

VITAMIN C AND NITRATES CONTENTS IN FRUIT AND VEGETABLES FROM FARMERS' MARKETS AND SUPERMARKETS

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ABSTRACT

Fruits and vegetables are the best food sources of vitamin C. However, fruits and vegetables can be also sources of potentially harmful substances to the human body, nitrates being one of these. The aim of this study was to compare vitamin C and nitrates contents in selected fruits and vegetables from supermarkets and local farmers' markets. Samples of plums, strawberries, apples, spinach, red peppers and tomatoes were chosen for analysis. Content of vitamin C and nitrates was analyzed by HPLC/DAD. The hypothesis was that local market fruits and vegetables contain more vitamin C and fewer nitrates than samples bought in supermarkets. Laboratory analyses showed that there were differences in vitamin C in the case of strawberries, tomatoes and red peppers. The highest level of ascorbic acid was in red pepper samples ($141 \text{ mg} \cdot 100\text{g}^{-1}$). In the case of fruit, the highest content was in strawberries ($70 \text{ mg} \cdot 100\text{g}^{-1}$). As far as nitrates content is concerned, in three cases out of six, the fruit and vegetables we tested from farmers' markets contained lower concentrations of nitrates than those purchased at supermarkets and the hypothesis was accepted in these cases. There was no significant difference between the nitrate content of the local market and supermarket strawberries and red peppers. Tomatoes had significantly higher nitrate content when purchased at farmers' markets than at supermarkets. Leafy vegetables are considered to be the major source of nitrates, and this was confirmed by this study. The highest content of nitrates was in the spinach sample ($2969 \text{ mg} \cdot \text{kg}^{-1}$). Among all fruit samples, strawberries had the highest nitrates levels (maximum $131 \text{ mg} \cdot \text{kg}^{-1}$). The results of this work showed that the content of ascorbic acid and nitrates differs significantly depending on the type of fruit or vegetables.

Keywords: ascorbic acid; nitrate; fruit; vegetable; farmers' market

INTRODUCTION

Fruit and vegetables are an important part of human nutrition and their adequate daily consumption can help prevent serious diseases (WHO, 2003). The WHO (2004) recommended at least 400 g of fruit and vegetables daily to prevent chronic diseases such as heart and cancer, type 2 diabetes mellitus and obesity, as well as to prevent and reduce micronutrient deficiencies, particularly in less developed countries (WHO, 2003).

Vitamin C is the most important vitamin in fruits and vegetables. Except for humans and other primates, most phylogenetically lower animals can synthesize this vitamin (Rekha et al., 2012). More than 90% of vitamin C in the human diet comes from fruit and vegetables. The highest amounts of this vitamin occur in blackcurrants, citrus fruits, spinach, tomatoes, red peppers (Lewin, 1976; Lee and Kader, 2000; Saxholt et al., 2008; Rekha et al., 2012).

Vitamin C improves immune system function, acts as an antioxidant, and reacts with oxygen and other molecules (Rekha et al., 2012; Soni et al., 2017). According to EFSA

(2017), the reference intake of vitamin C for a healthy adult should be 90 mg per day. Vitamin C content in vegetables and fruits depends on several factors, such as variety, habitat, growing year, storage and processing (Mařáková, 2008; Matějková and Petříková, 2010; Oyetade et al., 2012; Combs, 2017).

Vitamin C is a very unstable compound. It is rapidly oxidized with oxidizing agents, especially iron, copper, various enzymes (e.g. ascorbase, peroxidase, cytochrome oxidase) and air/oxygen (Jeney-Nagy mate and Fodor, 2008). Moreover, the stability of vitamin C decreases with increasing temperature, pH (Jeney-Nagy mate and Fodor, 2008) and light access (Nováková, Solich and Solichová, 2008). During processing, the stability of vitamin C is higher in fruit than in vegetables due to their lower pH (Mařáková, 2008).

Nitrates are created in fruits and vegetables mainly via the nitrification of ammonia nitrogen. They play an important role in plant nutrition, growth and development. Higher nitrates concentrations accumulate in leaves, while lower

concentrations are present in roots, tubers, seeds and fruits. For this reason, leafy vegetables (spinach, lettuce, etc.) are the most important source of nitrates and may contain more than 2000 mg.kg⁻¹ (Maynard et al., 1976; Santamaria, 2006).

