Determination of the Ascorbic Acid Content and the Antioxidant Activity of Different Varieties of Vegetables Consumed in Romania, from Farmers and Supermarkets

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Abstract: Vitamin C sustains the health of the human organism. It reduces the risk of chronic diseases and it can help to control arterial hypertension. In addition, it prevents and reduces the risk of developing various heart diseases, it normalizes the level of uric acid in the blood, it can help with the prevention of gout attacks, it helps to prevent iron deficiency and strengthens the immune system. Considering these aspects, it can be stated that a diet rich in vitamin C plays an essential role in a person’s daily food intake. Within the present study, we identified the content of vitamin C in various types of bell peppers and tomatoes consumed in Romania. The vitamin C content was determined by using the titration and the iodometric methods. The research results pointed out that the content of vitamin C in the analyzed bell peppers is between 4.693 and 11.264 mg/100 g, and in the analyzed tomatoes is between 0.939 and 4.639 mg/100 g. The antioxidant activity was studied as well, by using the DPPH radical and the Trolox equivalent antioxidant capacity (TEAC). The antioxidant activity was correlated with the content of ascorbic acid, present in the samples. The studies revealed that the vegetables bought from the farmers had a higher content of vitamin C than the ones bought from the supermarkets. This aspect was also confirmed by their increased antioxidant activity, which points out that the local vegetables are a rich source of natural antioxidants, which can be used to prevent various health conditions caused by oxidative stress.

Keywords: ascorbic acid; antioxidant activity; DPPH; TEAC; vegetable

1. Introduction

From a structural point of view, vitamin C is the γ-lactone of the L-gluconic acid, which has six carbon atoms, which have grafted four OH groups, out of which two are alcoholic at C4 and C5 and two are enolic at C2 and C3 [1] (Figure 1).

Figure 1. The chemical structure of vitamin C.
Vitamin C, or ascorbic acid, is an organic acid which has antioxidant properties which are involved in a series of processes which occur within the living cells. In the human organism, vitamin C has a very complex and important role, since it protects the active biological compounds against oxidative degradation, it strengthens the functions of the immune system, it stimulates the biosynthesis processes of collagen, steroid hormones and of certain neurotransmitters. It is an essential nutrient which plays a vital role in protecting the organism against infections and inflammatory diseases. In addition, it is involved in the absorption process of inorganic iron, in reducing the levels of cholesterol in the sanguine plasma and inhibits the formation of nitrosamine [2]. The lack of vitamin C in the human organism leads to scurvy, also known as the “sailors’ disease”, or to gingivitis, parodontids, frail blood vessels, inflammation of the joints, and anemia [3]. Because of its antioxidant activity, it has been reported that it reduces the risks associated with the development of arteriosclerosis, heart disease, infectious diseases [4], asthma, cataracts, diabetes and several types of cancer (breast and colon cancer) [5,6]. High dosages of vitamin C are recommended to optimize the micro and macro blood circulation and to reduce the size of cell lesions. It is a renowned fact that vitamin C restores the affected micro circulatory flux, by inhibiting the activation of the nicotinamide adenine dinucleotide phosphate-phosphate-oxidase, thus preventing the decoupling of oxidative phosphorylation [7]. It can be synthetized by superior plants, certain microorganisms and the majority of animals, with the exception of primates (human beings and anthropoid apes), guinea pigs and certain birds which do not have the galen lactone oxidase enzyme [1].

Since the human organism cannot synthetize the vitamin C from fructose, as plants do [8], its level within the organism depends entirely on the exogenous sources of vitamin C [9,10].

The most common vitamin C sources, which assures around 90% of the necessary amount for the human diet, is represented by fruits (mainly citrus fruits and the juice obtained from them), but also other fruits with a variable vitamin C content, such as melons, cherries, kiwis, mangoes, papayas, and raspberries, as well as vegetables, such as bell peppers, tomatoes, broccoli, spinach and even potatoes [1]. A dosage of 10 mg/day prevents avitaminosis C, but the recommended daily amount for an adult is of 60 mg [11]. The human organism cannot store more than 2.5 g of vitamin C. Vitamin C is partially oxidated by two metabolites—the principal and active dehydroascorbic acid and the inactive oxalic acid.

