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# Natural vegetable juices – a valuable source of antioxidant compounds

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***Abstract***

The objective of this study was to obtain and characterize some natural juices using various vegetable as follows: tomatoes, parsley (leaves), carrots, celery (leaves) and spinach. The fresh natural juices have been prepared from individual vegetables and also from mixture of the above mentioned vegetables. Prior to natural juice processing using a home scale juicer, the edible parts of fresh vegetables were washed and suitable cut. The fresh juices were analyzed in terms of total soluble content (°Bx), vitamin C by titration with a 2,6-dichlorophenolindophenol sodium, total phenolic content by Folin-Ciocalteu method and total antioxidant capacity by FRAP assay. Vitamin C, the most abundant antioxidant in vegetables, was found in spinach (52.4 mg/100g). The highest amount of vitamin C (19.6 mg/100 mL) was detected in tomato juice and the highest of total phenolic contents was found in mix vegetable juice, mainly in juice of carrot and tomatoes in ratio 1:1 (v/v) (26.00 mg/L). Our results have revealed that the fresh natural vegetable juices are a valuable source of antioxidant compounds strongly recommended in a healthy diet.

***Keywords***: natural vegetable juices, tomato, parsley, carrots, celery, spinach

## 1. Introduction

Vegetables are known to contain large amounts of bioactive compounds that confer antioxidant activity and are related to health-benefits [1]. Vegetable juice can be made attractive to people as a drink rather than only vegetable. Children love juice than raw vegetable. So, in a juice form it can be supplied to kids [2].

Tomatoes (*Lycopersicum esculentum*) are some of the popular and most consumed vegetables in the world. Tomatoes are especially important for the human diet because of their content of vitamin C, carotenes, lycopene and phenolic compounds. Vitamin C, lycopene and phenolic compounds are a major source of antioxidants [3]. Tomato juice is rich in beta carotene and lycopene and offers many health benefits [4].

Carrot (*Daucus carota*) is one of the popular root vegetables grown throughout the world [5]; carrots were ranked tenth in terms of their nutritional value among 38 other fruits and vegetables [6]. Carrot is a significant source of phytochemicals, including phenolics and carotenoids [7]. Yield and quality of carrot juice extracted by pressing vary with the pre-treatment condition such as pH, temperature and time [5]. Although the juice yield in carrots is 60–70% [7], carrot juice and blends thereof are among the most popular non-alcoholic beverages and steady increase in consumption has been reported from various countries [5,8].

Leaves and stems of vegetables are consumed as food but are not very stable when stored [9]. Parsley (*Petroselinum crispum*) is an herbaceous vegetable used as foodstuff, spice and medicinal plant because it provides antioxidants especially flavonoids,

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vitamins (K, C and A) and volatile oils [10]. Parsley is a vegetable with pleasant flavor and taste [11]. Parsley juice comprise of all the nutrition in the leaves; like most green superfood drinks, is generally considered too best drink for kidney cleansing and liver detoxification [12].

Celery (*Apium graveolens*) is a flavor tasty vegetable much appreciated for its nutritive and therapeutic values [11] and fresh celery juice is one of the most powerful and healing juices. Celery juice has significant anti-inflammatory properties, is strongly alkaline and helps to prevent various diseases [13].

Spinach (*Spinacia oleracea*) provides a rich source of vitamin K [9]. Spinach is also one of the best non-heme (plant-based) sources of iron [14]. Spinach juice serves as a rich source of several nutrients but spinach's mild taste yields a juice lacking in flavor. Therefore, spinach juice mixes with carrot and other vegetable juices for a good-tasting drink [9].

All vegetable juices there are significant sources of polyphenols [15]. Mixed vegetable juice is important for health to supply vitamins and minerals [2]. Large variation exists in the content of bioactive compounds in vegetables depending on the plant species and even among cultivars [1]. Our study investigated the some fresh vegetables juices in terms of its antioxidant compounds content.

## 2. Materials and Methods

### *2.1. Juice preparation*

Vegetables used in this work included: tomato, carrots, parsley leaves, celery leaves and spinach were obtained from Timisoara, local market. Because spinach is highly perishable, the proper storage is essential to maintain its antioxidant properties. Therefore, the fresh vegetables were squeezed to juices immediately, without storage. So, the carrots were washed, peeled and sliced into smaller pieces (3-5 mm). Tomatoes were washed and cutting into quarters. Thus, was have obtained 200 g of each vegetables used for juice. Other juices were obtained from chopped leaves of parsley, celery and spinach; 200 g fresh leaves with 100 mL water were incubated at room temperature for 30 min and go to the squeeze using a fruit and vegetable home scale juicer Tefal ZN355C3E. Five natural juices were obtaining: tomatoes juice (J1), parsley juice (leaves) (J2), carrot juice (J3), celery juice (leaves) (J4) and spinach juice (J5). After that, were prepared a mixture of some vegetable juices: the juice of celery and carrot was blended in ratio 1:1(v/v) (J6) and the juice of carrot and tomatoes in ratio 1:1 (v/v) (J7).