Nitrates themselves are relatively nontoxic, but their metabolites (nitroso compounds), which could be formed in the human body, can cause several health problems (Santamaria, 2006). Consumption of vegetables with high nitrate content may increase the risk of methemoglobinemia or gastrointestinal cancer (Du, Zhang and Lin, 2007). Bevc et al. (2012) reported an association between nitrates and cancer of the bladder, ovary, stomach and liver. According to EFSA (2008), the acceptable daily intake for nitrates (ADI) is 3.7 mg per kg of body weight per day. Temme et al. (2011) reported a real average daily nitrate intake of 1.38 mg per kg of body weight per day. The main sources of nitrates are vegetables (mainly lettuce) and drinking water. Due to the undesirable effect of nitrates on human health, their content in certain kinds of vegetables is regulated by Commission Regulation (EC) No 1881/2006.

On the other hand, intake of small amounts of nitrates can also have a positive effect on the gastrointestinal tract (Duncan et al., 1999) and the cardiovascular system (Webb et al., 2008; Sobko et al., 2010; Lundberg et al., 2011). The negative effect of nitrates on human health can be significantly limited by the simultaneous presence of vitamin C (Kopeck, 2010; Shehata, 2010).

The accumulation of nitrates in fruit and vegetables depends on many factors - mainly their type or genotype, variety, maturity, climatic conditions (light intensity, air temperature and carbon dioxide concentration), agronomic factors (e.g. timing and form of nitrogen application), soil type and harvest time (Sorensen, Johansen, and Poulsen, 1994; Colla et al., 2018) and also by heat treatment (i.e., frying, baking, cooking), storage or preservation (Prasad and Chetty, 2008; Temme et al., 2011).

Farmers' markets are a form of selling agricultural and food goods to the general public, with the aim of a) supporting small and medium-sized agricultural growers, breeders and food producers; b) supplying citizens with fresh agricultural crops and food of mainly national and regional origin; c) creating new social space which, in addition to the sale of agricultural goods, serves to get people together and to bring the urban population closer to the agricultural season and natural cycles; d) revitalizing selected urban areas and improving their ambience. Farmers' markets usually take place in the open air. Only seasonal and local goods should be sold at farmers' markets (Bohatec, 2011; Sedláček, 2015).

The most common products at farmers' markets include fruit and vegetables (Brůčková, 2012). Unlike organic food, there is no legal or generally accepted definition for local food. Many authors describe it as "local food" such foods that were produced within 100 km of the consumer. Other authors argue that local foods are those produced in a certain region or country.

Another positive factor for buying local food is its freshness. At farmer's markets, we find fresh fruits and vegetables that were picked just before the sale, while in supermarkets we can come across food that has traveled to the counters for several days and matured on the way. This also relates to the carbon footprint; the production of local

food is significantly more energy-efficient and thus more environmentally friendly (Brůčková, 2012; Kukla 2012).

For most consumers, fruits and vegetables that come from farmers' markets are considered healthier than usual "conventional" supermarket products. However, it is not clear whether these farm products contain more nutrients and/or less harmful substances (Wunderlich et al., 2009). Therefore, this work aimed to compare the content of vitamin C and nitrate in selected fruit and vegetables purchased at farmers' markets and in supermarkets.

Scientific hypothesis

Fruits and vegetables from farmers' markets will have a higher vitamin C content and a lower nitrate content than those from supermarkets.

MATERIAL AND METHODOLOGY

Vitamin C and nitrates levels were monitored in three different kinds of fruit (apples, plums and strawberries) and three different kinds of vegetables (spinach, red peppers and tomatoes). The Jonagold apple variety was used for analysis. For other analyzed fruit and vegetables the variety was not declared by supermarkets and farmer's markets. Fruit and vegetables (except spinach) were purchased in the period September–November (spinach in the period October–November) in four different supermarkets and four different farmers' markets in the same locality. The same kind of fruit or vegetables were always bought at the same time in the supermarket and the farmers' market.

Samples preparation

All fruit and vegetable samples were cleaned before analysis. Parts that are not consumed were removed. The edible parts were homogenized for 1 minute in a kitchen blender (Zepter, Italy). In the case of ascorbic acid determination, 2.5 g of the sample plus 15 mL of 3% metaphosphoric acid (Honeywell, Germany) were mixed. The sample was filtered through filter paper to a 25 mL volumetric flask, filled up to the mark with the extraction solvent, filtered through a PTFE membrane 0.45 µm filter, and directly injected into the HPLC 20 µL Rheodyne 7725i loop (Rheodyne, USA).