There are numerous methods which are used for the quantitative determination of vitamin C, such as the titrimetric–iodometric method [12], the 2,6 dichloro indophenol method [13], the voltametric methods [14,15], the spectrophotometric method [16], and the chromatographic method [17–19]. The simplest and fastest methods to analyze vitamin C is the titration method because it gives similar results to the spectrophotometric and the chromatographic methods [20]. This method allows the determination of vitamin C through a series of vegetal products with different complexities. However, the extractive processes must be performed with a high yield and in a short amount of time, in order to avoid the rapid oxidation of vitamin C. The iodometric method is a method used to determine the concentration of vitamin C, on the basis of its reductive properties, through redox titration using iodine as a result, due to the oxidation reaction of the ascobic acid with excessive iodine [21]. As the iodine is added during the titration process, the ascorbic acid is oxidated and it becomes dehydroascorbic acid while the iodine is reduced to iodide ions (Figure 2). The method is based on the oxidation of ascorbic acid with excessive iodine, according to the reaction.
As an oxidant, it is used in the iodine generated at the site, following the reaction of iodate with the potassium iodide, according to the reaction [21]:

$$\text{KIO}_3 + 6\text{HCl} + 5\text{KI} \rightarrow 6\text{KCl} + 3\text{I}_2 + 3\text{H}_2\text{O}$$

(1)

The bell pepper (Capsicum annuum L.), originating from Central and South America, is widely cultivated and consumed in Romania. The bell pepper contains a series of nutrients, such as carbohydrates, proteins, fats, minerals (potassium, calcium, phosphorous, and iron), and vitamins (A, B, and C) [22,23]. Due to these compounds, which offer a specific color and taste, the bell pepper is largely used as a seasoning. The new studies in the field support the idea of using the new ingredients in the bell pepper within the food technology, as food additives and preservers [24].

The tomato (Lycopersicon esculentum) is a very valuable vegetable, due to its nutritional benefits that stand out, due to its contents that consist of different chemical compounds, such as citric acid, ascorbic acid (vitamin C), carbohydrates, minerals, and a series of antioxidant compounds [25].

Vitamin C, which is present in nature in the majority of plants, mainly in fresh vegetables and fruits, is also known as the “vitamin of the fresh food products” [26].

Karin Jacob and others demonstrated the importance of drinking tomato juice enriched with vitamin C. They pointed out the positive results on several biomarkers on oxidative stress and inflammation [27].

Imran and others pointed out the antioxidant activity of lycopene, present in tomatoes. In their study, they emphasized the anticarcinogenic role that lycopene plays, as well as the positive aspects, such as its antidiabetic properties and its heart, liver, and neuro protective characteristics. In addition, they explained that lycopene has antioxidant and protective effects on bones [28].

Chaudhary and others explained the importance of tomato consumption for a healthy diet, by pointing out the nutrient quantity in the various types of tomatoes [29].

In Romanian supermarkets, most of vegetables are imported. The most prevalent vegetables are pepper and tomatoes. Due to this, the article presents a comparison between the vegetables from supermarkets and vegetables from Romania’s production.

The purpose of this article is to determine the content of vitamin C in vegetables, such as bell peppers and tomatoes, which are frequently consumed in Romania and to compare the level of the vitamin C content in these vegetables, according to their provenance, from local farmers (local production) or supermarkets (imported vegetables). Another aim was to establish a correlation between the antioxidant activity and the vitamin C content.

2. Material and Method

2.1. Materials

The determination of the vitamin C content was made using two different types of vegetables: the bell pepper and the tomato. Eight samples of bell peppers (two types: the yellow Silver Bell and the red California Supreme) and seven samples of tomatoes (three types: the large Campbell, the medium-sized Red Morning, and the small Allarosa) were
collected. The vegetables were bought from local farmers in Sanpetru German and Curtici, and from supermarkets (the Dorobanti greenhouses in Romania, Italy, and Spain).