### *2.2. Chemical analysis*

The fresh juices were analyzed in terms of total soluble substances (TSS), vitamin C, total antioxidant capacity (TAC) and total phenolic content (TP).

**Total soluble substances** (TSS) were determined with DR201-95 KRUSS digital handheld refractometer. The results were reported as $^{0}$Brix at 20$^{0}$C.

**The Vitamin C evaluation** in vegetable juice has been carried out following 2,6-dichlorophenolindophenol sodium assay [16]. Vitamin C is a strong reducing agent. It gets oxidized to dehydroascorbic acid by 2,6 - dichlorophenol indophenol dye. At the same time the dye gets reduced to a colorless compound. Thus, the reaction with end point can easily be determined [17]. The vitamin C content has been measured in both fresh vegetables (mg/100g fresh weight) as well as vegetable juices (mg/100mL).

For assessing the total phenolic compounds and total antioxidant capacity the samples were subjected to alcoholic extraction, as follows: 1 mL of each juice sample was added to 9 mL ethanol 45% (v/v). After 60 min the solution was filtered.

The **total antioxidant capacity** (TAC) has been measured by FRAP (ferric reducing antioxidant power) assay (Benzie & Strain, 1996) [18]. The FRAP method depends upon the reduction of ferric tripyridyltriazine complex to the ferrous tripyridyltriazine at low pH. This ferrous tripyridyltriazine complex has an intensive blue color and can be monitored at the wavelength of 593 nm. FRAP reagent was prepared freshly as a mixture of 10 mM TPTZ (2,4,6-Tris(2-pyridyl)-s-triazine) solution (diluted in HCl 40 mM), 20 mM $FeCl_3 \cdot 6H_2O$ solution and 300 mM sodium acetate buffer at pH 3.6 in the ratio of 1:1:10. 0.5 mL of hydroalcoholic extract diluted in the ratio 1:10 (v/v) in distilled water has been added to 2.5 mL FRAP reagent. Absorbance was read after 30 minutes, using an aqueous solution of $FeSO_4$ as standard.

Correlation coefficient ($r^2$) for calibration curve was 0.9991. Total antioxidant capacity was expressed as mM $Fe^{2+}$/L.

**Total phenolic content** (TP) of juice samples were determined by the Folin–Ciocalteau method [19]. Briefly, 0.5 mL of hydroalcoholic extract samples diluted in the ratio 1:10 (v/v) in distilled water was mixed to 2.5 mL of Folin-Ciocalteu reagent diluted 1:10 (v/v) in distilled water. Then, 2.0 mL of 7.5% sodium carbonate solution was added. After 2 hours of samples incubation at room temperature, the absorbance has been measured using the UV-VIS Spectrophotometer SPECORD 205 by Analytik Jena at wavelength of 750 nm. The gallic acid has been used to prepare the calibration curve ($r^2$ = 0.9980). The results were expressed in mM gallic acid equivalent (GAE)/L. All tests were performed in triplicate.

### *2.3. Statistical analysis*

Simple linear regression analysis was applied using the Origin 7.0 software program for obtaining some correlations between the investigated parameters of vegetable juices. Pearson correlation was conducted using Microsoft Office Excel 2010 for Windows.

## 3. Results and Discussions

The vitamin C content of fresh vegetables, used as a raw material, was determined, as it was shown in the *Table 1*. The highest content of vitamin C, the most abundant compounds with antioxidant properties from vegetables, has been found in spinach (52.4 mg/100 g), which is similar to the data reported by Leonard et al. (2002) [20]. The tomatoes contain vitamin C at a level of 21.1 mg/100 g. Some researchers [2, 5] showed that the vitamin C content in tomatoes ranges between 21.7-25.8 mg/100 g.

***Table 1.*** Vitamin C content of fresh vegetables

| Vegetables | Vitamin C content (mg/100 g FW) |
|---|---|
| tomato | 21.1 |
| parsley (leaves) | 12.80 |
| carrot | 9.0 |
| celery (leaves) | 7.8 |
| spinach | 52.4 |

The data in Table 2 summarized the antioxidant compounds of vegetable juices.