In the case of nitrates determination, 5 g of homogenized sample was placed into a 150 mL beaker with 60 mL of demineralized water and left in an ultrasonic bath for 10 minutes. After that, it was filtered through filter paper to a 100 mL volumetric flask, filled up to the mark with extraction solvent, filtered through a membrane filter, and injected into the HPLC system as mentioned above. Each sample was measured in triplicate.

Instrumental analysis

A high-performance liquid chromatographic (HPLC) method was used to determine ascorbic acid and nitrates contents. The HPLC system (P680 HPLC pump, Thermostatted Column Compartment TCC-100, and DAD detector UVD340U (Dionex, USA set at 254 nm) consisted of a C18 guard column (10 x 10 mm) and a Luna® 5 µm C18 analytical column (250 x 4.6 mm; Phenomenex, Germany) heated at 25 °C. The mobile phase was 5% methanol (Lach-Ner, Czech Republic) adjusted to pH 3 by o-phosphoric acid (Lachema, Czech Republic) with

a flow rate of 0.8 mL.min⁻¹. The calibration curve was determined using standard solutions of ascorbic acid p. a. (Lach-Ner, Czech Republic) at concentrations of 5, 10, 20, 60 and 100 mg.L⁻¹. The correlation coefficient of the calibration curve (R²) was 0.9992.

The same HPLC instrumentation was used for the determination of nitrates content. The detector was set at 214 nm and KH₂PO₄ solution (c = 10 g.L⁻¹, pH 3, Lach-Ner, Czech Republic) was used as a mobile phase with a flow rate of 1 mL.min⁻¹. The calibration curve was determined using standard solutions of sodium nitrate p. a. (Sigma, Japan) at concentrations of 10, 30, 50 and 100 mg.L⁻¹. The correlation coefficient of the calibration curve (R²) was 0.9957.

Statistical analysis

Linear regression equations, regression coefficients (R²) as well as other results (means and standard deviations) were calculated from the data using Microsoft Office16 Excel. The differences between samples were evaluated using a one-way analysis of variance (ANOVA). Scheffe's test was used to calculate statistically significant differences between samples using statistical software Statistica 12 (StatSoft Inc.). For all statistical tests, a 5% level of significance was used.

RESULTS

Ascorbic acid content

The data from the analysis of ascorbic acid in fruit and vegetable samples are in Table 1. Concerning the fruit samples, the values of vitamin C content in plums did not vary much and was around 5 mg.100g⁻¹ of the sample (from 4.24 to 6.38 mg.100g⁻¹). There was no statistical difference in vitamin C content between plums from farmers' markets and those from supermarkets. Similarly, in apple samples, the vitamin C content was less the same, ranging from 3.56 to 5.86 mg.100g⁻¹ of sample and there was no difference between samples from local producers and those from supermarkets. In contrast, all strawberry samples from farmers' markets had a significantly higher vitamin C content than supermarket samples (the maximum of all analyzed samples was 70.53 mg.100g⁻¹, the minimum was 39.98 mg.100g⁻¹).

Considering vegetables, the vitamin C content in the spinach samples (ranging from 23.98 to 42.46 mg.100g⁻¹) was around an average of 30 mg.100g⁻¹ and there were no differences between the market sources. There were differences in the case of tomatoes (18.00 to

32.54 mg.100g⁻¹) or red peppers samples (58.57 – 141.26 mg.100g⁻¹) from farmers' markets and supermarkets. Samples of red peppers from the supermarket had significantly higher vitamin C contents than red peppers from farmers' markets, but the opposite was true for tomatoes. In farmers' tomatoes, the average content of ascorbic acid was by 6 mg.100g⁻¹ higher than in tomatoes from supermarkets. In the overall comparison of fruit and vegetables, the highest content of vitamin C was found in red pepper and the lowest in apples and plums. The major determinant of vitamin C content is the species of plant (*p* <0.0001) rather than where the fruit or vegetable is purchased (*p* = 0.9140).

