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THE POSSIBILITY OF SATISFYING VITAMIN C DAILY NEEDS BY CONSUMING FRESH ORANGE AND GRAPEFRUIT

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Abstract

Diet recommendations emphasize the importance of daily allowances of vitamin C, necessary for maintaining our health. Significant amounts of this vitamin can be found in citruses.

In this paper the content of vitamin C was examined in fresh orange and grapefruit which come from three locations (Spain, Greece, Turkey and Italy), and were bought in the area of Serbia. Determining vitamin C was done by a modified spectrophotometry method (at 515 nm), and afterwards via calculations a level of satisfying daily needs was determined by consuming fresh orange and grapefruit.

Acquired results show that the content of vitamin C varies depending on the origin and type of fruit. The largest amount of vitamin content was determined in the orange fruit originating from Spain (average value is 47.67 mg of vitamin C/100 cm^3 juice). The fruit of grapefruit from Turkey had the largest amount of vitamin C (41.89 mg of vitamin C/100 cm^3 fruit). Satisfying daily needs for this vitamin with most healthy, adult persons can be achieved foremost by consuming orange from Spain (men 189 g, women 157g daily). Consuming 100 g of grapefruit a day which comes from Italy or Turkey can satisfy 50% of needs for vitamin C with women, and with men a little less than a half (from 42 to 47%). With children aged 9 to 13 years, by taking around 100 g of orange or grapefruit a day can satisfy from 74 to 100% of the vitamin C needs.

Obtained results show that by consuming orange and grapefruit can completely satisfy the daily needs for vitamin C.

***Key words**: Vitamin C, Daily needs, Orange, Grapefruit.*

1. Introduction

Diet recommendations emphasize the significance of fruit and vegetable consumption increase in everyday nutrition. Numerous studies point out the connection between diet and healt (Dauchet *et al.,* [1]; He *et al.,* [2], Bhupathiraju *et al.,* [3]) as well as large amount of fruit and vegetable consumption being linked to smaller incidences of chronic diseases such as cancer and heart disease (Yiğit *et al.,* [4], Ames *et al.,* [5], Kaleem *et al.,* [6], Joshipura *et al.,* [7]).

Citrus is the most wide spread fruit in the world and is cultivated in more than 80 countries. Citruses or agrumes is the generic name for the fruit of plants within the *Rutaceae* family, which originate from the tropical parts of Southeast Asia. Economically the most important fruit in the family is *Citrus* which includes: mandarine (*Citrus reticulata*), orange (*Citrus aurantum*), lemon (*Citrus x limon*), lime (*Citrus x aurantifolia*) and grapefruit (*Citrus x paradise*) (Tatić and Blečić, [8]). They are the most popular for consumers around the world due to their pleasant taste, nutritional value, and at the same time they are one of the richest nutrients. They are consumed fresh, but also industrially processed. The pulpes are rich in diluted sugars, considerable amounts of vitamin C (Ladaniya, [9]), fibers and different organic acids, and is therefore mostly used for processing into juice (Garway *et al.,* [10]). Thanks to its diverse chemical ingredients, due to its nature, the citrus is a raw material for a wide product range (Simmons, [11], Tulin *et al.,* [12]). Carbon hidrates such as fructose, glucose and sucrose, together with non-starch polysaccharides, pectin, cellulose and hemicellulose are present in a large amount. The fat content is very low, whereas the presence of potassium is very high compared to the amount of sodium. Apart from that, all citruses synthesize and accumulate several categories of phytochemical components (Ladaniya [9]) such as: polyphenols (flavonoids, organic acids, anthocyanins, polymethoxyflavones) (Kawaii, *et al.,* [13]); coumarins (possess properties to supress appetite), limonoids compounds known as tetranorterpenoids (present in seeds and albedo part of citrus fruits, responsible for the fruit bitterness), carotenoids and terpenoids, etc. (Ladaniya [9]).