***Table 2.*** Chemical characteristics of vegetable juices

| Characteristics | Juice | | | | | | |
|---|---|---|---|---|---|---|---|
| | J1 | J2 | J3 | J4 | J5 | J6 | J7 |
| TSS (°Bx) | 6.20 | 8.20 | 11.00 | 9.80 | 5.20 | 10.60 | 9.04 |
| Vitamin C (mg/100 mL) | 19.60 | 5.25 | 3.88 | 7.40 | 4.80 | 5.65 | 11.89 |
| TAC (mM $Fe^{2+}$/L) | 31.08 | 31.45 | 34.60 | 26.84 | 29.00 | 37.42 | 39.68 |
| TP (mM GAE/L) | 21.75 | 22.37 | 24.20 | 19.80 | 20.10 | 25.48 | 26.00 |

The content of total soluble solids (TSS) of all juice samples varies from 5.20 to11°Bx (*Table 2*), according to Romanian standard [21]. After international standard [2], the TSS values of juice products are in the range 10-20°Bx. The highest content of TSS was found in J3. The TSS represents an index of the juice sweetness [6] and varies among the vegetables using as raw materials in juice preparation.

The vitamin C level in the vegetable juices is affected by the vitamin C level found in fresh vegetable as well as the technological processing which always causes a decrease in vitamin C content of the final product [22]. Another important factor which helps to maintain the vitamin C in tomato juice is the pH.

Thus, maintaining the vegetable juice at a pH close to 2 has a stabilizing effect on the vitamin C content in tomato juice [22, 23]. Vitamin C is easily destroyed by oxidation, especially at a high temperature [22]. Similarly, Rickman et al. [24] observed that the vitamin C is the least stable nutrient during processing. It is highly sensitive to oxidation and leaching into water-soluble media during processing, storage and cooking of fresh, frozen and canned fruits and vegetables. As it was reported by Rickman et al. [24], the losses of vitamin C acid during carrots processing range up to 90% (on wet weight basis). Although vegetables used in this study have not undergone storage and cooking, the squeeze processing occurs with losses in vitamin C content.

*Table 2* shows the amount of vitamin C of each vegetable juice sample. Based on our results, the highest value of vitamin C was detected in J1 (19.6 mg/100 mL) and the lowest value in J5 (4.80 mg/100 mL). Dumbrava et al. (2011) [25] found similar results for tomato juice obtained from Romanian tomatoes cultivars. According to Ionica (2002) [26], the tomatoes grown in climatic conditions of Romanian country are highlighted by high values of sugar content, acidity, vitamin C and carotenoids, especially the tomatoes grown in the field conditions from July to September, due to the high temperature and the solar radiation. Hallman et al. [22] showed that the cultivation system of tomato has a significant impact on bioactive compounds content of tomato juice.

The FRAP values obtained for investigated juice samples showed that the highest value of antioxidant capacity has been reached for the J7 (39.68 mM $Fe^{2+}$/L) whereas the lowest value has been noted for J4 (26.84 mM $Fe^{2+}$/L). According to Papuc et al. (2011) [10], the ferric reducing antioxidant power of a juice reflects the ability of antioxidants to act as reducing agents.

The antioxidant activity has been found to be strongly correlated with the total phenolic content [27]. Indeed, the antioxidant capacity in vegetable juices decreases as follows: J7 > J6 > J3 > J2 > J1 > J5 > J4. Also, the highest value of total phenolic content has been found in J7 (26.00 mM GAE/L) followed by J6 (25.48 mM GAE/L), J3 (24.20 mM GAE/L), J2 (22.37 mM GAE/L), J1 (21.75 mM GAE/L), J5 (20.10 mM GAE/L) and J4 (19.80 mM GAE/L), as it can be shown in the *Table 2*.

Since phenolic compounds are antioxidants, they are subject to oxidation during food processing and storage. Furthermore, the phenolic compounds and the other phytochemicals are found in significant amounts in the peels of fruits, so, some losses of these compounds occur during the peeling step **[24].** As reported by Mercier et al. (1994) [28], in carrots, the phenolic compounds are located in roots but are highly concentrated in the periderm tissue. Thus, the carrot juice (J3) contains the highest amount of total phenolic compounds from investigated vegetables. The mixed vegetable juice prepared from carrot and other vegetable (J6 and J7) showed a high amount of antioxidant compounds.