Nitrates content

The levels of nitrates in samples are seen in Table 2. In the case of fruit samples, the plum samples contained from 1.80 mg.kg⁻¹ to 5.00 mg.kg⁻¹ of nitrates. One sample from the supermarket contained up to twice as many nitrates as the sample from the farmers' markets. The nitrates content of plum samples from supermarkets varied quite a lot from 3.25 to 5.00 mg.kg⁻¹. Similarly, apple samples from farmers' markets had significantly fewer nitrates than samples from supermarkets. The highest nitrate content was measured in a sample from the supermarket (13.02 mg.kg⁻¹), while the lowest nitrate content was measured in one sample from the farmers' market (6.36 mg.kg⁻¹). In contrast, there was no difference in nitrates content (110.17 – 131.90 mg.kg⁻¹) between strawberry samples from farmers' markets and supermarkets.

Comparing the monitored vegetable samples, there was a significant difference between spinach samples from farmers' markets and supermarket samples. The nitrate content of samples from farmers' markets was less variable (1332 – 1509 mg.kg⁻¹) than their content in samples from supermarkets (from 1084 to 2969 mg.kg⁻¹). The same was observed in the case of tomatoes (the values ranged from 37 to 53 mg.kg⁻¹) where the average measured nitrate content in samples from supermarkets was significantly higher (by 10 mg.kg⁻¹) compared to samples from local producers. On the contrary, red peppers did not show any difference between the sources where they were purchased. The nitrates contents were quite similar (around 35 mg.kg⁻¹), except for one sample from the farmer's market (71 mg.kg⁻¹).

The levels of nitrates differed significantly among all analyzed samples from supermarkets and farmers' markets (*p* = 0.0349) and also among the assayed kinds of fruit and

Table 1 Ascorbic acid content in fruit and vegetables from supermarkets and farmers' markets.

Fruit or vegetable	Ascorbic acid content		
	Supermarkets (mg.100g ⁻¹ ±SD)	Farmers' markets (mg.100g ⁻¹ ±SD)	<i>p</i> -value
Apple	4.86 ±1.00	5.58 ±0.16	0.0613
Plum	5.32 ±0.95	5.25 ±0.50	0.8664
Strawberry	52.09 ±9.01	66.35 ±3.84	0.0008
Tomato	22.40 ±3.20	28.40 ±4.55	0.0076
Spinach	28.07 ±4.04	32.51 ±7.67	0.1199
Red pepper	105.53 ±26.56	78.92 ±14.99	0.0253

Note: *p*-values numbers marked in bold indicate numbers that are significant on the 95% confidence limit.

Table 2 Nitrates content in fruit and vegetables from supermarkets and farmers' markets.

Fruit or vegetable	Nitrates content		
	Supermarkets (mg.kg ⁻¹ ±SD)	Farmers' markets (mg.kg ⁻¹ ±SD)	<i>p</i> -value
Apple	11.84 ±1.82	7.90 ±1.40	0.0002
Plum	4.41 ±0.91	2.02 ±0.50	0.0001
Strawberry	122.39 ±7.95	116.63 ±5.90	0.1193
Tomato	42.55 ±4.35	52.33 ±3.60	0.0002
Spinach	2052.71 ±760.05	1391.36 ±148.87	0.0242
Red pepper	38.57 ±8.52	46.26 ±17.32	0.2767

Note: *p*-values numbers marked in bold indicate numbers that are significant on the 95% confidence limit.

vegetables (*p* < 0.0001). The highest amount was in spinach, the least in plums.

DISCUSSION

Many factors are affecting the level of vitamin C in fruit and vegetables and, therefore, its content can vary a lot. From this point of view, our experimentally measured values are generally in line with literature data. Of the assayed samples, the highest content of vitamin C was in red peppers. Its average contents were 78.9 mg.100g⁻¹ (from farmers' markets) and 105.5 mg.100g⁻¹ (from supermarkets). This is less than observed in other studies. **McCance and Widdowson (2014)** reported an average content of 120 mg.100g⁻¹ of vitamin C in red peppers in their study; **Lee and Kader (2000)** and **Saxholt et al. (2008)** reported values up to 151 mg.100g⁻¹. Strawberries had the second-highest average vitamin C content of 52 mg.100g⁻¹ (supermarket) and 66 mg.100g⁻¹ (farmers' markets). Similar results were obtained by **Lewin (1976)**, **Lee and Kader (2000)**, and **Saxholt et al. (2008)**, who reported vitamin C levels in strawberries ranging from 35 to 60 mg.100g⁻¹. Vitamin C levels in strawberries are comparable to those in citrus fruits (40 – 50 mg.100g⁻¹) (**Lee and Kader, 2000**).