2.2. Determination of the Ascorbic Acid Content

The vegetable samples were washed prior to being analyzed. The inedible parts were removed. The edible parts (15.00 ± 0.01 g) were milled vigorously with a 10 mL solution of HCl 2% and 2.50 g of quartz sand, for 10 min. Then, the sample was filtrated and brought to a volume of 50 mL with HCl 2%. To 10 mL of this solution, was added 3 mL of distilled water, 5 mL of HCl, and the 2.50 mL solution served as the starch indicator. The sample was titrated with a solution of KIO₃ 0.0008 M, until the appearance of blue coloring that lasted over one minute.

The analysis was performed on three parallel samples, taking as the final value, the average value of the titrations (V in mL).

The vitamin C content was calculated in mg/100 g of the vegetal material, using the formula:

\[ \text{Vitamin C mg %} = \frac{V \times 70.4}{G} \]

where:
\[ V = \text{no. of KIO}_3 \text{ 0.0008 M Mol used for the titration process} \]
\[ G = \text{the mass measured in g of the material used for the analysis} \]

2.3. Determination of the Antioxidant Activity

2.3.1. Determination of the Free Radical Scavenging Activity by the 1,1-Di[phenyl-2-picyrylhydrazyl (DPPH)–Assay

The method used to determine the antioxidant activity is the one proposed by Brand-Williams [30]. A volume of 2800 µL DPPH solution, freshly prepared in 98% methanol, was mixed with 400 µL sample and the absorbance was measured at 515 nm for 60 minutes with the help of a UV-VIS SP-8001 Metertech spectrophotometer. The antioxidant activity (expressed in Trolox µM/L) was calculated using the calibration curve for Trolox in the domain 0–200 µM (R² = 0.998).

The antioxidant activity was calculated using the formula:

\[ \% \text{DPPH scavenging activity} = \left[ 1 - \frac{A}{A_0} \right] \cdot 100 \]

where A is the sample absorbance and A₀ is the absorbance of the DPPH solution.

The results were expressed as si µM Trolox equivalent (TE)/100 g vegetal material µM TE/100 g d.w.

2.3.2. The Trolox Equivalent of the Antioxidative Capacity (TEAC)

The TEAC method described by Zuzuleta [31], was slightly changed. Thus, the ABTS cation was generated by adding 7 mM 2,2-azino-bis (3-ethyl-benzo-thiazoline-6-sulphonic acid), diammonium salt (ABTS), and a stock solution with 2.45 mM potassium persulfate (1:1, v/v). It was kept in a dark environment for 12 to 16 h, until the reaction was complete and the absorbance stable.

The absorbance of the ABTS radical solution was balanced to 0.700 (0.02) through the dilution with water. Then, a 1 mL reactive was mixed with a sample of 100 µL (1–1.05 mg/mL) and the absorbance was read after six minutes, at 737 mn using a UV-VIS SP-8001 Metertech spectrophotometer.

The annihilation activity of the free radicals was calculated with the formula:

\[ \% \text{Inhibition} = \left[ \frac{(A_{\text{blank}} - A_{\text{sample}})}{A_{\text{blank}}} \right] \cdot 100 \]

where A_blank = solvent absorbance and A_sample = sample absorbance

The calibration curve for Trolox was made for the concentration in the domain, ranging from 0 to 250 µM. The values of the sample concentrations were calculated and expressed in Trolox equivalents (µM TE).
2.4. Statistical Analysis

All analyses were carried out in triplicate, and the continuous variables were expressed as mean ± standard deviation (SD). All graphs, the descriptive and inferential statistical analyses were performed using MedCalc® Statistical Software version 20.015 (MedCalc Software Ltd., Ostend, Belgium; https://www.medcalc.org; 2021 (accessed on 1 August 2022). The use of the parametric vs. non-parametric tests was decided, based on the Shapiro–Wilk test (at 95% confidence). The ANOVA with post-hoc HSD test was performed to analyze how significant were the differences between the groups. A \( p \) value of < 0.05 was considered to indicate a statistically significant difference.

3. Results

3.1. Ascorbic Acid Content

The values of the level of vitamin C in the analyzed vegetables are presented in Table 1.

