

Nutrition quality of different tomato cultivars

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Abstract

Ten cultivars ('Viltis', 'Milžiniai', 'Skariai', 'Laukiai', 'Vėža', 'Pažar', 'Vilina', 'Ruža', 'Ranij 310', 'Elbrus') of edible tomato (*Lycopersicon esculentum* Mill.) were investigated at the Lithuanian Institute of Horticulture in 2007–2008. The aim of this experiment was to evaluate and select tomato cultivars, which could be grown for raw material production and future breeding, taking into account their nutrition composition. The following fruit quality parameters were evaluated: the amount of lycopene, β -carotene, ascorbic acid, total sugar and nitrates in fresh tomato matter. The quality of tomato fruit at harvesting was evaluated at the Laboratory of Biochemistry and Technology of LIH applying chemical and physical methods of investigations. It was established that according to amount of lycopene and β -carotene in tomato cultivars 'Ranij 310' and 'Elbrus', they could be grown for raw material production. Tomato cultivar 'Vilina', as a source of ascorbic acid with low nitrate content and cultivar 'Elbrus' as a source of total sugar can be grown for raw material production and may be used in future breeding.

Key words: ascorbic acid, β -carotene, lycopene, *Lycopersicon esculentum* Mill., nitrates, total sugar.

Introduction

The replacement of synthetic antioxidants by "safer natural mixtures" is being advocated increasingly by food industry nowadays. This trend has been imposed by the worldwide preference of consumers for the use of natural antioxidants, some of which may exist inherently in foods or be added intentionally during their processing. Among these, carotenoids comprise the group of the most abundant micronutrients in vegetables and fruits, and their dietary consumption is associated with a lower incidence of certain types of cancer as well as with enhanced protection against cardiovascular diseases /Kritchovski, 1999; Kiokias, Gordon, 2004/.

The colour of flowers and fruits is caused by the presence of different kinds of pigment belonging to the phenylpropanoid and terpenoid classes, whose three major groups are chlorophylls, carotenoids and anthocyanins. In some crops, domestication has possibly resulted in selection of agronomic traits that prevail over colour characteristics, whereas in others, an increase or refinement in the pigments naturally present in the edible tissues has occurred. This is likely to apply to tomato (*Lycopersicon esculentum* Mill.), the fruit of which is rich in several carotenoid pigments, such as lycopene and β -carotene. The amount of these carotenoids depends on tomato cultivar and its genotype

/Tijksens, Evelo, 1994; Khachik et al., 2002/. It was established that carotene, nitrates and sugar amount in fruits and root-crop vegetables depended on plant genotype, meteorological conditions, fertiliser and soil composition /Karklelienė et al., 2003; Jankauskienė et al., 2007; Brazienė, 2009/. The levels of the essential antioxidant vitamins, in contrast to other antioxidative defenses, are determined mainly by their dietary supply. Major vitamin enriching human diet is antioxidant vitamin C. This vitamin can counteract the oxidizing effects of lipids by scavenging free radicals, which have been found to be the major promoters of certain diseases. Recently it has been demonstrated that carotenoids react cooperatively and synergistically with vitamin C serving to regenerate a pro-oxidant radical carotenoid following the anti-oxidant reduction of a radical species /Simon, 1992; Johnson, 2009/. Ascorbic acid (vitamin C) is a natural antioxidant mainly present in fruits and vegetables. Its use as an additive in fruit juices, jams, dairy products, etc. is allowed by the European Commission. Vitamin C is well known for its important role in biochemical processes, such as collagen formation, iron absorption and its involvement in neurotransmission and immune responses. However, high levels of ascorbic acid in human body could cause adverse effects. Therefore, the accurate determination of this antioxidant in different species and cultivars is of great importance /Simon, 1992; Peng et al., 2008/. There seems to be little doubt that acids and sugars not only contribute to sweetness and sourness of tomatoes, but they are also the major factor in overall flavor intensity. Since the lack of flavor is a common complaint about fresh market tomatoes, increases in sugar and acid content could make a contribution improving tomato flavor /Stevens et al., 1979/.

Nitrate is a naturally occurring compound that is a part of the nitrogen cycle, as well as an approved food additive. It plays an important role in the nutrition and function of plants. Nitrate is an important component of vegetables due to its potential to accumulate; this can be affected by a number of biotic and abiotic factors. Human exposure to nitrate is mainly exogenous through the consumption of vegetables and to a lesser extent – water and other foods. Vegetables are the major vehicles for the entry of nitrate into human system. Ever-increasing concern over nitrate toxicity has directed a number of countries to lay down maximum allowable threshold concentration with regards to nitrate-N in vegetables /Corre, Breimer, 1979; Staugaitis, 1997/.