Citruses contain different amounts of vitamin C depending on the species, fruit ripeness as well as storage conditions (Djordjevic *et al.,* [14]; Devi Ramaiya *et al.,* [15]). Numerous factors influence the amount of this element in fruit and vegetables (Seung and Kader, [16]) such as genotype differences, climate conditions, ripeness level, harvest, as well as handeling after harvest. A higher intensity of light during vegetation can provide a higher content of vitamin C in plant tissues, as well as irregular watering with many crops. Temperature management after the harvest is one of the most important factors for maintaining vitamin C in fruit, and longer storage at higher temperatures accelerates water loss (Seung and Kader [16], Mditshwa *et al.,* [17]). Vitamin C sustainability during storage with juices is influenced by the packaging material in which the juice is packed (Kaleem, *et al.,* [6]).

Vitamin C (ascorbic acid) is one of the essential vitamins necessary for body health and serves for improving the immune system (García, [18]). It belongs to a group of vitamins which dillute in water. It is of crucial importance for maintaining optimal health (including collagen biosynthesis, melanin reduction, iron and folate) (Zajac and Kucharski, [19]) and also is widely used as a food supplement. Vitamin C, known as ascorbic acid, in biochemical reactions represents an electrone donor whereby it contributes to the forming of chemical connections forming strong bonds between collagen molecules within the tissue. This vitamin has an important role in the synthesis reactions of other cell components, including thyroid gland and steroid hormones, bile acid and carnitine necessary for fatty acid decomposition. Also, antioxydant characteristics of vitamin C (Bolling *et al.,* [20]) manifest themselves in the capability to neutralize reactive oxidative molecules, whereby it prevents changes in the immune system, structure and function of certain organs in the human organism (Schlueter and Johnston, [21]). This vitamin decreases oxidative stress, i.e. it can help protect the cell from oxidative damage caused by free radicals. Oxidative stress occurs when free radicals production surpasses the body's ability to neutralize them, i.e. eliminate, due to a deficiency of antioxidans or abundance of free radicals. Antioxidants include: vitamins, carotenoid phenols, dietary glutathione and endogen metabolite (Hanasaki *et al.,* [22]).

With persons whose intake of vitamin C is decreased, mild to serious health problems can occur, depending on how long they were deprived of this essential component (García, [18], Jackson, [23]). Recommended daily allowances for most vitamins is similar from country to country, year after year, which is not the case with vitamin C. Most authors agree that the minimal daily demand for vitamin C is 10 mg or a little less (World Health Organization, [24]). Recommended daily amounts of vitamin C according to the recommended dietary allowance - RDA, with healthy persons depend on numerous factors - body weight, age and gender. Currently recommended daily allowances for adult, healthy persons are 90 mg for men and 75 mg for women. Pregnant women and women during lactation are recommended to increase the amount of vitamin C from 85 to 120 mg a day. Smokers are recommended to increase the amount for 35 mg a day regardless of the gender (García, [16]). Some research shows that daily allowance of 400 mg vitamin C and more protects from the consequences of oxidative stress, certain types of cancer, degenerative and chronic diseases (Aguirre and May [25], Kucharski and Zajac, [26], World Health Organization [27]).

The aim of this paper is to determine the amount of vitamin C in fresh, citrus fruit - orange and grapefruit, optimal ripeness (following manufacturer's instructions) available on our market, and calculate meeting of daily needs with children and adults with vitamin C, by consuming fresh fruit.

2. Materials and Methods

2.1 Materials

Fresh fruit was used in this paper (oranges and grapefruit), bought at optimal commercial value, at local markets and supermarkets in the city of Novi Sad, Vojvodina region, Serbia. Fruit was imported from various countries: Spain, Greece, Turkey, and Italy. For each citrus, three samples were examined, from three different regions (Table 1). For each analyzed citrus, three fruits of the same origin were examined, and each test was repeated three times.