<table>
<thead>
<tr>
<th>Name of the Analyzed Product</th>
<th>Origin</th>
<th>Color</th>
<th>Vitamin C Content in mg/100 g of the Analyzed Product (^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>BELL PEPPER-A1</td>
<td>Farmer</td>
<td>Yellow</td>
<td>11.24 ± 0.01</td>
</tr>
<tr>
<td>BELL PEPPER-A2</td>
<td>Supermarket</td>
<td>Red</td>
<td>4.68 ± 0.01</td>
</tr>
<tr>
<td>BELL PEPPER-A3</td>
<td>Supermarket</td>
<td>Yellow</td>
<td>7.97 ± 0.01</td>
</tr>
<tr>
<td>BELL PEPPER-A4</td>
<td>Supermarket</td>
<td>Yellow</td>
<td>10.78 ± 0.01</td>
</tr>
<tr>
<td>BELL PEPPER-A5</td>
<td>Supermarket</td>
<td>Red</td>
<td>4.67 ± 0.02</td>
</tr>
<tr>
<td>BELL PEPPER-A6</td>
<td>Farmer</td>
<td>Yellow</td>
<td>9.84 ± 0.01</td>
</tr>
<tr>
<td>BELL PEPPER-A7</td>
<td>Supermarket</td>
<td>Red</td>
<td>5.14 ± 0.01</td>
</tr>
<tr>
<td>BELL PEPPER-A8</td>
<td>Farmer</td>
<td>Yellow</td>
<td>9.36 ± 0.01</td>
</tr>
</tbody>
</table>

\(^1\) The results were expressed as mean values (±SD) of three determinations.

Considering the data obtained during the analysis process, the vitamin C content was calculated in mg/100 g of the analyzed product. The vitamin C content in the analyzed bell pepper varies between 4.693 and 11.264 mg/100 g (Table 1). In the case of the other vegetable that was analyzed during the present study, the values of the vitamin C levels in the tomatoes are presented in Table 2.

<table>
<thead>
<tr>
<th>Name of the Analyzed Product</th>
<th>Origin</th>
<th>Vitamin C Content in mg/100 g of the Analyzed Product (^1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOMATOES-R1</td>
<td>Farmer</td>
<td>2.35 ± 0.05</td>
</tr>
<tr>
<td>TOMATOES-R2</td>
<td>Supermarket</td>
<td>2.34 ± 1.04</td>
</tr>
<tr>
<td>TOMATOES-R3</td>
<td>Farmer</td>
<td>3.74 ± 1.67</td>
</tr>
<tr>
<td>TOMATOES-R4</td>
<td>Farmer</td>
<td>2.33 ± 1.04</td>
</tr>
<tr>
<td>TOMATOES-R5</td>
<td>Farmer</td>
<td>2.34 ± 1.04</td>
</tr>
<tr>
<td>TOMATOES-R6</td>
<td>Supermarket</td>
<td>0.93 ± 0.41</td>
</tr>
<tr>
<td>TOMATOES-R7</td>
<td>Supermarket</td>
<td>4.58 ± 1.99</td>
</tr>
</tbody>
</table>

\(^1\) The results were expressed as mean values (±SD) of three determinations.

On the basis of the data written in the product file during the analysis process, the vitamin C content was calculated in mg/100 g of the analyzed product. The content of vitamin C in the analyzed tomatoes varied between 0.939 and 4.693 mg/100 g.

The content of vitamin C in the bell peppers and in the tomatoes, according to their origin (farmers or supermarket, Romania or other countries) is presented in Figure 3.
Concentrations were observed in all of the samples that were subjected to the analysis process. During their study presented in 2019 [33], important differences linked to the content of the active biological compounds, as it is the case of the ascorbic acid content, were identified. The antioxidant activity of the samples was studied in the present paper. The results of the determination of the antioxidant activity through the DPPH method are presented in Table 3. The important differences between the Trolox concentrations were observed in all of the samples that were subjected to the analysis process.

### 3.2. Antioxidant Activity

A variety of methods used to determine the antioxidant activity of the vegetal products were employed, because vegetal extracts have a very complex composition [32]. Some studies point out that the antioxidant activity of the samples with a vegetal origin is also linked to the content of the active biological compounds, as it is the case of the ascorbic acid that was studied in the present paper. The results of the determination of the antioxidant activity through the DPPH method are presented in Table 3. The important differences between the Trolox concentrations were observed in all of the samples that were subjected to the analysis process.