The aim of this investigation was to evaluate and select tomato cultivars, which could be grown for the raw material production and future breeding, according to their nutrition composition.

Materials and methods

Ten cultivars ('Viltis', 'Milžiniai', 'Skariai', 'Laukiai', 'Vėža', 'Pažar', 'Vilina', 'Ruža', 'Ranij 310', 'Elbrus') of tomato (*Lycopersicon esculentum* Mill.) were investigated in 2007–2008. Tomatoes were grown under the same conditions at the Lithuanian Institute of Horticulture, in not heated greenhouse covered with polymeric film and in the natural soil – in loam on loam more deeply epihypogleyc luvisol (IDg8-k), *Calc(ar)i-Epihypogleyc Luvisol (Lv-p-w-cc)*, enriched with peat-compost substrate at the distance of 35 x 70 cm.

During investigation the following fruit quality parameters were evaluated: the amount of lycopene, β -carotene, ascorbic acid, total sugar and nitrates in fresh tomato matter.

For every replication, 10 fully ripen tomatoes were harvested at random. The tomatoes were cut in small pieces immediately after harvesting, homogenized and filtered. The quality of tomato fruit at harvesting was evaluated at the Laboratory of Biochemistry and Technology applying chemical and physical methods of investigations. Ascorbic acid was measured by titration with 2,6-dichlorophenolindophenol sodium chloride solution; sugar content (inverted sugar and sucrose) – by Bertrand method; the amount of nitrates – potentiometrically, with ionselective electrode /Ермаков, 1987; AOAC, 1990/. In order to establish the nutrition of tomatoes, ripen fruits were homogenized by crusher “Bosch Easy Mixx” (type CNHR6, “Robert Bosch GmbH”, Germany). The amount of lycopene and β -carotene was established spectrophotometrically /Scott, 2001/.

The data are presented as the averages of three measurements. For the evaluation of data significance there were used statistic programs SAS and *Anova* /Tarakanovas, Raudonius, 2003/.

Results and discussion

Tomatoes and related tomato products are the major source of lycopene compounds; besides, they are considered an important source of carotenoids and vitamins in human diet /Mangels et al., 1993; Rao, Rao, 2007; Desai et al., 2008/. Therefore, considerable work has been conducted to increase their levels in tomatoes through breeding programmes /Rosati et al., 2000/. The amount of carotenes and their antioxidant activity as well as their biochemical composition are significantly influenced by tomato variety and maturity /Arias et al., 2000/. The importance of genotype selection for high nutritional value is outlined first, followed by the optimization of environmental conditions and optimization of agricultural practices /Martine et al., 2008/. Normalized values of lycopene content in different tomato cultivars in California ranged from 8.4 to 17.2 mg 100 g⁻¹, i. e. there was 100% difference from lowest to highest /Barrett, Anthon, 2001/. According to P. Viškelis, the highest amount of lycopene (over 10 mg 100 g⁻¹) was established in Lithuanian cultivar ‘Rutuliai’ and was 1.6 time higher comparing with hybrid ‘Admiro’ and 2 times higher comparing with hybrid ‘Kassa’ /Viškelis et al., 2007/.

Based on the data of our investigation (Fig. 1), the highest amount of lycopene was established in cultivars ‘Ranij 310’ (13.56 mg 100 g⁻¹) and ‘Elbrus’ (12.57 mg 100 g⁻¹). The least amount of lycopene was established in the fruits of cultivars ‘Skariai’ (8.55 mg 100 g⁻¹) and ‘Milžiniai’ (8.75 mg 100 g⁻¹). In other cultivars lycopene amount varied from 9.57 (‘Vėža’) to 12.08 mg 100 g⁻¹ (‘Laukiai’). Lycopene is the most abundant carotene in red tomato fruit, accounting for up to 90% of the total amount of carotenoids. Typical red-pigmented tomato fruit also contains lesser amount of β -carotene and other carotenoids. β -carotene occurs in tomato fruits and varies in amounts of 0.23–2.83 mg 100 g⁻¹ /Stommel, 1992; Agarwal, Rao, 2000/. Our studies showed (Fig. 2) that significantly highest amount of β -carotene accumulated two cultivars – ‘Ranij 310’ and ‘Elbrus’, accordingly 2.34 and 2.16 mg 100 g⁻¹. The least amount of β -carotene was established in

cultivar 'Vėža' and reached 1.33 mg 100 g⁻¹. Most of investigated cultivars had a similar amount of β-carotene, which varied from 1.43 to 1.70 mg 100 g⁻¹.

