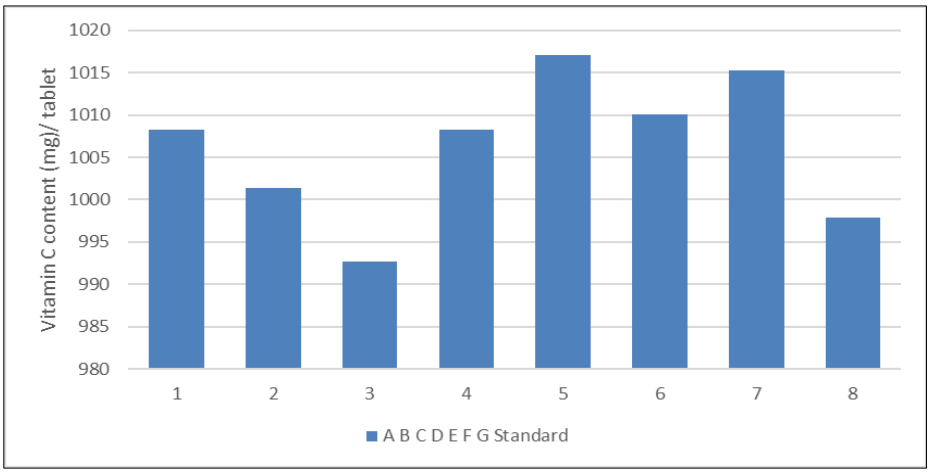


**Figure 4** Amount of vitamin C contents in compressed tablets using the indicator titration method

In conclusion, the redox titration approach with potassium iodate is preferable for measuring vitamin C content in pharmaceutical forms. In contrast, UV-VIS spectroscopy and HPLC are preferred to detect vitamin C in fruit and plant extract samples.

## 4. Conclusion

We can summarize that redox titration using potassium iodate is a valuable tool, a selected, safe, fast, and cost-effective method. The results revealed significant variation in vitamin C across different fruits, and khat leaf types, and notably, the highest amount of vitamin C exists in oranges, while the lowest amount is in the khat leaves. Also, this study found no significant difference between the measured vitamin C content in the commercial tablets ($p < 0.05$) and the amount stated on the product label. The redox titration has been selected since it can determine the amount of vitamin C with zero interference with other acids in the sample. However, further research is important to address its disadvantages and minimize its interface. Consumption of fruits high in vitamin C can assist in reducing diseases and enhancing immunity. These studies indicate the different nutritional aspects of several fruits and their prospective implications for fulfilling daily vitamin C demands.

## Compliance with ethical standards

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### *Disclosure of conflict of interest*

The author decides that no conflict of interest occurred while conducting this research and writing this article.

## References

[1] Y. Hernández, M.G. Lobo, M. González, Determination of vitamin C in tropical fruits: A comparative evaluation of methods, Food chemistry, 96 (2006) 654-664.

[2] M. Doseděl, E. Jirkovský, K. Macáková, L.K. Krčmová, L. Javorská, J. Pourová, L. Mercolini ,F. Remião, L. Nováková, P. Mladěnka, Vitamin C—sources, physiological role, kinetics, deficiency, use, toxicity, and determination, Nutrients, 13 (2021) 615.

[3] K. Pathy, Process for preparation of vitamin C and method for determination of vitamin C in tablets, SF J Chem Res, 2 (2018) 2.

[4] I. Dioha, O. Olugbemi, T. Onuegbu, Z. Shahru, Determination of ascorbic acid content of some tropical fruits by iodometric titration, International Journal of Biological and Chemical Sciences, 5 (2011) 2180-2184.

[5] A. Limenie, T. Dugul, E. Eshetu, D. Gurmu, Effects of *Catha edulis* Forsk (Khat) and ascorbic acid on serum electrolytes in swiss albino male rats, East African Medical Journal, 95 (2018) 2083-2090.

[6] A. Gashawa, T. Getachew, The chemistry of khat and adverse effect of khat chewing, American Scientific Research Journal for Engineering, Technology, and Sciences, 9 (2014) 35-46.

[7] N. Al-Hebshi, N. Skaug, Khat (*Catha edulis*)—an updated review, Addiction biology, 10 (2005) 299-307.

[8] M. Getasetegn, Chemical composition of *Catha edulis* (khat): a review, Phytochemistry Reviews, 15 (2016) 907-920.

[9] I. Klimczak, A. Gliszczyńska-Świgło, Comparison of UPLC and HPLC methods for determination of vitamin C, Food chemistry, 175 (2015) 100-105.

[10] S.B. Mussa, I. Sharaa, Analysis of vitamin C (ascorbic acid) contents packed fruit juice by UV-spectrophotometry and redox titration methods, IOSR Journal of Applied Physics, 6 (2014) 46-52.

[11] M.M. Rahman, M.M.R. Khan, M.M. Hosain, Analysis of vitamin C (ascorbic acid) contents in various fruits and vegetables by UV-spectrophotometry, Bangladesh Journal of Scientific and Industrial Research, 42 (2007) 417-424.

[12] Q.Y. Mohammed, W.M. Hamad, E.K. Mohammed, Spectrophotometric determination of total vitamin C in some fruits and vegetables at Koya Area–Kurdistan Region/Iraq, Journal of Kirkuk University–Scientific Studies, 4 .(2009)

[13] M. Nejati-Yazdinejad, Indirect determination of ascorbic acid (vitamin C) by spectrophotometric method, International journal of food science & technology, 42 (2007) 1402-1407.

[14] I.E.H. Elgailani, M. Elkareem, E. Noh, O. Adam, A. Alghamdi, Comparison of two methods for the determination of vitamin C (ascorbic acid) in some fruits, Am. J. Chem, 2 (2017) 1-7.

[15] C.V. Ramona, DETERMINATION OF VITAMIN C IN FOOD BY THE TITRATION OF IODINE, Annals of'Constantin Brancusi'University of Targu-Jiu. Engineering Series/Analele Universităţii Constantin Brâncuşi din Târgu-Jiu. Seria Inginerie.(2021) ,

[16] C. Nweze, M. Abdulganiyu, O. Erhabor, Comparative analysis of vitamin C in fresh fruits juice of Malus domestica, Citrus sinensi, Ananas comosus and Citrullus lanatus by iodometric titration, International Journal of Science, Environment and Technology, 4 (2015) 17-22.

[17] K. Al-Alimi ,A. Abdul Razak, R. Saub, A. Alabsi, Tannins acid, ascorbic acid and fluoride from khat chewing plant, Int J Dent Oral Health, 3..(2017)