### Table 3. The antioxidant activity for the bell pepper and tomato samples, determined using the DPPH method.

<table>
<thead>
<tr>
<th>Pepper Sample</th>
<th>µM Trolox/g Plant Material ¹</th>
<th>Tomatoe Sample</th>
<th>µM Trolox/g Plant Material ¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>124.26 ± 0.50</td>
<td>R1</td>
<td>22.10 ± 0.47</td>
</tr>
<tr>
<td>A2</td>
<td>60.25 ± 0.44</td>
<td>R2</td>
<td>25.12 ± 0.30</td>
</tr>
<tr>
<td>A3</td>
<td>100.20 ± 0.66</td>
<td>R3</td>
<td>38.22 ± 0.46</td>
</tr>
<tr>
<td>A4</td>
<td>111.85 ± 0.66</td>
<td>R4</td>
<td>22.00 ± 1.12</td>
</tr>
<tr>
<td>A5</td>
<td>50.55 ± 0.14</td>
<td>R5</td>
<td>25.00 ± 0.88</td>
</tr>
<tr>
<td>A6</td>
<td>108.56 ± 1.04</td>
<td>R6</td>
<td>10.30 ± 0.34</td>
</tr>
<tr>
<td>A7</td>
<td>80.22 ± 0.62</td>
<td>R7</td>
<td>50.02 ± 1.17</td>
</tr>
<tr>
<td>A8</td>
<td>103.28 ± 0.47</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹The results were expressed as mean values (±SD) of three determinations.

The antioxidant activity of the bell peppers varies between 50.55 ± 0.05 µM Trolox/g of the vegetal material and 124.8 ± 1.41 µM Trolox/g of the vegetal material, and for tomatoes between 10.30 ± 0.56 µM Trolox/g of the vegetal material and 50.02 ± 2.89 µM Trolox/g of the vegetal material.

The antioxidant activity determined through the TEAC methods, varies between 46.89 ± 1.95 µM Trolox/g of the vegetal material and 120.1 ± 2.02 µM Trolox/g of the vegetal material for the bell pepper samples, and between 80.00 ± 0.09 µM Trolox/g of the vegetal material and 48.56 ± 2.56 for the tomato samples (Table 4). The antioxidant activity of the bell pepper is similar to the one identified by Mansor Hamed and his collaborators, during their study presented in 2019 [33].
Table 4. The antioxidant activity for the bell pepper and tomato samples, determined through the TEAC method.

<table>
<thead>
<tr>
<th>Pepper Sample</th>
<th>µM Trolox/g Plant Material 1</th>
<th>Tomatoe Sample</th>
<th>µM Trolox/g Plant Material 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>120.11 ± 0.95</td>
<td>R1</td>
<td>18.22 ± 0.01</td>
</tr>
<tr>
<td>A2</td>
<td>57.26 ± 0.34</td>
<td>R2</td>
<td>19.28 ± 0.38</td>
</tr>
<tr>
<td>A3</td>
<td>95.02 ± 0.84</td>
<td>R3</td>
<td>35.25 ± 0.07</td>
</tr>
<tr>
<td>A4</td>
<td>98.89 ± 0.43</td>
<td>R4</td>
<td>20.50 ± 0.38</td>
</tr>
<tr>
<td>A5</td>
<td>46.89 ± 0.86</td>
<td>R5</td>
<td>22.21 ± 0.39</td>
</tr>
<tr>
<td>A6</td>
<td>100.25 ± 0.02</td>
<td>R6</td>
<td>9.80 ± 1.10</td>
</tr>
<tr>
<td>A7</td>
<td>75.56 ± 0.11</td>
<td>R7</td>
<td>48.56 ± 0.06</td>
</tr>
<tr>
<td>A8</td>
<td>98.23 ± 0.02</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1 The results were expressed as mean values (±SD) of three determinations.

3.3. Correlation between the Ascorbic Acid and the Antioxidant Activity

The correlation of the ascorbic acid content and the antioxidant activity (the DPPH method and the TEAC method, respectively), can be seen in Figures 4 and 5, respectively.

Figure 4. Correlation between the antioxidant activity (DPPH-(A), TEAC-(B)) and the ascorbic acid content in the peppers.