Spinach is a vegetable with a high content of vitamins and minerals. Our value for vitamin C content was similar to values observed by **Bureau et al. (2015)** (23.7 mg.100g⁻¹). The vitamin C content we found in tomatoes is following literature values, 30 – 35 mg.100g⁻¹ (**Lewin, 1976**). According to **George, Kaur, Khurdiya, et al. (2004)**, however, the vitamin C content of tomato pulp may be 84 to 324 mg.100g⁻¹. The deviations of some of our results for the content of vitamin C from the data in the literature may have been affected by analyzing samples purchased in the autumn and the way of their storage (**Matějková and Petříková, 2010**).

Our results indicated that only in the case of strawberries, tomatoes, and peppers from farmers' markets and supermarkets were significant differences in vitamin C content found. The biggest difference was in strawberry samples. Strawberries from farmers' markets contained 27.4% more vitamin C than strawberries from supermarkets. In contrast, the content of vitamin C in plums from farmers' markets and supermarkets was almost identical. There is not much information in the literature comparing products from farmers and supermarkets. Studies are usually focused on the differences between organic and conventional fruit and vegetables and their findings are often controversial (**Silva et al., 2018**;

Andrade et al., 2017). **Andrade et al. (2017)** tested the quality of strawberries grown in organic and conventional systems. The content of vitamin C in organic strawberries was (49.07 mg.100g⁻¹) and in conventional strawberries (52.32 mg.100g⁻¹). According to these authors, the content of vitamin C in strawberries does not differ significantly between the conventional and organic systems. The authors state that vitamin C content depends on many factors, including variety, ripeness, growing conditions and harvest time. These factors could then lead to significant variations in results, both between studies and within studies.

Esch et al. (2010) looked for differences in vitamin C content between organic and conventional fruits.

The tested fruits were oranges, mangoes, kiwi, lemons, gala apples and red apples. Of these six fruits, the only lemon showed a significant difference between organically (higher content) and conventionally grown samples. This study confirmed that the content of vitamin C depends on several factors, not just the way of cultivation. **Wunderlich et al. (2009)** reported that pre- and post-harvest conditions have a major effect on vitamin C levels in vegetables.

Based on our results, the hypothesis that fruit and vegetables from farmers' markets have a higher vitamin C content can, therefore, neither be accepted.

Fruit and vegetables also contain substances that could have a negative impact on human health. For this reason, the second half of this work was focused on nitrate content in fruits and vegetables from farmers' markets and supermarkets. It can be stated that there were significant differences in the nitrates content among the assayed kinds of fruits and vegetables.

According to **Prugar (2008)** and **Colla et al. (2018)**, fruit and vegetables can be divided into four categories according to nitrates content. The highest nitrate content is in leafy vegetables such as spinach. **Maynard et al. (1976)** and **Santamaria (2006)** reported that nitrates accumulate primarily in leaves, while lower nitrate concentrations are present in roots, tubers, seeds and fruits. For this reason, leafy vegetables (spinach, lettuce, parsley, etc.) are considered the most important source of nitrates. Tomatoes and peppers belong to the group with nitrates content of less than 250 mg.kg⁻¹ (**Colla et al., 2018**).

Maximum levels for nitrates content are given by **Commission Regulation (EC) No 1881/2006** only for salad and spinach. The maximum limit for spinach is set in two categories, i.e. 3500 mg NO₃.kg⁻¹ for the harvest from 1 October to 31 March and 2500 mg NO₃.kg⁻¹ for the harvest from 1 April to 30 September. The highest measured nitrates content in the spinach sample in our case was

2969 mg.kg⁻¹. As the purchase of the samples took place in October, it can be assumed that the maximum limit for nitrate content was not exceeded.

Prugar (2008) and **Colla et al. (2018)** classified spinach into the “very high nitrates category”, i.e. more than 2000 mg.kg⁻¹. In this study, the results of spinach from farmers' markets with average nitrates content of 1391 mg.kg⁻¹, would fit to the “high nitrates category” (i.e. 1000 – 2000 mg.kg⁻¹). Supermarket spinach contained 47.5% more nitrates than spinach from farmers' markets. This difference was most likely due to different growing conditions. Fruit and vegetables from wholesalers come very often from greenhouses.