Tabela 1. Fruit samples, name of the importer and country of origin

Name of fruit	Fruit origin	
Orange	Natalia	Spain
Orange	Extra Fourta	Greece
Orange	Kilic	Turkey
Grapefruit	Aris	Spain
Grapefruit	Eko	Italy
Grapefruit	Cayir	Turkey

2.2 Methods

2.2.1 Sample preparation and procedure for analysis of vitamin-C content in fresh fruit

Preparing samples implied pressing fresh citrus fruits, filtrating it through gauzes, measuring 4 mL of pressed juice which was then evaporated on a rotational vacuum vapourater (40 ^{0}C) until dry. Dry extract underwent extraction 1% *meta*-phosphoric acid. *Meta*-phosphoric acid inactivates the vitamin C enzyme oxidase and protects the vitamin C itself from oxydation. Some compounds (phenols and thiols) have the ability to reduce the 2,6-dichlorophenolindophenol (DCIP) reagents colour and if they are present in the examined sample, they lead to an interference. This problem is surpassed by preparing extracts in *meta*-phosphoric acid, which slows down the reaction between the reagent and the mentioned compounds.

2.2.2 Analysis of vitamin-C content in liquid

Vitamin C content was determined by a method given in the literature adapted for 96-well microplates (Klajn and Perry, [28], Nađpal, *et al.,* [29]). The applied method for determining vitamin C in fresh fruit is optimized (Dabić *et al.,* [30]).

The method is based on the redox reaction of ascorbic acid with 2,6- dichlorophenolindophenol (DCIP), whereby 2,6-indophenol is reduced to a colourless compound (figure 1).

DCIP (blue) + H^+ DCIPH (pink)

DCIPH (pink) + Vit C DCIPH$_2$ (colourless)

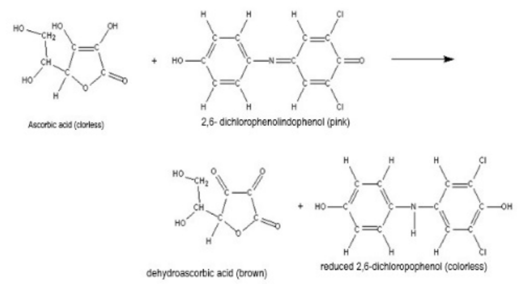

Figure 1. Reaction 2,6- dichlorophenolindophenol and ascorbic acid

In short, each sample was evaporated in vacuum at 40 ^{0}C and mixed with metaphosphoric acid (from 0.1 g/mL) in order to get final concentration of 50, 75 and 100 mg/mL for all extracts. The mixtures were stirred for 45 min. at room temperature. After the extraction, the obtained extracts were centrifuged, for a duration of 10 minutes, at 2500 × g. After centrifuging a series of three solutions was prepared for extract dilution. Prepared extracts in meta-phosphoric acid (30 mL) were mixed with 270 mL 2,6 - dichlorophenolindophenol (72 mg/mL) and absorption measuring was carried out at 515 nm (using UV-VIS Spectrophotometer Thermo Scientific Multiscan Spectrum, Finland) within 5 min.

The vitamin C content was determined based on standard solution calibration curve of ascorbic acid (in a range of 5 - 320 μg/mL), and the results were shown as middle values of three measurements. All samples were, immediately upon preparation, used for determining vitamin C at room temperature.

2.2.3 Statistical analysis

All tests were performed in triplicates. For all obtained results were using descritive statistics in Microsoft Office Excel 2007 package.

3. Results and Discussion

Results of determining the vitamin C content in different samples of orange are shown in Figure 2. Several studies show that unwanted conditions during storage (temperature, air exposure) and fruit processing (cutting, peeling, etc.) are conditions that can lead to loss in chemical and/or physical quality of the fruit and vitamin C content (Oyetade *et al.,* [31], Kaleem *et al.,* [6], Jeney-Nagymate and Fodor, [32], Seung and Kader [13]). In order to prevent this for the conducted vitamin C content determining, samples used were stored at temperature upto +4 ^{0}C, and the temperature of the measuring itself was room temperature whereby the possibility of a greater loss of vitamin C was eliminated.