Figure 5. Correlation between the antioxidant activity (DPPH-(A), TEAC-(B)) and the ascorbic acid content in the tomatoes.
Table 5 shows the Pearson correlation coefficient (r) between the different antioxidant assay and the ascorbic acid content.

Table 5. The correlation of the analyzed parameters.

<table>
<thead>
<tr>
<th></th>
<th>Multivariate Correlations *</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Acid Asc content DPPH TEAC</td>
</tr>
<tr>
<td>PEPPER Acid Asc content DPPH TEAC</td>
<td>1 0.953 0.933</td>
</tr>
<tr>
<td>TOMATOE Acid Asc content DPPH TEAC</td>
<td>1 0.992 0.980</td>
</tr>
</tbody>
</table>

* All correlations are significant at the 0.01 level (2-tailed).

4. Discussions

4.1. Ascorbic Acid Content

The bell pepper is an important vegetable crop, available on the global market of fresh and processed food products. Therefore, a huge variety of types belongs to the Capsicum annuum species, which has a series of phenotypic characteristics (color, form, and taste) and culinary properties. These are sustained by distinctive psychologies and metabolisms. During the growth, development, and fruit maturation processes, every type can respond in a different manner, to the adverse conditions generated by the biotic and abiotic stress factors, environment elements, and climatic changes, mainly temperature. Thus, the content of ascorbic acid varies in accordance with all of these parameters [34–36].

During the present study, it was observed that the two analyzed pepper varieties, the Silver Bell and California Supreme, obtained from the local farmers (Sanpetru German and Curtici) had a higher content of ascorbic acid, in comparison with the same varieties purchased from the supermarkets (Dorobanti greenhouses in Romania or Italy or Spain).

The content of vitamin C in the bell peppers harvested from the garden was of 8.135 mg/100 g, while in the bell peppers bought from the supermarkets, the content was equal to 7.884 mg/100 g (Figure 3). Vitamin C is present in an important quantity of products cultivated in our country, while the imported ones have lower quantities of this vitamin.

The vitamin C content in the analyzed tomatoes was compared, in accordance with the types, and it was observed that of all the varieties bought from local farmers, the medium-sized round-shaped tomatoes had the highest level of vitamin C, equal to 3.735 mg/100 g of the tomatoes. In the case of the tomatoes bought from supermarkets, it was observed that the medium-sized round Spanish tomatoes had the lowest content of vitamin C, equal to 0.939 mg/100 g of analyzed the tomatoes.

This might occur due to the fact that tomatoes of the same variety and size grown in greenhouses have a lower content of vitamin C than the ones grown outdoors. This is the result of the low values of light intensity (natural light) in greenhouses. In the case of mature greenhouse tomatoes (green) the ones that are commercialized in supermarkets, the content of ascorbic acid is lower than in the ripe tomatoes (red) cultivated in the field, which have a higher content of vitamin C. This is also due to the fact that the tomatoes in supermarkets are stored in dark spaces, at low temperatures, in order to ripen. As a result, they lose the important vitamin C quantities by the time they are fully ripened. Both the exposures to the light and the dark of the developing vegetables have an important influence on the concentration of ascorbic acid. Thus, the part of the tomato which is directly exposed to light has higher quantities of vitamin C than the part that grows in a shaded area. The vegetables bought from supermarkets reached maturity in an environment with
temperatures ranging from 7 to 10 °C. The vegetables bought from farmers were already matured when they were harvested/used [35,37].

The maturation of the vegetables is a very important process, in terms of their content and quality. Numerous studies have pointed out that the culture system and the harvesting time influences the nutritive value of the vegetables. The plants cultivated in Romania were harvested when they were fully grown, while the ones bought from supermarkets were not [38].

### 4.2. Antioxidant Activity

The latest research on the implications of antioxidants in the physiology of bell pepper fruits [39,40] were the impetus for us to investigate the antioxidant response of the two vegetable species which were subjected to different temperatures, during the development and maturation stages (according to their origin—farmer or supermarket). This is a perspective which until now has not been given sufficient attention, by the academic world.