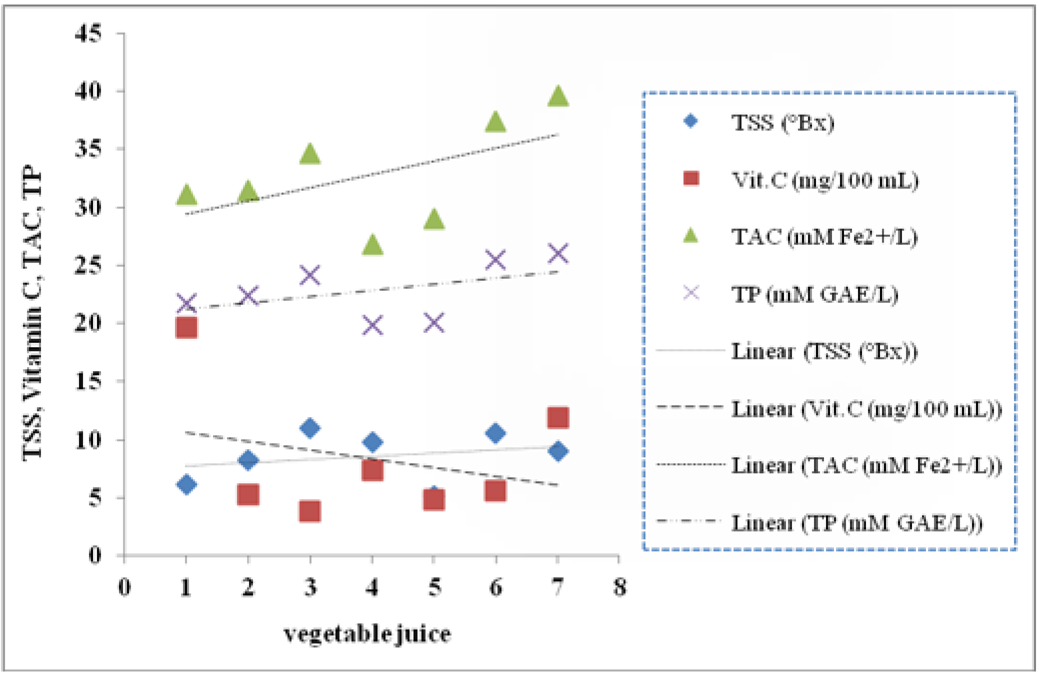


***Figure 1.*** The correlation of investigated characteristics and vegetable juice samples
TSS: $Y=0.2686 \cdot X + 7.5029$ ($R^2=0.07$); Vitamin C: $Y=-0.7646 \cdot X + 11.411$ ($R^2=0.0864$);
TAC: $Y=1.1479 \cdot X + 28.276$ ($R^2=0.2913$); TP: $Y=0.5311 \cdot X + 20.69$ ($R^2=0.2137$)

***Table 3.*** The Pearson correlation among investigated characteristics of vegetable juices

| | TSS (°Bx) | Vitamin C (mg/100 mL) | TAC (mM $Fe^{2+}$/L) | TP (mM GAE/L) |
|---|---|---|---|---|
| TSS (°Bx) | 1 | | | |
| Vitamin C (mg/100 mL) | -0.397 | 1 | | |
| TAC (mM $Fe^{2+}$/L) | 0.447 | 0.050 | 1 | |
| TP (mM GAE/L) | 0.563 | -0.002 | 0.985 | 1 |

*Figure 1* shows that there is a weak correlation between TAC and the juice samples (the coefficient of determination $R^2$ = 0.2913). Also, a weak correlation has been found for TP and the analyzed vegetable juices ($R^2$ = 0.2137). Additionally, insignificant correlations have been reported for TSS and Vitamin C and juice samples.

As regards the linear correlations between the investigated characteristics, the results of statistical analysis are shown in the Table 3. On the base of the reported data it can be seen that TSS shows mild correlation with TAC (r = 0.447) [29] and moderate correlation with TP (r=0.563). The correlation of vitamin C with TAC (r=0.050) was positively, while it was negative with TP (r =-0,002). On other hand, a high correlation has been found between TAC and TP (r=0.985). This finding of our study confirms, again, the strong correlation between these two representative parameters for antioxidant properties of natural vegetable juices.

## 4. Conclusion

Our results reveal that the vegetable juices are healthy drinks, containing high amount of antioxidant compounds. Vitamin C is the most abundant compound in the tomato juice. Carrot juice makes a beverage base rich in antioxidant compounds. The mixed juices (celery and carrots, carrots and tomatoes) showed high total phenolic compounds content. A strong correlation between total antioxidant capacity and total phenolics content has been found for investigated vegetable juice samples. This finding suggests that the phenolic compounds are the main responsible for antioxidant properties of natural vegetable juices. Thus, the including in daily diet of vegetable juices, rich in antioxidant compounds could protect the human body against several diseases. Our results prove that the tomato juice and the mix of vegetables juice are recommended as a valuable source of polyphenolic compounds and vitamin C.

**Compliance with Ethics Requirements.** Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human / or animal subjects (if exist) respect the specific regulation and standards.

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