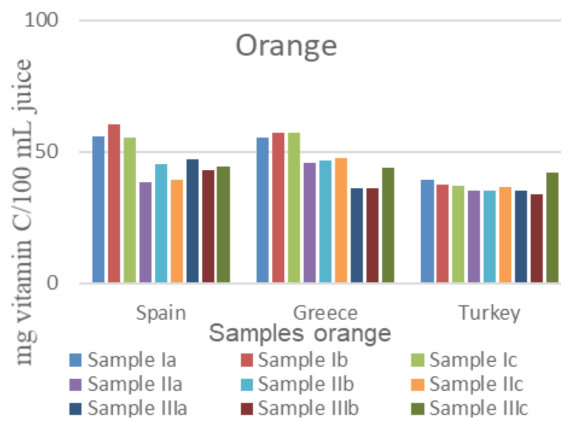

Figure 2. Vitamin C values in orange from Spain, Greece and Turkey

Analyzed results show that the least difference in vitamin C content were with orange samples from Turkey, whereas in orange samples from Greece and Spain the values differ. It is most probably the consequence of different fruit ripping conditions and its storage. Namely, it is possible that the fruits were harvested from different trees (different sun exposure, watering, distant areas, etc.), but also that they were stored in different conditions, and later put together.

Approximate values in vitamin C content were determined in orange species imported from Spain and Greece and those values are in accordance with literature data (Pisoschi *et al.,* [33], Davey et al [34]), whereas some lower vitamin C values were found in orange originating from Turkey. The average vitamin C value is the highest with oranges imported from Spain and it is 47.67 mg vitamin C/100 mL juice.

According to the obtained results, and comparing with the available literature data (Jackson *et al.,* [23], Kaleem *et al.,* [6]) it can be concluded that examined oranges have high vitamin C values.

In Figure 3, a certain content of vitamin C in grapefruit is shown. According to the obtained data, the most vitamin C was determined in grapefruit samples from Turkey, the average value is 41.89 mg vit. C/100 mL juice. The least fluctuation in the content of this vitamin were seen in samples from Spain, but these samples were on an average with a lower vitamin content which is 33.52 mg vitamin C/100 mL juice.

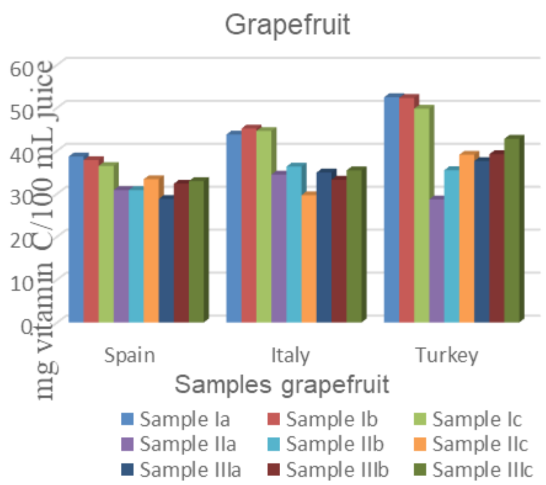

Figure 3. Vitamin C values in grapefruit from Spain, Italy and Turkey

Obtained results were compared with literature data (Lee and Kim, [35], Davey *et al.,* [34]) and vitamin C content in all nine shown samples of grapefruit is considered to be average.

3.1 Satisfying daily vitamin C needs

It is known that a well- balanced diet can prevent vitamin deficit in the organism. Also, World Health Organization (WHO) recommends daily consumption of 5 - 10 portions or at least 400 g of fresh fruit and vegetables daily. Therefore, determining the necessary amount of fruit (in g) was carried out, which would provide satisfying the daily vitamin C needs with children and adults. The percentage of satisfying daily vitamin C needs was calculated, which would be provided by consuming 100g of examined citrus samples. Calculation results are shown in table 2.