A high percentage of the radical capture was registered at an increased concentration of the tested samples, which points out their powerful antioxidant activity. For this reason, we can suggest that the remarkable anti-radical properties against the DPPH and ABTS stable radicals, were demonstrated in the bell pepper and tomato samples bought from the local farmers.

Statistically, the antioxidant activity of bell peppers was highlighted as being ($p < 0.01$) the highest, using the more powerful agent for scavenging the DPPH free radicals, with a value of 124.26 ± 0.50 µM Trolox/g of the vegetal material which is two times higher than the one present in the bell pepper samples coming from the supermarket (50.55 ± 0.14 µM Trolox/g of the vegetal material) when its ascorbic acid content is relatively at its lowest (Table 3). It was interesting to point out that its activity to scavenge the DPPH, seems to be significantly lower than the one of the synthetic standards (BHT, BHA) and of the pure natural compounds (ascorbic acid and gallic acid). However, the anti-radical activity of the tomato samples against the DPPH radicals, was statistically ($p < 0.01$) lower than the one belonging to the bell pepper samples.

In comparison with this, the tomato sample seems to have ($p < 0.01$) a lower scavenging activity against the ABTS cationic radical, than the one registered for the bell peppers, with values ranging between 9.80 µM Trolox/g of the vegetal material and 32.25 µM Trolox/g of the vegetal material, respectively.

Our results are totally in accordance with the ones reported by Zuravwik et al. [41], who demonstrated that the bell pepper samples have the highest capacity to adjust against both the DPPH and ABTS radicals. Erge et al. [41] reported, in the case of the tomato samples, the values of the antioxidant activity against the ABTS and the DPPH radicals, which were mostly lower than the ones presented in the sample analyzed in our study [41].

The antioxidant activity of the bell pepper samples proved to be much higher than the one obtained in the tomato sample, against both the DPPH and ABTS radicals, which makes the bell pepper more effective against the free radicals.

Regarding the present results, we assumed that the remarkable scavenging activity of the bell pepper samples might be the result of their high content of ascorbic acid and phenolic biocompounds.

### 4.3. Correlation between the Ascorbic Acid and the Antioxidant Activity

By correlating the ascorbic acid content and the antioxidant activity (the DPPH method and the TEAC method, respectively), our research pointed out a good correlation for the bell pepper samples ($R^2 = 0.9090$ for the DPPH method, $R^2 = 0.8705$ for the TEAC method) and for the tomato samples ($R^2 = 0.9855$ for the DPPH method, $R^2 = 0.9671$ for the TEAC method) (Figures 4 and 5).

A positive correlation between the contents of ascorbic acid and the antioxidant activity can be observed. The bell pepper samples have both a greater antioxidant activity and a
higher ascorbic acid content. The relation between these parameters could be observed in the bell pepper sample, even without using the statistical analysis. The yellow bell pepper samples had the highest ascorbic acid quantity ($r = 0.903, p < 0.05$). The significant correlations between the color parameters, ascorbic acid, and the antioxidant capacity, have been demonstrated by Beretta et al. (2011) [22].

By comparing the correlation coefficients ($r$-values), it is possible to suggest that acid ascorbic is responsible for the antioxidant activity of the selected vegetables.

The content of ascorbic acid in the bell pepper samples bought from the farmers, varied between $5.14 \pm 0.01$ mg/100 g of the vegetal material and $9.84 \pm 0.01$ mg/100 g of the vegetal material (the exception of sample A1, of the supermarket-farmer origin) while the content of ascorbic acid in the imported bell peppers varied between $4.67 \pm 0.01$ mg/100 g of the vegetal material and $7.97 \pm 0.01$ mg/100 g of the vegetal material. The ascorbic acid content in the bell peppers was correlated with the original source presenting a statistical importance ($p < 0.05$), in comparison with the bell pepper samples from the supermarkets, which were mostly imported. The ascorbic acid content of the bell pepper samples and the original source also presented a good correlation ($r = 0.946, p < 0.05$).

In the case of the tomato samples coming from farmers, the content of ascorbic acid varied between $2.34 \pm 1.04$ mg/100 g of the vegetal material and $3.74 \pm 0.01$ mg/100 g of the vegetal material (with the exception of the R7 sample of the supermarket-farmer origin) while the content of ascorbic acid in the imported or supermarket tomatoes varies between $0.93 \pm 0.41$ mg/100 g and $2.34 \pm 1.04$ mg/100 g of the vegetal material. Since the variation of the ascorbic acid content had a quite close interval, they were not correlated from a statistical point of view.