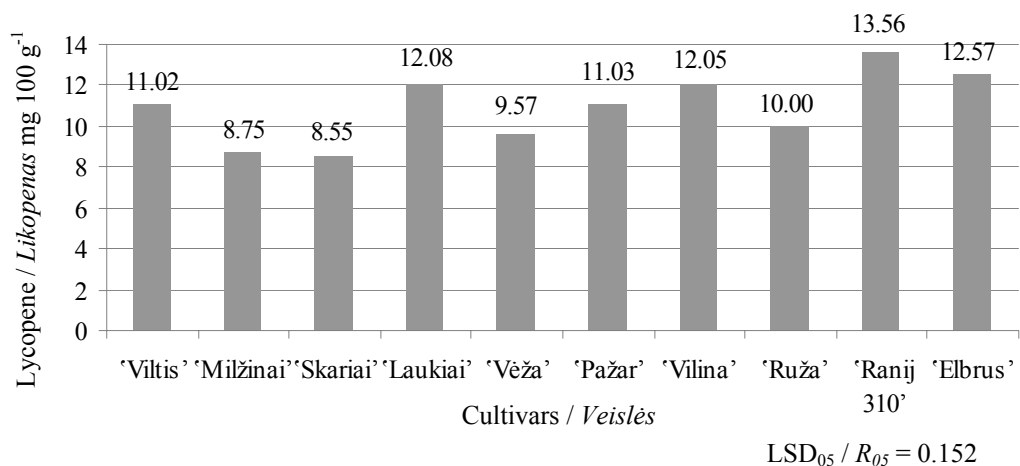


Figure 1. The amount of lycopene in tomato fruits
1 paveikslas. Likopeno kiekis pomidorų vaisiuose

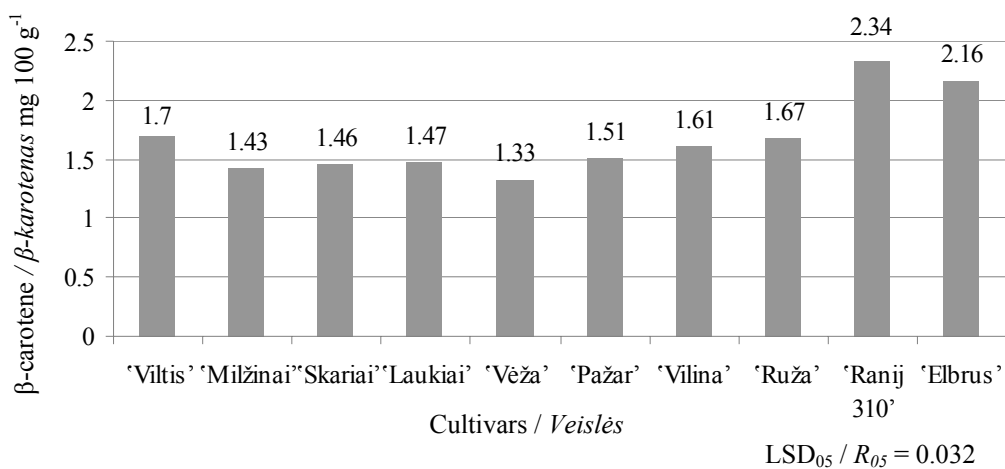


Figure 2. The amount of β-carotene in tomato fruits
2 paveikslas. β-karoteno kiekis pomidorų vaisiuose

Tomatoes are good dietary source of ascorbic acid (vitamin C), however, ascorbic acid content vary greatly in cultivars. Many factors contribute to this variation and environmental growing conditions with cultivars genotype have been reported as having major effects on the ascorbic acid content /Simon, 1992; Peng et al., 2008/. There is a large variation in ascorbic acid content of different cultivars. According to Mathews research, vitamin C values for forty-one cultivar ranged from 10.7 to 20.9 mg 100 g⁻¹ /Mathews, 1973/. Ten years' data presented by Lithuanian scientists show that the

average amount of ascorbic acid in different tomato cultivars is 16.20 mg 100 g⁻¹ /Viškelis et al., 2005/. According to our data (Fig. 3), tomato cultivar ‘Vilina’ had significantly highest amount (15.9 mg 100 g⁻¹) of ascorbic acid compared to the other eight cultivars. Nevertheless, cultivar ‘Laukiai’ did not differ significantly – it accumulated 12.2 mg 100 g⁻¹ of ascorbic acid. The least amount of ascorbic acid was established in cultivar ‘Viltis’ and reached 7.8 mg 100 g⁻¹.