The main factors contributing to the increased nitrate concentration are temperature, lack of light and strong fertilizer concentration. In contrast, products from farmers' markets are usually grown in the open air in fields with enough light. Moreover, it is best to buy vegetables from the afternoon harvest. In the morning, the nitrate content in fruits and vegetables is higher than in the evening. It is therefore recommended to harvest agricultural products in the afternoon (**Sorensen, Johansen and Poulsen, 1994; Colla et al., 2018**).

Muramoto (1999) conducted a similar study with iceberg lettuce, Roman lettuce and spinach from supermarkets (conventional cultivation) and farmers' markets (organic cultivation). This author concluded that samples of spinach from the supermarket (average nitrates content 2540 mg.kg⁻¹) had a significantly higher nitrates concentration than samples from farmers' markets (average nitrates content 1810 mg.kg⁻¹). **Muramoto (1999)** also suggested that the use of nitrogen fertilizers may be the main cause of this difference. In other studies, **Barker (1975)** and **Stopes et al. (1989)** reported a positive correlation between the number of nitrogen fertilizers and nitrates accumulation in spinach.

Compared to vegetables, the fruit samples had much lower nitrates content. **Bahadoran et al. (2016)** reported an average of 27 mg nitrates per 100 g plums in their study. The highest nitrates content of our fruit samples was found in strawberries, which belong (together with bananas) to a “higher nitrates category”. **Walker (1990)** reported up to 150 mg of nitrates in 1 kg of strawberries in his study. We observed average nitrates content of strawberries from 116.63 mg.kg⁻¹ (from farmers' markets) to 122.39 mg.kg⁻¹ (from supermarkets). The explanation for the high nitrate content could be the presence of a thin, porous layer on the surface of strawberries, their frequent fertilization, or the way of growing in greenhouses where the lack of light causes the accumulation of nitrates.

In the case of our samples, no significant difference was found between strawberries from supermarkets and farmers' markets. This observation is consistent with the study of **Bordeleau et al. (2002)**, who also examined the difference in nitrates content of strawberries from farmers' markets and supermarkets. Other samples – plums, red pepper, tomatoes, and apples contained less than 250 mg of nitrates per kg, thus belonging to the low nitrate fruit and vegetable category according to the nitrates content classification (**Prugar, 2008; Colla et al., 2018**).

In three cases out of six, the fruit and vegetables tested by us from farmers' markets contained statistically lower nitrates concentrations than those purchased in

supermarkets. In these cases, the hypothesis that fruits and vegetables from farmers' markets have lower nitrates content than fruits and vegetables from the supermarket can, therefore, be accepted. On the other hand, there was no significant difference between the nitrates contents of strawberries and red peppers from farmers' markets or supermarkets, whereas tomatoes had significantly higher nitrates content when bought from farmers' markets.

Studies that have found significantly lower levels of nitrates in products from farmers' markets generally explain this by a lower fertilization rate. **Bordeleau et al. (2002)** stated that mineral fertilizers have a greater effect on nitrates levels than livestock fertilizers or humus. Other important factors influencing nitrates content are weather and light conditions.

CONCLUSION

The results of this work showed that the content of ascorbic acid and nitrates differs significantly depending on the type of fruit and vegetables. The most important source of vitamin C from the assayed fruits and vegetables was red pepper. One hundred grams of it would sufficiently cover the recommended daily dose of 90 mg. Comparing the different kinds of fruit and vegetables, significant differences in vitamin C content between samples from farmers' markets and samples from supermarkets were found in strawberries, red peppers and tomatoes.

Analyses of nitrates content showed significantly lower nitrates content in spinach, apples and plums from farmers' markets than from supermarkets. The most important source of nitrates was spinach, but the content did not exceed the limit set by legislation. Compared to vegetables, the fruit samples had much lower nitrates contents. Strawberries had the highest nitrates content of the fruit samples examined.

Overall, there were significant differences in nitrate content in fruit and vegetables from supermarkets and farmer's markets. On the other hand, differences in vitamin C content were not found.

Since the majority of studies compare the quality of organic and conventional products rather than comparing the nitrates and vitamin C contents of fruit and vegetables from farmers' and supermarkets, it would be better to focus on this area in the future. Our findings suggest that farm products may not always be a better choice in terms of vitamin C and nitrates content than fruit and vegetables purchased in supermarkets.

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