Furthermore, a post-hoc analysis was performed (Tukey’s test) which pointed out that the correlation of the vitamin C content with the antioxidant activity is significant for all of the analyzed samples ($p < 0.01$), and is more representative in the case of the bell peppers.

5. Conclusions

The results of determining vitamin C in the various types of bell peppers and tomatoes, through the iodometric method, highlighted the fact that the bell pepper has the highest content of vitamin C (Table 1).

The present study states that the content of ascorbic acid in fifteen different types (genotypes), eight types of *Capsicum annum* L. and seven types of *Lycopersicum esculentum*, presented variations from one type to another. Thus, the types A1 and R7 presented the highest levels of ascorbic acid. The research pointed out that the content of ascorbic acid increased from the yellow peppers to the red peppers. In the case of the tomatoes, it increased from those with the biggest size to the smallest size.

The bell peppers grown in outdoor gardens have a higher content of vitamin C than the bell peppers in supermarkets. The tomatoes grown in outdoor gardens and fields (with a medium or small size) have a higher content of vitamin C than the tomatoes in supermarkets.

Temperature management after harvesting is the most important element for maintaining the content of vitamin C. The losses are accelerated by the high temperatures and long storing times. However, vegetables that are sensitive to cold (e.g., tomatoes), register greater vitamin C losses when the temperatures are lower.

These results are correlated with the fact that most vegetables in supermarkets were grown either in greenhouses and did not benefit from direct exposure to sunlight or were harvested before reaching maturity and thus were stored for a longer period of time.

The study of the antioxidant activity pointed out the relation between the antioxidant activity of vegetables subjected to analysis and their ascorbic acid content. The antioxidant compounds present in vegetables, especially the analyzed ascorbic acid, represent a standard of the antioxidant activity. It plays an important role in the antioxidant activity of the analyzed vegetables and therefore it can be an alternative for allopathic medicine.
The conclusions of the present study suggest that the vegetables grown by farmers might be a better choice in terms of vitamin C content, in comparison with the vegetables in supermarkets. The post hoc analysis (Tukey’s test) pointed out an important correlation of the vitamin C content with the antioxidant activity.

The results of this study show that Romanian vegetables have advantages to consumer health. Romania’s people can easily take vegetables from their allotments or farm, than from supermarkets, which would shorten the distribution chain. The data confirmed evidence of the fact that locally-grown vegetables are more sustainable for health and the economy.

Nadeem and others [21] stated, in their study, that the bell pepper is an important source of vitamin C and its antioxidant activity is directly linked with its content of bioactive compounds, such as vitamin C. The antioxidant activity is lower in yellow and green bell peppers, than in the red ones. However, our research revealed that yellow bell peppers have an increased antioxidant activity, in comparison with the antioxidant activity in the red bell peppers.

Ergeand Karadeniz [41] studied the antioxidant activity of tomatoes, by using the TEAC and the DPPH methods and obtained an important correlation only when he applied the TEAC method. However, our research revealed the important correlations for both methods.

Numerous studies point out the vital importance of consuming vegetables that are rich in vitamin C. Thus, Sánchez-Moreno and others (2006) pointed out, in their study, the importance of bell peppers and tomatoes for the human diet, highlighting the bioavailability of vitamin C, even in a Mediterranean vegetable soup (gazpacho) [42].

Since not all vegetables have the same phytochemical bioactive composition and not all phytochemicals have the same antioxidant capacity, it is important to identify the vegetables that have the highest antioxidant capacity and introduce them into our daily diet. If, from a nutritional point of view, bell peppers are an important source of a mixture of antioxidants, ascorbic acid, carotids, flavonoids, and polyphenols included, it is essential for the compositional studies to be carried out by taking into consideration the various elements, such as the vegetable varieties, seasons, and climatic conditions, before and after harvest. All of these can affect the chemical composition of the active compounds in plants. This aspect will represent the subject of some of our future research activities.

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