Male adults need to take in daily from 189 to 244 g orange in order to satisfy daily need for vitamin C. Considering that oranges originating from Spain and Greece vary little in content of this vitamin, needs are satisfied with almost the same amount (189 g, i.e. 190 g) of fruit. It is only necessary to eat a little more oranges from Turkey in order to satisfy the daily need (244 g).

With healthy adult women by eating 157 g of orange from Spain, i.e. 159 g of orange from Greece the vitamin C need will be met. Fruit originating from Turkey should be taken in the amount of 204 g.

Table 2. Satisfying the daily vitamin C needs with children and adults by consuming fresh orange and grapefruit

RDA* (mg/day)	**Men (M) - 90 Women (W) - 75 Children (C) (9-13 y) - 45**											
Fruit type	**Orange**						**Grapefruit**					
	Natalia, Spain		Extra Frouta, Greece		Kilic, Turkey		Aris, Spain		Eko, Italy		Cayir, Turkey	
Average content vitamin C mg/100 mL juice	47.67		47.27		36.85		33.52		37.48		41.89	
Consuming fruit (g/day)	M	189	M	190	M	244	M	269	M	240	M	215
	W	157	W	159	W	204	W	224	W	200	W	179
	C	94	C	95	C	122	C	134	C	120	C	107
Percent of daily needs satisfied by 100 g fruit (%)	M	53	M	53	M	41	M	37	M	42	M	47
	W	64	W	63	W	49	W	45	W	50	W	56
	C	106	C	105	C	82	C	74	C	83	C	93

Legend: RDA - Recommended dietary allowance (RDA): average daily level of intake sufficient to meet the nutrient requirements of nearly all (97 - 98%) healthy people (WHO 2004).

For a sufficient vitamin intake with children age 9 to 13 years, it is necessary to eat from 94 g to 122 g of orange. Amount of grapefruit which will satisfy daily needs with men is 269 g for grapefruit from Spain, 240 g grapefruit from Greece and somewhat less grapefruit from Turkey 215 g. Women should take from 179 g (grapefruit from Turkey) to 224 g of this fruit from Spain in order to be certain that they have taken the sufficient amount of vitamin.

With children it is enough that they take 107 g grapefruit (Turkey), i.e. 120 g (Italy) or 134 g grapefruit from Spain, in order for the vitamin C daily allowance to be optimal.

Since during the day a regular diet has more than one fresh food or fruit, a % was calculated of satisfying daily allowances by taking 100 g of analyzed citruses and the results show the following (Table 2):

- With children by taking 100g or orange from Spain and Greece the recommended daily allowances (RDA) are completely met, whereas the same amount of orange from Turkey satisfies 82% of daily allowances; with 100 g of grapefruit children cover from 74% (from Spain) to 93% of allowances (originating from Turkey).
- With women orange from Turkey satisfies about half daily needs (49%), whereby other samples of this fruit provide 63% i.e. 64% of daily needs; consuming grapefruit provides around half of total needs (45% Spain, 50 % Italy and 56% Turkey).
- Male adult population a higher percentage of daily allowances is met by consuming 100 g of orange (53% orange from Spain and Greece, 41% from Turkey), than 100g grapefruit , where percentage goes from 37 % (Spain), 42% Italy to 47% of allowances met by grapefruit originating from Turkey.

4. Conclusions

- Results of vitamin C content in analysed samples show that orange and grapefruit are exceptional sources of this vitamin. This paper shows that by taking 100 g of orange or grapefruit about a half or more of the daily allowances for this vitamin are met, depending on the gender and age.

- Due to the instability of this vitamin and loses which can occur during storage, it is necessary to pay special attention to that part. Regarding the increased use of citrus fruit during winter as well as their availability on the market in Serbia during the entire year, in future work seasonal monitoring of vitamin C variations in citruses is planned and the influence of storage and conditions of storing on variations in vitamin C content is planned.

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