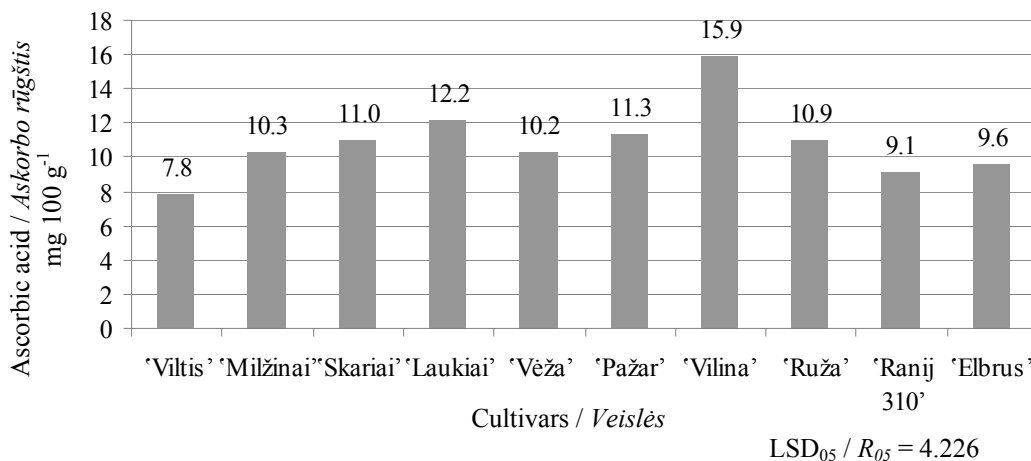


Figure 3. The amount of ascorbic acid in tomato fruits *3 paveikslas. Ascorbo rūgšties kiekis pomidorų vaisiuose*

Sugars and acids are particularly important taste constituents of tomatoes. Sugar content of ripe tomatoes on the average is 3% /Jones, Scott, 1983/, but in the tomatoes grown in Lithuania, the average amount of total sugar is 4.37% /Viškelis et al., 2005/. Other researches showed that the amount of total sugar little varied in different cultivars and ranged from 4.01 to 4.17% /Viškelis et al., 2007/. In our research total sugar content had a little variation too. It varied from 4.32% in cultivar ‘Viltis’ to 5.03% in cultivar ‘Elbrus’ (Fig. 4).

Nitrate content in vegetables may range from 1 to 10 000 mg kg⁻¹ /Nitrates..., 1996/. Various reasons for this wide range are excessive use of fertilizer, crop variety, types of N-fertilizers, light and temperature conditions, lack of water etc. /Corré, Breimer, 1979/. A combination of these factors accounts for different nitrate values reported for vegetables in different countries. The complexity with regards to nutritional exploitation of vegetables is the presence of nitrate (nitrite) as antinutritional and toxic in nature. Nitrate content is an important quality characteristic of vegetables /Santamaria, 2006/. Amr and Hadidi report that cultivar had a significant effect on the nitrate content in the tomatoes grown in greenhouse /Amr, Hadidi, 2001/. According to G. Staugaitis, tomatoes belong to the group, which accumulates low content (100–150 mg kg⁻¹) of nitrates /Staugaitis, 1997/. This was demonstrated in our investigation (Fig. 5). Besides, all tomato cultivars had a low content of nitrates compared to other vegetables. The amount of nitrates ranged from 55 (‘Vilina’) to 91 mg kg⁻¹ (‘Elbrus’).

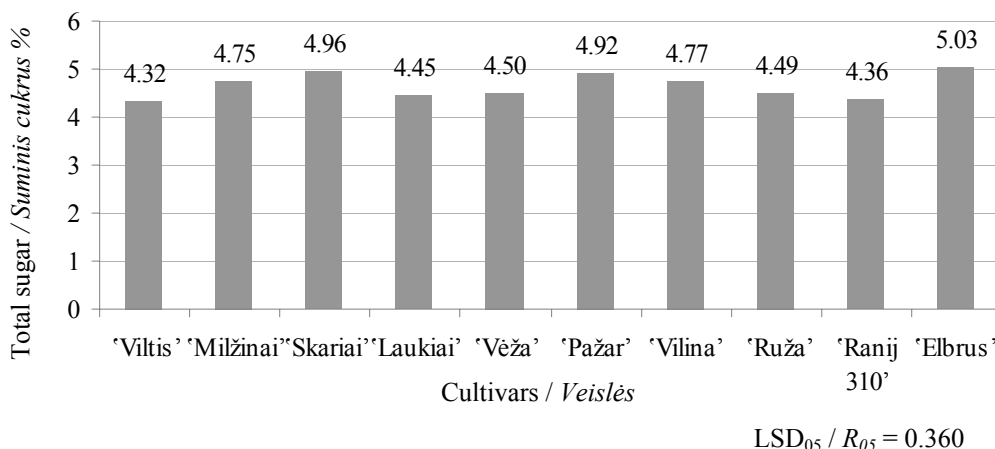


Figure 4. The amount of total sugar in tomato fruits
4 paveikslas. Suminio cukraus kiekis pomidorų vaisiuose

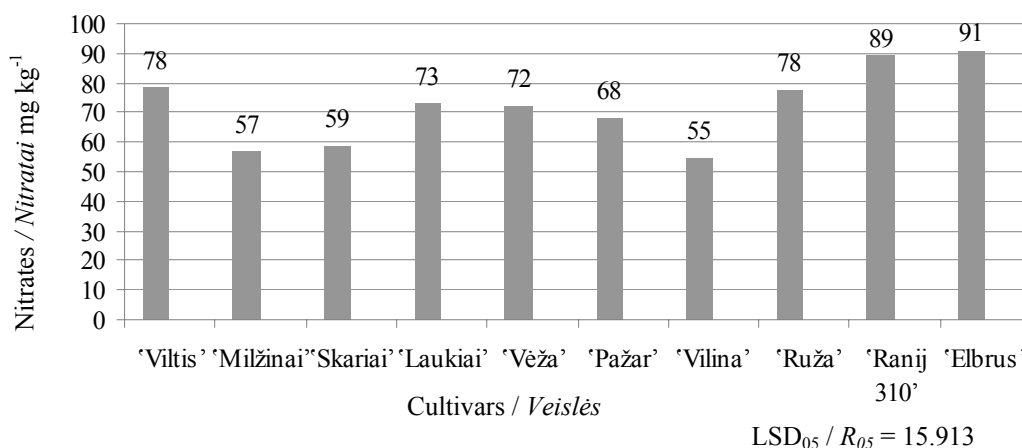


Figure 5. The amount of nitrates in tomato fruits
5 paveikslas. Nitratų kiekis pomidorų vaisiuose

Conclusions

1. According to the detected amount of lycopene and β -carotene in tomato cultivars 'Ranij 310' and 'Elbrus', they can be grown for raw material production.
2. Tomato cultivar 'Vilina', as a source of ascorbic acid with low nitrate content and cultivar 'Elbrus' as a source of total sugar can be grown for raw material production and may be used in future breeding.

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Skirtingų veislių pomidorų vaisių maistinė vertė

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Santrauka

2007–2008 m. Lietuvos sodininkystės ir daržininkystės institute tirta dešimt valgomojo pomidoro (*Lycopersicon esculentum* Mill.) veislių: 'Viltis', 'Milžinai', 'Skariai', 'Laukiai', 'Vėža', 'Pažar', 'Vilina', 'Ruža', 'Ranij 310' ir 'Elbrus'. Tyrimo tikslas – įvertinti ir atrinkti veisles pomidorų, tinkamų perdirbti, atsižvelgiant į jų maistinę vertę. Tyrimo tikslui pasiekti buvo nustatyti ir įvertinti pomidorų vaisių kokybiniai rodikliai: likopeno, β -karoteno, askorbo rūgšties, suminio cukraus ir nitratų kiekis. Remiantis gautais rezultatais, daugiausia suminio cukraus sukaupe veislės 'Elbrus' pomidorai, o veislės 'Vilina' vaisiai sukaupe daugiausia askorbo rūgšties ir mažiausiai nitratų. Didžiausias likopeno ir β -karoteno kiekis nustatytas pomidorų veislių 'Ranij 310' ir 'Elbrus' vaisiuose, todėl šių veislių pomidorai gali būti perdirbami. Pagal likopeno ir β -karoteno kiekį vaisiuose šios pomidorų veislės gali būti naudojamos kaip pradinė medžiaga tolesnei selekcijai, siekiant sukurti naujas, daug karotenoidų vaisiuose turinčias veisles.

Reikšminiai žodžiai: askorbo rūgštis, β -karotenas, likopenas, *Lycopersicon esculentum* Mill., nitratai, suminis cukrus.